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Abstract

Background: Malnutrition is a widespread public health problem in Togo. The aim of this article is to identify the risk factors for malnutrition in children under five and the variations between socio-economic factors.

Methods: We conducted a simultaneous quantile regression analysis to identify the risk factors of malnutrition in Togo. In addition, concentration curves were constructed to explore the nature of variability in malnutrition. We identified risk factors at the child level such as child gender, age, health insurance, wealth index that explain the risk of stunting and underweight.

Results: The decomposition results show that the mother's education contributes about 0.07% of the variability for stunting and underweight for secondary or higher education. Simultaneous quantile regression results show that children of mothers with primary education have a lower risk of stunting (q.0.2 coef 0.2, p-value 0.041) while health insurance is associated with a lower risk of severe stunting in children under five years of age (q0.5, coef = 0.348, p-value .032). Finally, health insurance contributed about 0.17% and living in an urban area contributed 0.12% to the variability in stunting and underweight respectively.

Conclusion: Critical risk factors for malnutrition can help in formulating policies for children's nutritional health. The results suggest that there is a need to encourage critical policies aimed at improving female literacy and universal health coverage to reduce child malnutrition.

Keywords: Child malnutrition, Concentration index, Maternal education, Health insurance.
Background

Malnutrition is a major problem and a major threat to public health that contributes to mortality and morbidity, especially in developing countries such as Togo, where rates remain unacceptable. It is a global problem that is both extremely serious and insufficiently addressed. In addition, child malnutrition has adverse effects on the survival, growth and cognitive development of children throughout their lives and has negative repercussions on the country, such as productivity and health expenditure [1]. It has an enormous human and economic cost, especially for poor people, as well as women and children [2]. It, therefore, poses a threat to human and economic progress by preventing children from fully realizing their mental and physical potential [1,3]. Reducing the prevalence of malnutrition in children under 5 years of age is at the heart of the Sustainable Development Goals. At the global level, 22.2% of children under the age of 5 in 2017 were chronically malnourished [4]. In the same year, 39% of stunted children lived in Africa and Africa is the only region that experienced an increase in the number of stunted children in 2017. Sub-Saharan Africa has one of the highest levels of child malnutrition in the world [5].

Poor nutrition can lead to a reduction in the immune system, impact physical development, and impair mental development leading to reduced productivity. Studies have shown that child malnutrition increases the risk of child mortality [6]. Wasting and stunting are associated with increased mortality rates, particularly among children with malnutrition, constituting major causes of mortality in developing countries [7]. According to FAO et al. [8], malnutrition is associated with 54% of child deaths or 10.8 million children each year in developing countries. It is a public health problem in developing countries, particularly in Togo.

In Togo, the prevalence of stunting, underweight and wasting is 15%, 23% and 5.7% respectively in 2017 (MICS 6), suggesting that the prevalence of malnutrition among children under five remains high. Regarding wasting, Togo has made improvements with weight for height measurements among children under five being 6.6% in 2014 against 5% in 2017 [9] and compared to a prevalence of 6.8% in 2019 in sub-Saharan Africa. Globally, about 45% of under-five deaths were attributable to malnutrition in 2017 and accounted for more than 50% of under-five deaths in developing countries [10]. Malnutrition also has a high economic cost in terms of loss of productivity and growth. It is more prevalent in poor households but also affects wealthier households [11]. Income is not the only determinant of stunting; food insecurity, inadequate dietary diversity, high rates of infectious diseases, inappropriate infant feeding and care, and inadequate hygiene and sanitation practices all contribute to malnutrition.
Furthermore, some studies have shown the influence of demographic factors such as age, sex and size of the child at birth, place of residence, wealth index on child malnutrition. Engebretsen et al. [13] found that age and sex are associated with stunting in children and stunting was more common in boys than girls. Findings on child stunting have shown that the prevalence of stunting is significantly higher in rural areas and that the determinants of stunting are associated with, premature delivery, mother's education and delivery in a health centre [14]. The level of education of the mother, the size of the household and the availability or access to safe drinking water is consistently associated with child undernutrition [15]. In addition, Aheto [16] identified factors such as type of birth, number of children in the household, health insurance status, gender, age, place of delivery and size at birth as significant risks of severe stunting factors in children under five years of age.

While the general determinants of malnutrition have been previously explored as reviewed above, the determinants of under-five malnutrition in Togo have received less attention. The importance of such context specific determination would inform context specific policies and programmes to reduce under-five malnutrition in Togo. To this end, we sought to identify the critical risk factors for malnutrition among children in Togo and investigate the contributions of the determinants of inequalities in child malnutrition in Togo.

**Methods**

A multivariate simultaneous quantitative regression model was used to identify the critical risk of stunting factors in children under five years of age. The primary objective of this study is to model a severe form of growth retardation (HAZ < -3), which corresponded to quantiles between 0.01 and 0.20 inclusive, according to WHO growth standards. The simultaneous use of quantile regression is of primary interest in modelling stunting between 0.2 and 0.5 of the lower part of height-for-age quantiles as well as ranges from 0.5 to 0.8 of the upper part of HAZ quantiles as opposed to ordinary least squares regression.

**Data and variables**

The data from which the study was conducted emanated from the MICS6 survey. The MICS6 survey represents a nationally representative sample of households, children aged 0-5 years, women aged 15-49 years and men aged 15-59 years. The survey was conducted by the Togolese Directorate of Statistics with financial and technical support from UNICEF, USAID and UNFPA, and the Ministry of Health. The aim for the survey was to verify the various indicators of maternal and child health. The information collected usually covers nutrition, immunisation
coverage, health care utilisation, health insurance coverage, socio-economic characteristics, etc. The information is then used to develop a national strategy for maternal and child health. Three different measures of child nutrition were used for the analysis. These were height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ). The z-scores were then classified into three categories: stunting, underweight and wasting.

**Statistical analyses**

**Simultaneous quantile regression**

Simultaneous quantile regression was used to investigate the determinants of stunting. Beyond stunting, examined the effects of risk factors at different points in the conditional distribution of stunting and underweight. This quantile regression is used to describe the conditional quantiles of the outcome variable in relation to the covariance. Thus, the quantile regression model is a model for describing the impact of the explanatory variables on a variable of interest and gives much more information. Analysis of the determinants of children's nutritional status corresponding to the quantiles of interest is either in the lower (0.10), median (0.50) or upper (0.90) part of the distribution rather than only studying the determinants of the mean distribution [16,17]. Quantile regression is rarely used, despite its advantages over linear regression, particularly for modelling anthropometric data. This method goes beyond the ordinary least square (OLS) method by allowing the determination of the effect of explanatory variables on the shape and size of the distribution of the variable of interest, using several different values from τ and not only the mean of the latter.

Either $Y$ the explanatory variable and $X$ a vector of the observed covariances. We can model the quantile regression τ the conditional variable $Y$ à $X$ as reflected in the following regression model:

$$Q_{y|x_i}(\tau|x_i) = x_i^T \beta_{\tau} \quad (1)$$

where, $Q_{y|x_i}(\tau|x_i)$ is the result of the regression of the conditional quantile $\tau^{th}$ is given by $x_i$, $\tau \in (0, 1)$ is the $\tau^{th}$ quantile of the outcome variable, which is growth retardation. In addition, $x_i = (x_{i1}, x_{i2}, x_{i3}, \ldots \ldots x_{ip})^T$ is the vector of covariances for each individual i, and $\beta_{\tau} = (\beta_{\tau 0}, \beta_{\tau 1}, \beta_{\tau 2}, \ldots \ldots \beta_{\tau p})^T$ is the vector of regression coefficients ($p + 1$) with $\tau$ known. This being the case, the quantile regression coefficients $\beta_{\tau}$ then represent the way in which the
specified quantiles change when one unit of a variable changes. \( x_i \) [17]. Finally, it offers a richer approach for estimating model parameters using the set of conditional quantiles.

The equation allows two or more variables to be modelled simultaneously while taking covariance into account. This provides a more complete picture of the distribution, not only for stunting and underweight but can be used to identify the most vulnerable groups.

We also applied the concentration index to analyse the socio-economic determinants of child malnutrition in Togo. The concentration index is the double covariance between the health variables \( y: \) stunting and underweight \( \) of individual \( i \) and the ranking of socio-economic status, \( r \), divided by the health variable \( \mu \) :

\[
C_i = \frac{2}{\mu} \mathcal{VOC}_w (y_i, R_i) \quad (2)
\]

It is the most widely used measure because it allows for the classification of individuals across all socio-economic groups, and sensitivities to population change to assess the relative distribution and absolute socio-economic breakdown [18; 19].

**Method for decomposing inequality by the concentration index**

Although concentration indices are relevant for measuring socio-economic inequalities in child malnutrition, they cannot explain the factors that have contributed to the observed inequalities. Therefore, this study has a great interest in knowing these factors, as they are essential to explain the underlying causes of inequality. To address this concern, the paper uses the concentration index decomposition methodology to explain inequality in child malnutrition. The contribution of each factor to socio-economic inequality is related to stunting/underweight which is calculated as the product of the sensitivity of stunting/underweight for each child and the degree of socio-economic inequality of each factor. A decomposition analysis was carried out to assess the extent to which each of the factors contributes to measuring inequalities in child malnutrition. We used the probit model with partial effects assessed using [21], which is expressed as the expression of the following model:

\[
y_i = \alpha + \sum \beta_j x_{ij} + \epsilon_i \quad (3)
\]

With \( \beta_j \) is the probability of malnutrition (underweight), is associated with determinants \( j \) [22, 23]. So CI \( y \) can be decomposed as follows

\[
CI_y = \sum (\beta_j \bar{x}_i/\mu_y)CI_{xj} + CI_u/\mu_y \quad (4)
\]
Where the second term on the right represents income-related socio-economic inequality in variable outcomes that cannot be explained by a systematic variation of $x$ by income. But we are interested in the first term on the right side of the equation, which represents the contribution of each determinant $CI_y$.

**Results**

**Description of variables**

Table 1 provides descriptive statistics for the variables included in the data analysis. The table shows that the average $z$-scores for height for age, weight for age and weight for height are -0.770, -0.778 and -0.141 respectively. There was a higher proportion of respondents in rural areas (55.98%) than in urban areas (44.02%). About 27.96% of the mothers had no formal education at all, compared to 31.76% with a primary level of education that is lower than that of women with at least secondary/higher education (40.28%). Similarly, about 17.70% of the respondents are in the lowest wealth quintile, compared to 23.25% in the highest wealth quintile. Descriptive statistics also show that there are more female children (50.31%) than male children (49.69%). Furthermore, health insurance coverage reveals that 95.11% of the sample have no health insurance coverage, compared with 4.89% who have health insurance coverage. Most pregnant women (76.91%) were assisted during childbirth by qualified health personnel compared with 23.09% of unqualified health personnel. Finally, out of 1968 children that were analysed, most (52.54%) had an average height with 13.82% children being small and 33.54% children being large. We also noted that most households in the sample were harboured married (53.95%) couples and 46.05% are never married.

**Table 1: Descriptive analyses of the variables**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average</th>
<th>Frequency</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth retardation</td>
<td>-0.770</td>
<td>-5.94</td>
<td>99.99</td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>-0.778</td>
<td>-5.97</td>
<td>99.99</td>
<td></td>
</tr>
<tr>
<td>Female child</td>
<td>-0.141</td>
<td>-4.86</td>
<td>99.99</td>
<td></td>
</tr>
<tr>
<td><strong>Women's education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>27.96</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>31.76</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Secondary/Higher</td>
<td>40.28</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Wealth Index</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poorest</td>
<td>17.70</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>18.77</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Less poor</td>
<td>20.07</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Rich</td>
<td>20.22</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Very rich</td>
<td>23.25</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
To achieve the main objective, multivariate simultaneous quantile regression models were adapted to different quantiles measuring stunting and underweight. For the regression quantile of stunting, socio-economic factors such as wealth index, marital status, place of residence, gender of the child, health insurance are identified as important socio-economic factors in stunting in children under five. On the other hand, the level of education of the mother, economic regions, are associated with a reduced risk of stunting in children under five.

The results show that the risk of stunting decreases if the children come from less poor women for all three quantiles (q.02 coef 0.47, p-value 0.000); (q.0.5 coef 0.49, p-value 0.006); (q.0.8 coef 0.374, p-value 0.009). Furthermore, children of mothers with primary education are at lower risk of stunting (q.0.2 coef 0.2, p-value 0.041). The results of the use of simultaneous quantile regression show that for the quantiles 0.2, female children have a higher chance of resisting difficulties in nutritional status than male children who have a slope (q0.10: coef = 0.27, p-value 0.003) and for (q0.5, coef =0.23; p-value 0.000) and (q0.8, coef =0.374; p-value 0.021). In addition, mothers with health insurance are associated with a reduced risk of severe stunting in children under five years of age (q0.5, coef = 0.348, p-value .032). Finally, the
coefficient of the variable rural area is associated with an increase in the risk of mortality in children under five years of age for \((q_{0.2}, \text{coef} = 0.12; \text{p-value} 0.021)\). Hence stunting is higher among children under five living in rural areas.

**Table 2: Results of the simultaneous regression analysis of quantiles**

<table>
<thead>
<tr>
<th>Size for age</th>
<th>Quantity 0.2</th>
<th></th>
<th>Quantity 0.5</th>
<th></th>
<th>Quantity 0.8</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>p-value</td>
<td>Sig</td>
<td>Coef</td>
<td>p-value</td>
<td>Sig</td>
</tr>
<tr>
<td>Age of the woman</td>
<td>.00</td>
<td>1</td>
<td>-.001</td>
<td>.341</td>
<td>.834</td>
<td>-.003</td>
</tr>
<tr>
<td><strong>Wealth Index</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>.57</td>
<td>.761</td>
<td>.181</td>
<td>.08</td>
<td>*</td>
<td>.146</td>
</tr>
<tr>
<td>Minus</td>
<td>.47</td>
<td>0</td>
<td>*</td>
<td>.491</td>
<td>**</td>
<td>.374</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>.27</td>
<td>.003</td>
<td>**</td>
<td>.234</td>
<td>**</td>
<td>.138</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>-.03</td>
<td>.727</td>
<td>.003</td>
<td>.955</td>
<td>.025</td>
<td>.796</td>
</tr>
<tr>
<td>Primary</td>
<td>.27</td>
<td>.041</td>
<td>**</td>
<td>.122</td>
<td>.132</td>
<td>.112</td>
</tr>
<tr>
<td><strong>Region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maritime</td>
<td>.04</td>
<td>.729</td>
<td>.113</td>
<td>.311</td>
<td>.145</td>
<td>.22</td>
</tr>
<tr>
<td>Trays</td>
<td>-.15</td>
<td>.409</td>
<td>-.043</td>
<td>.663</td>
<td>.07</td>
<td>.542</td>
</tr>
<tr>
<td>Central</td>
<td>.15</td>
<td>.159</td>
<td>.079</td>
<td>.297</td>
<td>.193</td>
<td>.222</td>
</tr>
<tr>
<td>Kara</td>
<td>.07</td>
<td>.503</td>
<td>-.065</td>
<td>.625</td>
<td>.026</td>
<td>.862</td>
</tr>
<tr>
<td>Savanes</td>
<td>0</td>
<td>1</td>
<td>.033</td>
<td>.811</td>
<td>.36</td>
<td>.128</td>
</tr>
<tr>
<td><strong>Insurance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have insurance</td>
<td>.12</td>
<td>.631</td>
<td>.348</td>
<td>.032</td>
<td>**</td>
<td>.215</td>
</tr>
<tr>
<td>Childbirth</td>
<td>-.02</td>
<td>.812</td>
<td>-.056</td>
<td>.559</td>
<td>.056</td>
<td>.704</td>
</tr>
<tr>
<td><strong>Residence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>environment</td>
<td>.12</td>
<td>.521</td>
<td>.088</td>
<td>.618</td>
<td>-.042</td>
<td>.749</td>
</tr>
<tr>
<td>Constant</td>
<td>-.242</td>
<td>0</td>
<td>***</td>
<td>-1.375</td>
<td>***</td>
<td>-.408</td>
</tr>
</tbody>
</table>

Analysis of the effects of the covariance of quantiles from 0.2 to 0.8.

The figures 1 shows the quantitative effects of covariance on different quantitative ranges for stunting (height for age) and underweight (weight for age). The results presented in Figure 1 represent the plots of the effects of the covariance of the different quantiles based on the simultaneous regression of the quantiles (black dots), which is associated with a 95% confidence interval (grey regions). The continuous black line in the intervals represents the line of the linear regression with their 95% confidence intervals (dashed black lines).

Figure 1 reveals that some covariance such as wealth index and marital status have a small effect at the lower quantiles of the z-score for height for age and larger effects at higher quantiles of the z-score for height for age while for others such as maternal health insurance age, the mother's residential environment and education had larger effects in the lower quantiles of the
age z-score and minimal or small effects in the upper quantiles of HAZ. The regression of the quantiles allowed the data to fit well especially in the lower and/or upper parts of the distribution for covariance such as maternal health insurance, maternal education and residence background than the ordinary least squares regression (i.e. the solid and dashed black lines in Figures 1) which indicates the statistical analyses of the variables.

For example, the impact of the household's home environment on stunting of children under five years of age is higher in the lower quantile and lower in the upper quantile of stunting. This finding suggests that children in the lower end of the stunting distribution are more likely to experience stunting. As a result, they are obliged to benefit from interventions aimed at providing these settings with the required benefits against nutritional status that children at the upper end of the distribution. Furthermore, the impact of the wealth index on stunting is lower at the lower end of the confidence interval but higher at the upper end. This suggests that children in the lower part of the confidence interval of this distribution are more likely to be severely stunted. Thus, they benefit less from interventions to address problems related to household income inequality than those at the top of the distribution. Variables such as residence background, wealth index increase the risk of severe stunting among children under five years of age across this quantile distribution.

Furthermore, children whose mothers have not received an education have an increased risk of severe stunting compared to children whose mothers have not received an education. The risk of stunting in children is high in the lower part of the confidence interval. Thus, the high level of education of mothers has been shown to protect children from malnutrition [3; 23]. This indicates that mothers' education leads to better knowledge about good child feeding practices, better health behaviour and the availability of information on the health status of the child. Well-educated mothers are expected to be more aware of their children's nutrition and health [24; 25, 26].

**Analysis of the decomposition of the index of concentration and contribution to the variability of malnutrition**

Economic inequality in health care results from certain factors, as does inequality in malnutrition [28]. Therefore, decomposition analyses are carried out to identify the absolute contribution of socio-economic factors to the variability in malnutrition in children under five years of age. The results of the inequality decomposition analysis are selected for explained variables such as height for age (stunting) and weight for age (underweight).
Table 3 presents the results of the decomposition analysis showing the socio-economic factors of households that contribute child malnutrition in Togo. Three different analyses were conducted for the decomposition results. Firstly, the impact of different individual characteristics on child malnutrition is estimated. Secondly, the concentration index for each of the socio-economic variables to show the variability of distribution, and finally, the percentage contribution of each of the variables to child malnutrition.

To facilitate the interpretation of the contribution of each explanatory variable to the inequality of malnutrition, it is important to first see the distribution of these variables according to their concentration index. The concentration indices for the explanatory variables suggest that with the exception of some variables such as nurses/midwives and the age of children, variability of all other variables is concentrated among the rich. On the other hand, the explanatory variables such as urban area, secondary/higher level of education, central region and the female sex of the child give a positive and significant sign, indicating an inequality of malnutrition among children in favour of the rich.

In addition, the percentage contribution of the different explanatory variables to child malnutrition is presented in the last column of Table 1. The absolute values show the contribution of the variables to the inequality of malnutrition. The positive (negative) sign is an indication that the variable contributes (does not contribute) to inequality.

For example, the z-score results for height for age indicate that maternal education, urban location, health insurance coverage, child gender and wealth index play an important role in the inequality of child malnutrition. In the case of z-weight-for-age z-score results for child malnutrition, mother's education, health insurance coverage and household wealth index are important in child malnutrition. Households belonging to the poor categories have a negative concentration index (-0.04), which indicates that children from this category are really less economically well off, while rich households have a positive concentration index (0.10), which means that they belong to the category of households with high economic status. It should be pointed out that the wealth index of rich households that contributes most to socio-economic inequality in terms of stunting and underweight children by 0.1 per cent and 0.11 per cent respectively among children under five years of age.

Specifically, households that have a wealth quintile plus contribute about 49% to the total inequality in child malnutrition measured by height for age. Another important factor is the mother's education, which contributed about 13% for secondary/superior level. Furthermore,
for z-scores of weight for age, households belonging to the highest wealth quintiles contributed about 42.6% to the risk of child malnutrition. Also, mothers' secondary or tertiary education contributed about 18.9% and 11.8%, respectively, to inequality in child malnutrition.

Similarly, the analysis shows that the prevalence of stunting and underweight is higher among mothers with primary education who live in the Savannah, Kara and Plateau regions. There is a negative contribution percentage for women with primary education of 0.1%. This absolute contribution is 0.01% in the Savannah, 0.003% in the Plateaux and 0.01% in Kara. On the other hand, wealthy households with a secondary/superior level of education and resident in Lomé Commune have the highest positive contribution to inequalities in malnutrition in stunting (0.1%; 0.07% and 0.04%) and underweight (0.11%; 0.07% and 0.03%) respectively. The positive value of the contribution means that the variable contributes to inequality in favour of the rich.

While observing variables related to the mother's characteristics, the study found that the mother's age, health insurance, the child's gender and the urban environment are important factors in child malnutrition. In fact, the sign of the concentration indices of these factors are positive for both indicators, namely stunting and underweight. This shows a high proportion of stunted and underweight children in Togo. It should be stressed that the socio-economic inequality related factors that contribute most to stunting among children are related to the age of the mother (11.8%) and the sex of the child (0.23%), the availability of health insurance (0.15%) and the urban environment (1.17%). Regarding underweight, the age of the mother (12.36%), the sex of the child (0.024%), the availability of health insurance (0.16%) and the urban environment (1.14%) were identified to contribute most. The age groups make a strong contribution to child malnutrition because women at the reproductive age have a greater need for health services. This is one of the determinants that has a high impact and has a greater contribution to the concentration index. The result of the decomposition indicates that the urban environment has a contribution of 1.17% to stunting and about 1.14% to underweight children under five years of age.

In addition, the characteristics of married mothers have a concentration index (0.059) with a significant contribution of (0.82%) to the reduction of stunting and a concentration index of (0.057) with a significant contribution of (0.81%) to the reduction of underweight. This shows that marital status has a lower contribution to stunting and underweight in children under five years of age.
Table 3: Results of the decomposition of height for age and weight for age.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Growth retardation</th>
<th>Underweight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concentration index</td>
<td>Contribution</td>
</tr>
<tr>
<td>Age of the woman</td>
<td>0.0156</td>
<td>0.012</td>
</tr>
<tr>
<td>Insurance</td>
<td>0.124</td>
<td>0.00017</td>
</tr>
<tr>
<td>Female Sex</td>
<td>0.018</td>
<td>0.00025</td>
</tr>
<tr>
<td>Urban environment</td>
<td>0.103</td>
<td>0.0013</td>
</tr>
<tr>
<td>Primary</td>
<td>-0.02</td>
<td>-0.0002</td>
</tr>
<tr>
<td>Secondary/Higher</td>
<td>0.065</td>
<td>0.0007</td>
</tr>
<tr>
<td>Poor</td>
<td>-0.04</td>
<td>-0.0002</td>
</tr>
<tr>
<td>Rich</td>
<td>0.101</td>
<td>0.0012</td>
</tr>
<tr>
<td>Bride</td>
<td>-0.059</td>
<td>-0.00089</td>
</tr>
<tr>
<td>Kara</td>
<td>-0.020</td>
<td>-0.0002</td>
</tr>
<tr>
<td>Central</td>
<td>0.0047</td>
<td>0.0001</td>
</tr>
<tr>
<td>Trays</td>
<td>-0.0053</td>
<td>-0.00003</td>
</tr>
<tr>
<td>Maritime</td>
<td>-0.034</td>
<td>-0.0002</td>
</tr>
<tr>
<td>Lomé-commune</td>
<td>0.097</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Discussion

We aimed to identify the risk factors for stunted growth and malnutrition in children under five years of age in Togo. We also examined the effects of these risk factors on different quantiles of stunting to propose appropriate intervention strategies for malnutrition. The risk factors associated with stunting are the mother's education, home environment and health insurance and marital status. The quantile modelling approach used in this study allows a richer characterisation of the data, revealing the effect of a covariance on the whole distribution of stunting, thus allowing the identification of the most vulnerable households. For example, the impact of the mother's education, place of residence, health insurance and marital status in households on HAZ was higher in the upper quantiles part of HAZ. Thus, the age of the child and the number of children under 5 years of age in households interventions to address severe stunting of children under 5 years of age may have a greater impact on children who are more at risk of severe stunting. In addition, the impact of multiple births and mothers with no formal education on HAZ was lower in the lower tail but higher in the upper tail, suggesting that children in the lower tail of the HAZ distribution.
In Togo, the high level of malnutrition has been a hotly debated topic over the past three decades. The World Hunger Index report indicates that Togo ranks 80th out of 119 countries in 2019 and the hunger situation is considered "severe" with 24.3 percent of the population suffering from hunger () indicating a prevalence of undernourishment and hunger-related problems in the country.

The results of the study show that there are inequalities in the malnutrition of children according to the place of residence or rural areas, where more than 18.1% of children are underweight compared to 29.7% of stunted growth, the level of education of the mother (mothers with no education represent more than 19.3% of children are underweight compared to 28.5 due to stunted growth), wealth status (the poorest / lowest quintile representing more than 23.9% of underweight children compared to 33.2% due to stunted growth), and region (the Savanes region has 22.8% compared to 10.3% in Lomé commune who are underweight). Data from the MICS 6 survey in 2017 reveals the presence of inequalities in terms of stunting and underweight among children under five. This allows the results to be deepened by focusing on the method of decomposing the causes of socio-economic inequalities in child malnutrition.

The results of the decomposition analysis suggest that the level of education of the mother and the environment of residence have a strong contribution to ensure an equal distribution of nutritional outcomes among children under five years of age. This is consistent with previous studies in other developing countries [29]. The result of differences in malnutrition by place of residence and maternal education is consistent with problems that have been reported in other studies in developing countries such as Mozambique and Uganda [29; 30].

The analysis of the breakdown shows that a more equitable distribution of health infrastructure in rural and urban areas will allow easy access to health centres for mothers and the extension of a health insurance coverage system would facilitate recourse to health care. All these contribute to reducing stunting and underweight children in Togo.

In addition, bridging the rural-urban gap in malnutrition requires the strengthening of existing health care services close to patients, such as community-based health care services to reduce child malnutrition. However, rural areas tend to have a high proportion of female mothers, or the fertility rate remains high, those with little wealth and found especially in areas far from the capital where there is a high rate of malnutrition. Therefore, a concerted effort would be made on poverty reduction indicators through economic programmes that empower women and improve their access to education and health, as these would greatly contribute to reducing child
malnutrition in the region. Some of these significant improvements can be attributed to nutritional rehabilitation and food service programmes and nutritional education programmes in the most disadvantaged areas (rural areas). However, this argument is only speculative.

The concentration curves show that the poor continue to be disproportionately underweight and stunted in Togo despite efforts by policy makers to reduce or neutralise socio-economic disparities in malnutrition. These results confirm the findings of van de Poel et al 2007 [22] that stunting and wasting disproportionately affect the poor.

The results of this study further show that height-for-age and weight-for-age, wealth status was the largest contributor to inequality, contributing about 49% to stunting and 43% to underweight.

**Limitations**

This study has certain limitations. Firstly, the study shows the factors that are associated with the risk of malnutrition and socio-economic inequality among children. Second, the mother's education, household wealth index and place of residence contributed to the socio-economic inequality of malnutrition. However, the distinction between rural and urban areas is not addressed due to the lack of a variable that captures variability in the urban area. This is because there is heterogeneity in the characteristics of children in urban areas. Finally, the measurement of wealth status has been based solely on household asset endowments.

**Conclusion**

The objectives of this study are to identify the risk factors for stunting and underweight children under five years of age. Through the simultaneous quantitative regression model, which identifies that the mother's level of education, place of residence, health insurance, gender of the child. The results of this study suggest the formulation of nutrition and child survival policies as well as interventions that improve health policies from the perspective of health care provision.

In addition, the study aims to understand the socio-economic inequalities linked to child malnutrition and to decompose the contribution of these different factors to this inequality in
child malnutrition. Using data from the MICS 2017 survey in Togo, the analysis carried out using the concentration and contribution indices suggests that there is a significant inequality in child malnutrition compared to the poor. The results also show that individual socio-economic characteristics such as level of wealth, mother's education, place of residence, health insurance, gender of the child are important factors in the inequality in child malnutrition. The findings of the study point to the implications of economic policies such as bringing rural and urban areas closer together with a particular focus on poverty levels and improving literacy and women's empowerment. It is important to take into account the high levels of poverty that may exist in urban areas, particularly in developing countries such as Togo. In addition, the health insurance system contributes positively to inequality in access to and use of health care. Hence the particular emphasis on coverage for mothers and children and their access to health care where a majority of the population is still not covered. In addition, public authorities should place particular emphasis on education policies for mothers and children in rural areas.

Ethics approval and consent to participate
The National Statistical Services of Togo, provided ethical clearance for household surveys. All participants in surveys provided informed, signed consent. The study was approved by the Institutional Review Board of the Directorate of Scientific and Technical Research (DRST) of the University of Lomé (Togo). Consentement à la publication.

Consent for publication
I fully agree to the publication of this manuscript. And I fully share the results obtained

Availability of data and materials
The data supporting the conclusions of this article are available at the National Statistical Services of Togo data repository and can be obtained with a written permission.

**Competing interests**

The author declares that he/she has no competing interests.

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**Author’s contributions**

The author read and approved the final manuscript.

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**Data availability**

The data sets used and/or analysed in this study are available from the corresponding National Institute of Statistics and Economic and Demographic Studies (INSEED) upon reasonable
Bibliography :


