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Highlights

- Dietary diversity is low in most low-and middle-income countries
- Stark disparities in diet diversity exist by rural/urban residence and wealth
- Diet quality is associated with income, maternal literacy, and food supply diversity
- >11 million stunting cases can be averted with major improvements in diet diversity

Estimates of dietary quality in infants and young children (6-23 months): evidence from demographic and health surveys of 49 low-and middle-income countries'

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Abstract

Objective

Dietary diversity in early life can prevent all forms of malnutrition and establish a healthier dietary pattern for later life, yet multi-country national estimates are lacking. We aimed to estimate the proportion of infants and young children (IYC) meeting the minimum dietary diversity (MMD), minimum meal frequency (MMF), and minimum acceptable diet (MAD).

Methods

We calculated the proportion of IYC (6-23 months) meeting the updated MDD, MMF, and MAD for 49 low and middle income countries. The proportion of IYC that met the MDD by region, rural/urban residence, and wealth quintile was calculated. The proportion of stunting cases that would have been averted if 90% of the IYC met their MDD was estimated.

Results

The proportion of IYC meeting MDD, MMF, and MAD was very low. Only 4/49 countries had> 50% of IYC meeting MDD. The lowest MDD was for the Sub-Saharan African region (18 %) and the highest for the Latin America & Caribbean (54%) region. Stark inequalities exist between countries, rural/urban residence, and wealth quintiles. A significant proportion (> 11 million) of stunting cases could have been averted if≥ 90% of IYC had met the MDD. MDD proportions increased with higher GNI PPP, women literacy and food supply diversity (P< 0.05).

Conclusion

Closing the gap in dietary inequalities between and within countries is urgently needed to prevent wider, long-term socio-economic and health inequalities. Diet quality targets should be set and monitored routinely to promote dietary diversity and prevent all forms of malnutrition.

Keywords: diet quality, complementary feeding, stunting, inequalities, dietary diversity, food supply

Introduction

With 800 million undernourished, 1.9 billion adults overweight/obese, and about two billion affected by micronutrient deficiencies, malnutrition is now a pandemic affecting one in three people worldwide [1,2]. Women and children in low and middle income countries (LMIC) are the most affected [3]. Poor quality diets, characterized by low diversity are an underlying cause of all forms of malnutrition and affect about three billion people worldwide [4]. For example, poor dietary diversity during the complementary feeding period is consistently associated with-stunting- failure to grow to an expected height for age[5,6] and lower micronutrient density of diets[7]. Stunting is a risk factor for diminished survival, impaired childhood and adult health, and deficits in learning capacity and productivity. With the recognition that the adverse effects of stunting (e.g. cognitive deficits) are largely irreversible past the age of two, interventions are focusing on the "window of opportunity" from pre-conception to the first two years of life[8].

The complementary feeding period of 6-23 months of age, is a critical life stage when energy and nutrient requirements are the highest [9]. It is also the period when growth faltering reaches its peak [10]. Monitoring diet quality during this period is thus critical. To this end, proxy indicators such as the minimum meal frequency (MMF), the minimum dietary diversity (MDD), and the minimum adequate diet (MAD) have been developed and validated in various settings[11, 12]. These indicators are relatively easier to implement in large surveys and provide a good estimation of energy (quantity) and nutrient intakes (quality) [12,7]. For example, dietary diversity has been consistently associated with child stunting[13,6]. Indeed, complementary diets that are constituted of as many food groups as possible can support the provision of adequate energy and nutrient intake [11], reduce exposure to food-borne toxins[14], and support flavor and taste learning[15] to acquire children with a broad repertoire of food preferences that could determine food preference, diets, and health later in life[16]. Consequently, dietary diversity is one of the key World Health Organization (WHO) indicators for assessing optimal infant and young child feeding practices [17]; hence, routine surveys like the Demographic Health Surveys (DHS) capture this indicator for various LMIC.

A recent study re-confirmed the consistent association between stunting and dietary diversity scores by analyzing pooled data from 39 DHS surveys [6]. White et al.[18] recently reported global and regional estimates of complementary feeding practices using the UNICEF global database. However, such regional/global analyses hide within-country heterogeneity in the drivers of dietary diversity. Moreover, the definition of dietary diversity score has been revised to allow more accurate comparisons between countries differing in the prevalence of continued breastfeeding [19,20]. Therefore, updated global, regional, but also country-level estimates of diet quality during the complementary feeding period through widely collected proxy indicators (e.g. dietary diversity) are indispensable to monitor and evaluate changes in diet quality in the Sustainable Development Goal (SDG) era.

Using the largest available, nationally representative, and mutually comparable cross-sectional DHS surveys from 49 LMIC, we investigated proxies of diet quality for infants and young children 6-23 months of age. We used the updated complementary feeding indicators to provide regional and country-level estimates. Missed opportunities in stunting reductions due to low proportion of children meeting minimum dietary diversity were estimated.

Methods

Data sources

Data were obtained from nationally representative cross-sectional DHS surveys from 49 LMIC. We used the most recent data from 2010 onwards. The DHS gather data on various child nutrition indicators including anthropometric measures and infant and young child feeding practices. For example dietary diversity, meal frequency, and the proportion of children meeting minimum adequate diet is captured using standardized questionnaires. The DHS uses a multistage stratified sampling design, with households drawn randomly at the last stage.

The FAO food supply data (FAO stat) was used to calculate food supply diversity (http://www.fao.org/faostat/en/). The 2016 Gross National Income based on purchasing power parity (GNI PPP) was downloaded from the World Bank website (https://datacatalog.worldbank.org/dataset/gni-capita-ranking-atlas-method-and-ppp-based) and was used to assess association between countries income and the proportion of children meeting minimum dietary diversity score.

Data analyses

Stunting was defined as length-for-age z-scores <-2 SD relative to WHO child growth standards [21]. The proportion of infants and young children meeting the MMF, MDD, and MAD were calculated using the revised UNICEF/WHO indicators presented in **Table 1**. As part of the DHS survey design, these indicators are collected from the youngest child under two years of age born to mothers aged 15-49 years and for children living with the mother at the time of the survey.

Wealth quintiles and place of residence were used as stratification variables in this analysis. DHS uses a wealth index derived using principal component analyses applied to a list of household assets/characteristics, which are country-specific. The first quintile (Q1) represents the 20% poorest families, and the last quintile (Q5) represents the 20% wealthiest families. Quintiles correspond to the relative position of households within each national sample, rather than absolute income for which data are not available for most studies. Because fertility is higher among the poor, the poorest quintile tends to include more than 20% of all children surveyed, whereas the richest quintiles include less than one fifth of all children. Urban and rural residence was classified according to boundaries provided by local authorities. We further explored associations between dietary diversity and national food supply diversity, GNI (PPP), and women literacy. These were included in the analyses because the food supply, income/purchasing power, and consumer behavior, largely influenced by women literacy, are considered key drivers of diet quality[22].

The food supply data of the three most recent years (2010-13) for which data was available was averaged and the supply diversity was calculated using the Shannon diversity index. The Shannon diversity index (H) is typically used in Ecology to characterize species diversity in a given area. The Shannon's index considers both richness (number of species) and abundance (how much of each species is present as proportion of the whole population) of the species and was calculated as follows:

$$\mathrm{H} = -\sum_{\mathrm{i}=1}^{7} \mathrm{p_i} \ln(\mathrm{p_i}) \dots \dots (1)$$

Where, p_i is the proportion of the total production coming from food group *i*. We considered the same seven food groups used for calculating MDD. Larger Shannon index values reflect higher diversity, whereas values close to zero indicate very low diversity.

Using the missed opportunity application in the Lives Saved Tool (LiST), we estimated the number of stunting cases that would have been averted if the proportion of MDD (used as a proxy of optimal complementary feeding in LiST) was scaled-up from current to 90%levels. This scenario was simulated by assuming that all other interventions remained at current coverage levels. This modeling approach uses the following assumption:

$$\text{Coverage change x effectiveness x affected fraction = impact} \ldots\ldots (2)$$

The LiST model was previously used in the *Lancet* Nutrition series to estimate the impact of scaling-up nutrition interventions on mortality and child growth [23]. Details about the assumptions, calculations and data sources can be found in earlier publications [24].

Ethics

All analyses were based on publicly available data from national DHS surveys. Ethical clearance was the responsibility of the institutions that administered the surveys. We registered and obtained access to DHS data files from the DHS website. Datasets used did not contain any personal identifiers.

Statistical analyses

Analyses were done using SPSS version 20. Descriptive statistics were presented as mean or median for continuous variables, and as percentage for counts. Inequalities in the proportion of children meeting MDD (%) are presented by wealth quintile and rural/urban using equiplot (http://www.equidade.org/equiplot.php) generated using STATA version 12. Each horizontal line shows the results by quintile or rural/urban for a given country. Normal distributions of the variables were checked using Shapiro-wilk test. Spearman correlations between % MDD and 1) GNI PPP, 2) food supply diversity, and 3) women literacy were run and associations were graphically presented using scatter plots. P-values< 0.05 were considered statistically significant.

Role of the funding source

This work was financially supported by the CGIAR Research Program, Agriculture for Nutrition and Health (A4NH). The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

A significant proportion of Infants and Young Children (IYC) have suboptimal complementary feeding practices **(Fig.1).** There was a high regional disparity in the proportion of children that met the MDD (consumed at least five of the eight food groups), with the lowest value for the Sub-Saharan African region (18 %), and the highest for the Latin America & Caribbean region (54%). MMF figures were slightly better, but followed the same regional trend. The lowest proportion of MMF (Table 1) was for the Sub-Saharan African region (41 %), whereas the highest was for the Latin America & Caribbean region (72%). Although the Latin America & Caribbean region has the highest proportion of children meeting MAD, this represented less than half of the children in the region. Only 9% of IYC's in Sub-Saharan Africa and 40 % in the Latin America & Caribbean region meet the criteria for MAD (Table 1).

Burkina Faso had the lowest proportion (5%) of IYC's meeting the MDD, while Peru had the highest proportion (78%) (**Fig. 2**). Only 4/49 countries had more than 50% of children meeting

MDD, and only 11/49 countries had a proportion that was higher than 30%. Complementary diets were predominantly starch-based (**Fig. 3**). Consumption of food groups like dairy, legumes, and other fruits and vegetables was <30%, irrespective of breastfeeding status. Meat, Fish and Poultry (MFP) and Vitamin-A rich fruits and vegetables was in the range of 30-40%.

Except for Mozambique, Kyrgyzstan and Egypt, the proportion of children meeting MDD in rural areas was always lower or equal to urban areas (**Fig. 4**). The highest rural/urban disparities were observed for Namibia, Niger, Yemen, Rwanda, and Cambodia, whereas Liberia, Mozambique, Egypt, Tajikistan and the Dominican Republic had the least inequality.

There was a high inequality in the proportion of children meeting MDD by wealth quintile **(Fig. 5)**. Except for few cases like Mozambique and Kyrgyzstan, the lowest MDD proportion was always for the poorest quintile and the highest MDD for the richest wealth quintile. In Namibia, Cameroon, Lesotho, Zimbabwe, Nepal, Rwanda and Indonesia there was a stark difference between the poorest and the richest. In Namibia for example there was more than five-fold difference in the proportion of MDD between the poorest and the richest.

More than 11 million cases of stunting could have been averted if the proportion of MDD was 90% **(Fig. 6).** These estimates take into account population size and the gap in MDD relative to an aspirational coverage value of 90%. Cases of stunting averted are generally higher in countries with higher population size and stunting prevalence and a low MDD coverage. About 5 million cases of stunting would have been averted in India, 1.3 million cases in Pakistan, 776,000 in ~~over half a million cases in~~ Nigeria and 541,000 in Ethiopia ~~each~~.

The proportion of children meeting MDD in a given country was positively associated with food supply diversity (rho= 0.399; P=0.005), GNI PPP (rho= 0.658; P<0.001), and women literacy (rho= 0.706; P<0.001; **Fig. 7**).

Discussion

The present study highlights that dietary diversity during the complementary feeding period is low in most of the studied LMICs. Stark disparities in dietary diversity were observed by residence (rural/urban) and wealth quintile. Diet quality during the complementary feeding period was positively associated with country's GNI PPP, maternal literacy, and food supply diversity. A significant number of stunting cases in LMIC could have been averted if the MDD was met by 90% or more of IYC.

Despite increased recognition of the importance of early child nutrition and the implementation of various programs and interventions in LMIC, adequate feeding practices during the complementary feeding period remains extremely poor. Positive progress has been slow and for some countries like Armenia, Malawi and Senegal there is downward trend in the proportion of children meeting their MDD. A review of the infant and young child nutrition-related national policies of 163 countries revealed that only in 26% of the policy documents were diet-related targets/goals/indicators mentioned, and MAD was the only indicator cited[25]. Dietary diversity was mentioned as indicator/target in national policies that promote healthy diet, but reference was made in only 18% of these[25]. A more explicit emphasis of nutrition policies on diet diversity and adequate Infant and Young Child Feeding (IYCF) practices is needed. This can happen by integrating IYCF targets/indicators (MDD, MMF and MAD) into the country's policies and programs and developing monitoring and evaluation plans that track these indicators.

There is also a need to marry agriculture and health programs at community level. Despite language contained within national strategic documents and the existence of multi-sectoral platforms at national, district and sometimes community levels in many of the countries, there are few examples of effective joint programming at local level. Many LMIC have complementary feeding counseling, often administered by Ministry of Health that includes promotion of diversified diet as routine interventions. While nutrition education has been demonstrated to have a positive impact on knowledge and practices, it would be advantageous to complement this approach with nutrition-sensitive agriculture programs.

Exposure to diversified diet in early life can track to dietary behaviors in later life and thus could reduce the risk of developing non-communicable diseases [26]. Unfortunately, the evidence of such tracking of dietary behaviors comes mostly from a small number of observational cohort studies and the length of the follow-up is often up to later childhood [27,28]. However, evidence from studies reporting adult consumption patterns in LMIC confirm the possibility of tracking as they report similar dietary patterns to children, which are also characterized by low dietary diversity [29,30]. For instance, more than 60% of the energy consumed by adults in the Prospective Urban Rural Epidemiology (PURE) study came from starchy foods, mostly from refined carbohydrates such as white bread or rice. Such diets dominated by highly processed starchy foods and with little fruits and vegetables are associated with increased risk of overall mortality and cardiovascular diseases [29]. Fortifying these refined foods with vitamins and minerals can certainly reduce nutrient deficits, but may do little to prevent the increased risk of mortality and cardiovascular diseases. Stunting in early life is also associated with increased risk of overweight/obesity and non-communicable diseases in adulthood [8,31]. This suggests that addressing diet quality in early life is an essential double-duty action that could prevent all forms of malnutrition. To this end, additional indicators that discriminately capture unhealthy dietary patterns in early life are urgently needed.

Addressing rural-urban and wealth inequalities in dietary diversity could help narrow the inequality gap of future generations. Inequalities in diet quality during the complementary feeding period predispose children to stunting, micronutrient deficiencies, poor health, and low productivity in adulthood and thus may be at the center of socio-economic and health inequalities [8]. In rural settings of LMICs, strengthening market infrastructure and making diverse diets accessible and affordable is essential. Access and affordability are intrinsically linked to prices and demand-supply issues that can be positively influenced by ensuring diversity of the food supply in a way that can support consumption of nutritionally-relevant food groups [32,22]. In this regard, governments should review current agriculture policies and incentives, as the focus has been on production and yield of staple crops, while other more nutrient-dense food groups like pulses, fruits and vegetables are under-promoted. This should be complemented with increasing economic wellbeing and access to education, particularly for women, as women's literacy was found to be strongly associated with child dietary diversity.

The present study provides a comprehensive overview on children's diet quality in LMICs through the analyses of mutually comparable, nationally-representative, DHS data. However, the following limitations need to be considered when interpreting our findings. First, two or more rounds of data on dietary diversity were only available for few countries, and thus we were only able to provide trends for a limited number of countries. Second, the cross-sectional nature of the study does not allow any causal inferences to be made. Third, the quality of the evidence rely on the quality of data available, which may vary between countries depending on the extent and quality of the country customization of questionnaires. Availability of data was variable by region. Fourth, our analyses do not capture seasonal effects on diet quality, and the proxy indicators do not provide quantitative measures of diet quality.

Notwithstanding the above limitations, the present study has highlighted that diet quality of IYC in many LMIC is poor and should be substantially improved for both the poor and the wealthy. Women's literacy, food supply diversity, and GNI PPP were all positively associated with better dietary diversity. Interventions that close the gap in dietary quality between the poorest and the richest, as well as the rural and urban are urgently needed to prevent wider, long-term socio-economic and health inequalities. Ensuring that ≥ 90% of infants and young children meet the minimum dietary diversity score would avert a substantial number of stunting cases. Therefore, such diet quality targets should be set and be monitored routinely to inform design of more effective food systems' interventions that can promote healthy diets and prevent all forms of malnutrition.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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None

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Figure captions

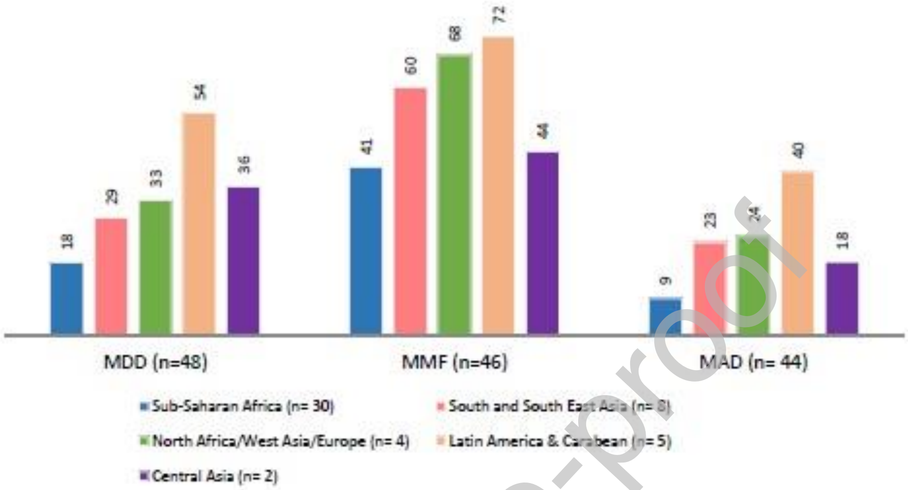

Fig.1 Diet quality of children 6-23 months of age in low and middle income countries

MDD, Minimum Dietary Diversity; MMF, Minimum Meal Frequency; MAD, Minimum Acceptable Diet

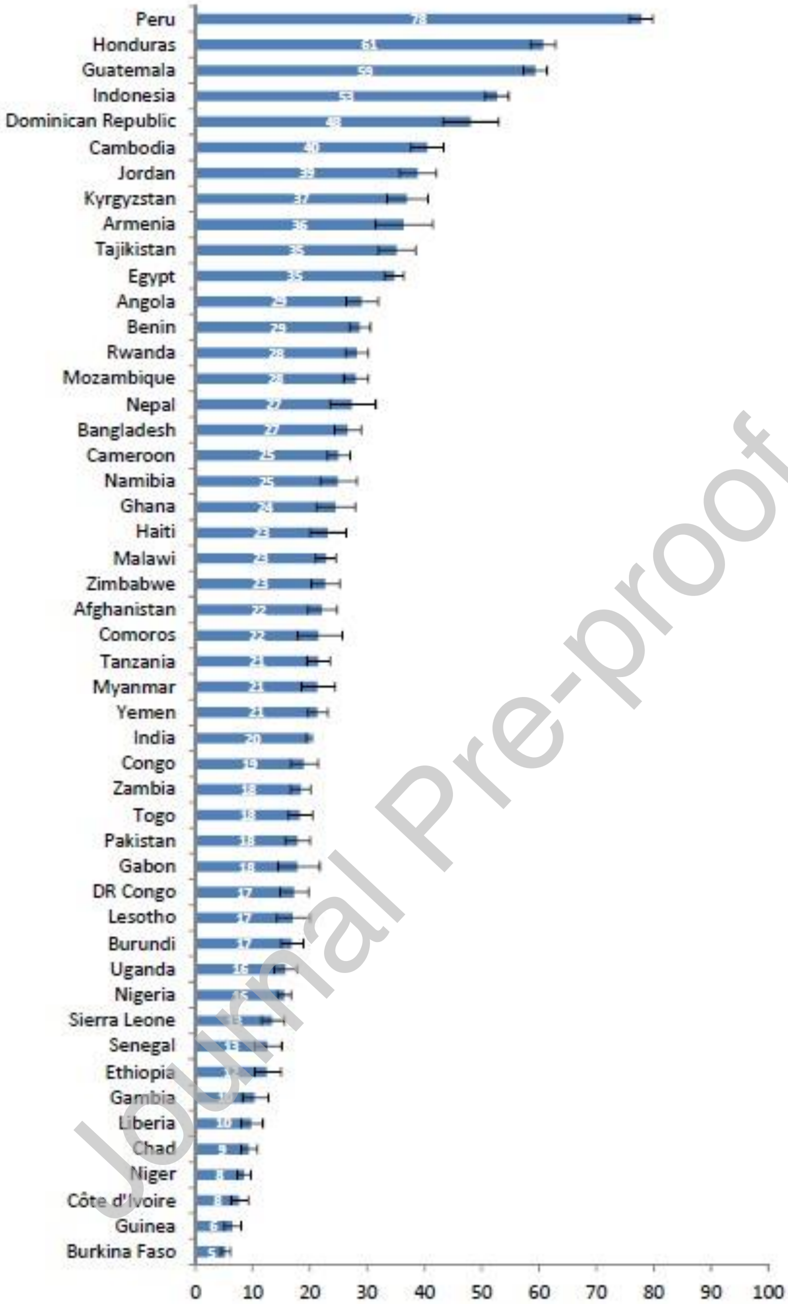

Fig. 2 Percentage of children meeting minimum dietary diversity in low- and middle-income countries

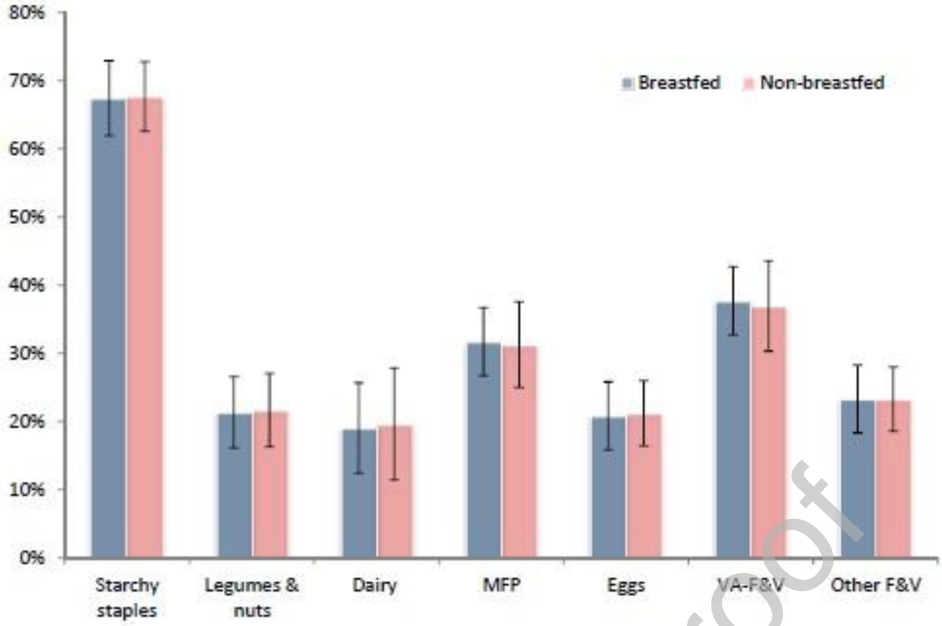

Fig. 3 Food groups consumed by breastfed and non-breastfed children (6-23 months of age) in low- and middle-income countries

Bars represent average prevalence; standard errors show 95% confidence intervals; MFP, meat, fish and poultry; VA-F&V; vitamin A-rich fruits and vegetables

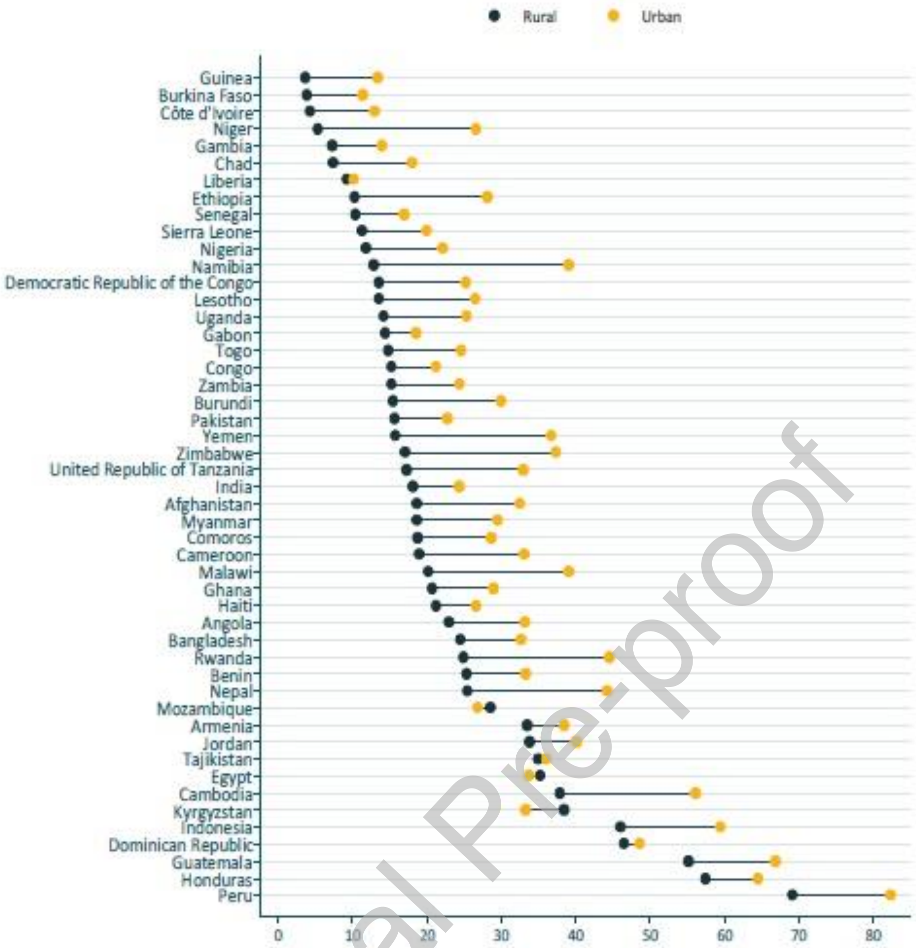

Fig. 4 Proportion of children (%) meeting dietary diversity by rural/urban residence

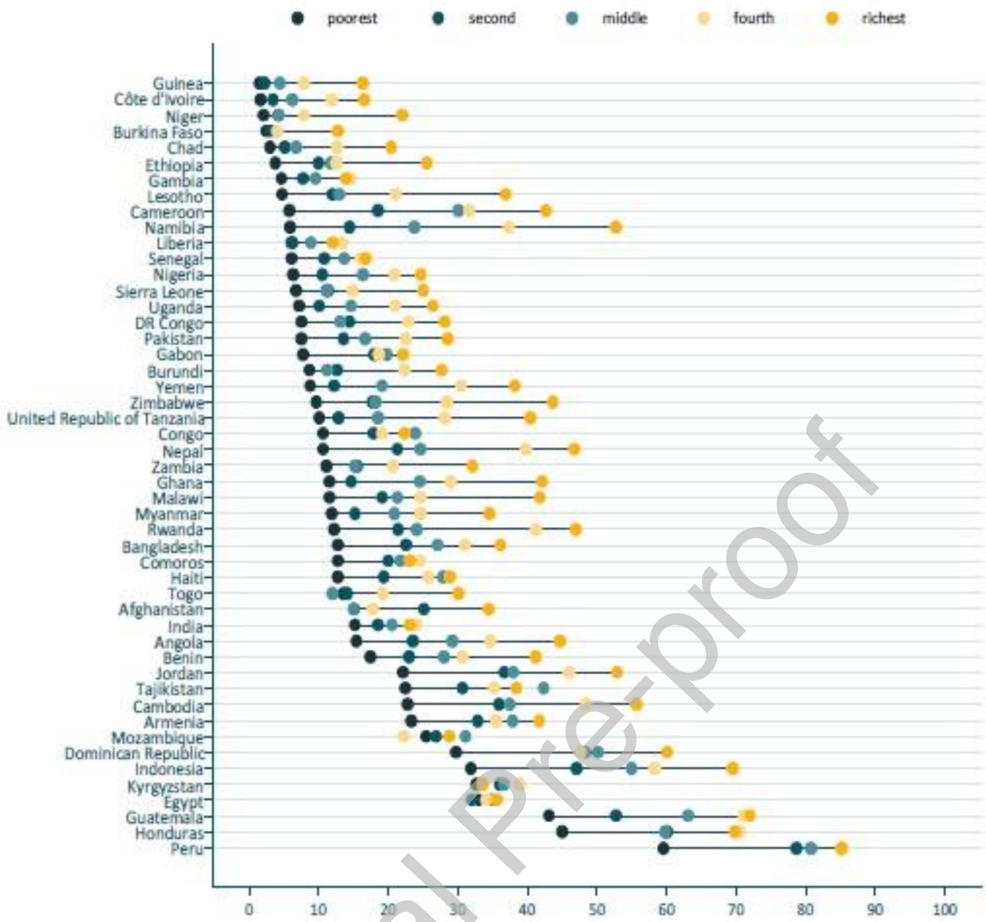

Fig. 5 Proportion of children (%) meeting minimum dietary diversity by wealth quintile

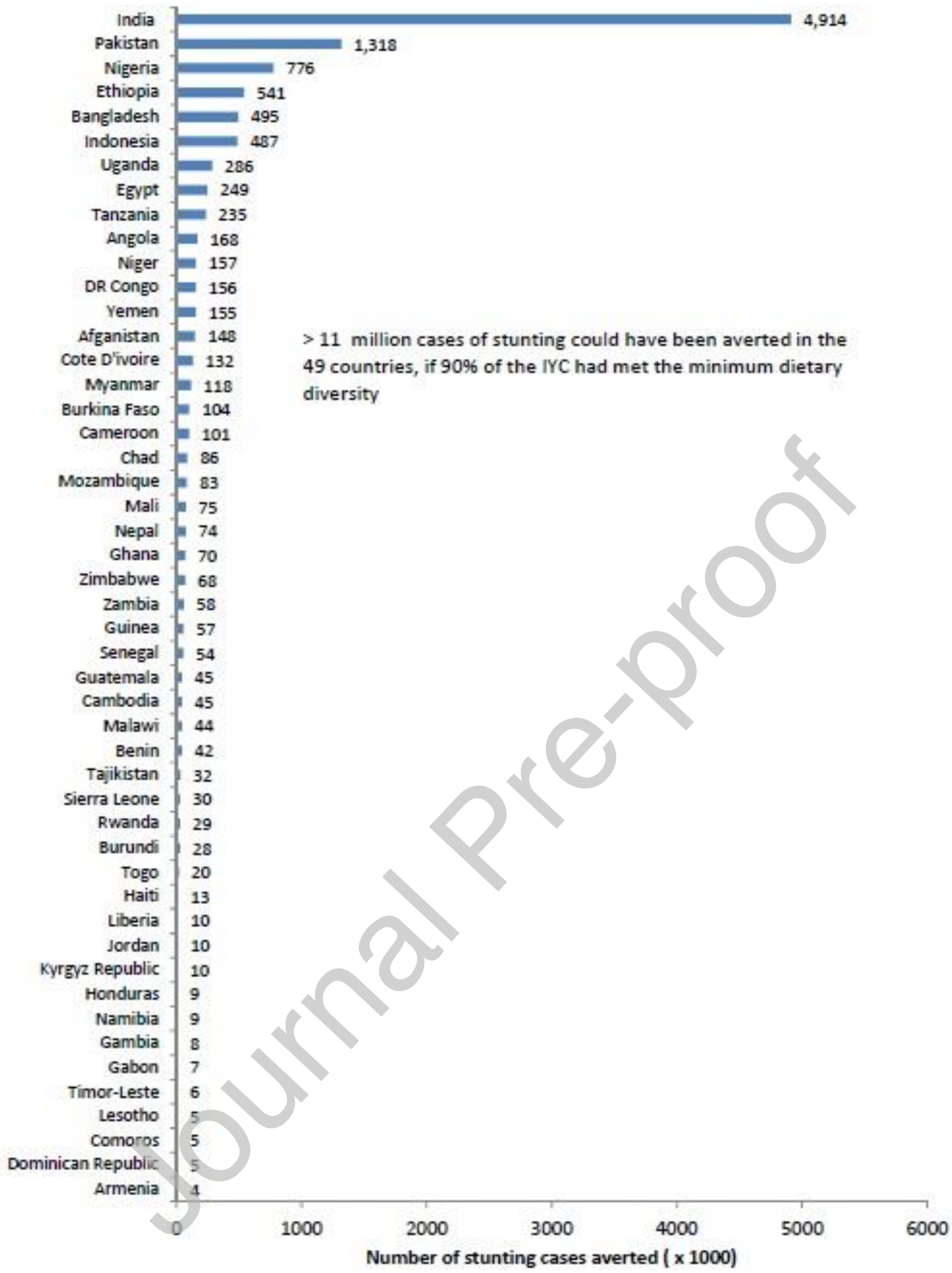

Fig. 6 Number of stunting cases averted with 90% of children meeting minimum dietary diversity

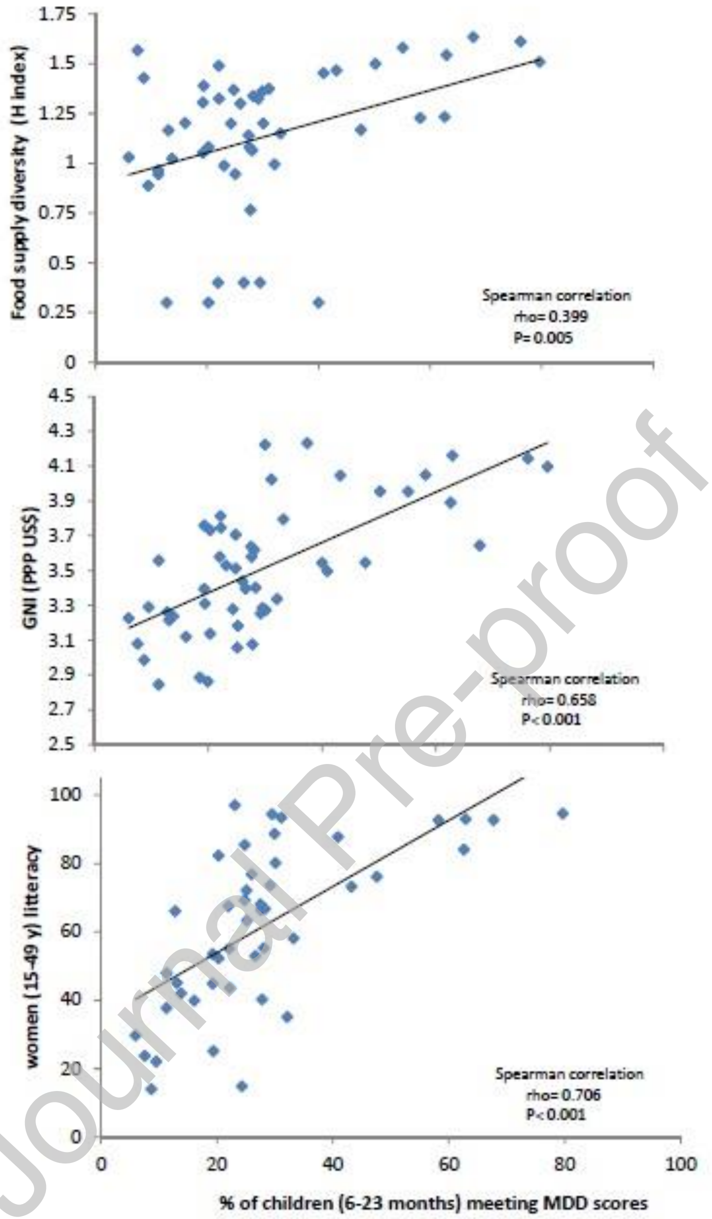

Fig. 7 Factors associated with prevalence of children meeting minimum dietary diversity scores

Table 1 Definition and calculation of Infants and young children feeding indicators

1. Minimum meal frequency (MMF)	
Definition	Percentage of children 6-23 months of age who received a minimum meal frequency
Numerator	Number of breastfed children 6–23 months of age who received solid, semi-solid or soft foods the minimum number of times* or more during the previous day AND the number of non-breastfed children 6–23 months of age who received solid, semi-solid or soft foods or milk feeds the minimum number of times or more during the previous day
Denominator	Breastfed children aged 6-23 months AND Non-breastfed children aged 6-23 months
Notes*	Definition of minimum number of meals: Breastfed 6-8 months of age: 2 times solid, semi-solid or soft foods Breastfed 9–23 months of age 3 times solid, semi-solid or soft foods Non-breastfed children 6–23months of age: 4 times solid, semi-solid or soft foods and/or milk feeds
2. Minimum dietary diversity (MDD)	
Definition	Percentage of children 6-23 months of age who received a minimum diet diversity
Numerator	Number of children 6-23 months of age who received foods from ≥ 5 (out of 8) food groups* during the previous day
Denominator	Children 6-23 months of age
Notes*	The eight food groups are: i) breastmilk; ii) grains, roots and tubers; iii) legumes and nuts; iv) dairy products ; v) flesh foods (meat, fish, poultry); vi) eggs; vii) vitamin-A rich fruits and vegetables; viii) other fruits and vegetables
3. Minimum acceptable diet (MAD)	
Definition	Percentage of children 6-23 months of age who received a minimum acceptable diet
Numerator	Breastfed children 6-23 months of age who had at least the minimum dietary diversity and the minimum meal frequency during the previous day AND Non-breastfed children 6-23 months of age who received at least two milk feedings and had at least the minimum dietary diversity not including milk feeds and the minimum meal frequency during the previous day
Denominator	Breastfed children aged 6-23 months AND Non-breastfed children aged 6-23 months