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Research Article

CHILD UNDERNUTRITION IN G5 SAHEL COUNTRIES: A META-ANALYSIS OF PREVALENCE DATA OF CHILDREN 6- 59 MONTHS FROM DEMOGRAPHIC AND HEALTH SURVEYS

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A B S T R A C T

Background: The G5 Sahel countries (Burkina Faso, Chad, Mali, Mauritania and Niger) face challenges in responding to childhood malnutrition. Data on prevalence of malnutrition in the region is sparse lending program targeting and benchmarking difficult for the region. Here, we analysed data from five Demographic and Health surveys conducted in the G5 Sahel to estimate the pooled prevalence of chronic and acute malnutrition among children aged 6 to 59 months.

Methods: Using data from Demographic and Health Surveys between 2006 and 2016, we calculated a pooled estimate prevalence of height-for-age Z-score(haz), weight-for-height Z-score(whz) and weight-for-age Z-score (waz) with corresponding 95% confidence intervals (CI) using a random effects model. Following WHO standards, wasting was defined as whz<-2 z-score, stunting as haz <-2 z-score and underweight as waz<-2 z-score. Sensitivity analyses was performed to examine outliers. Publication Bias was assessed with Doi plot and asymmetry was evaluated with LFK index.

Results: A total of four surveys met our criteria, with no surveys from Mauritania. Significant heterogeneity was found (I^2>50%). The pooled prevalence in G5 Sahel countries of stunting was 41.8% (95%CI: 37.8%-46.0%), wasting: 14.0% (95% CI: 11.9%-16.4%), and underweight: 30.4% (95% CI: 25.4%-35.6%).

In this dataset, Niger has the highest prevalence rate of stunting (47. 4%), followed by Chad (43.2%), Mali (39.8%) and Burkina Faso with (37.2%). Wasting was also higher in Niger (17.8%), compared to Burkina Faso (14.2%), Chad (12.4%) and Mali (12.2%). The highest underweight prevalence was found in Niger (38.8%), followed by Chad (30.5%), Burkina Faso (26.6%) and Mali (26.2%).

Conclusion: Our study shows a high pooled prevalence of stunting, wasting and underweight among children aged 6-59 months in G5 Sahel countries.

INTRODUCTION

Malnutrition is a major public health issue which affects children under five specifically in under developing countries (Black *et al* 2008). World Health Organization (WHO) 1995) define malnutrition as clinical conditions including several syndromes like muscle wasting in adult and grow failure in childhood. It's unbalance between the dietary need and food intake which can engender over or under nutrition. The first 1000 days during pregnancy, and the first 2 years of life period of child are a critical window for child growth in which rapid physical and mental development occurs (Leroy JL *et al* 2014). Under nutrition during this period can have irreversible consequences on a child's growth leading to an increased risk of morbidity and mortality (Blessing J *et al* 2017).Chronic under nutrition in early childhood can result in diminished cognitive, and physical development.

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It can put children at a disadvantage at school and during adult age. They can have weak performance at school, and as adults they can be less productive and earn less money. They are more at risk of disease than adults who were not undernourished as children (Unicef 2009).Wasting is a consequence of recent illness and/or insufficient dietary intake due to food depletion or sub optimal feeding. A framework developed by UNICEF recognizes the basic and underlying causes of under nutrition, including the environmental, economic, and socio-political contextual factors, with poverty having a central role (Black *et al* 2008).Child growth is in general used measure of children's nutritional status.

It is estimated that 155 million children under 5 years are stunted (chronically malnourished, with low height-for-age) and 52 million are wasted (low weight-for height)(FAO 2017a). Under nutrition including fetal growth restriction, suboptimum breastfeeding, stunting, wasting, and deficiencies of vitamin A and zinc is estimated as a cause or contributing cause of 45% of all deaths of children younger than 5 years, representing more than 3 million deaths each year (3.1 million

of the 6.9 million child deaths in 2011) (Black *et al* 2013) .The "G5 Sahel" is a group of five Sahelian countries: Burkina Faso, Chad, Mali, Mauritania and Niger. Four of them are landlocked. The G5 Sahel countries face challenges of development, demography, immigration, climate change and security. (Secretariat permanent G5 Sahel) Al though individual studies report burden and highlight factors exacerbating childhood under nutrition. Their variable methodologies lead to complexities in interpretation. We used meta-analysis of prevalence to generate the Pooled prevalence. Meta-analysis of prevalence is used in epidemiology to determine diseases frequencies such as incidence and prevalence in a wide population with specific statistic methodology. In G5 Sahel countries, prevalence of under nutrition among children under five was widely documented by several surveys conducted by governments of these countries and partners. To date, there are no pooled prevalence estimates for G5 Sahel countries which could be used to improve programming in the region. To fill this gap in G5 Sahel countries, we report a meta-analysis of nutrition indicators using the most recent (2006-2016) Demographic and Health Survey (DHS) to provide an estimate for the region.

METHODS

We demanded and obtained from DHS dataset from G5 Sahel countries (https://dhsprogram.com/data). This period corresponds to the decade after the introduction of the WHO Child Growth Standards which aimed to better identify children suffering from malnutrition (Mercedes *et al* 2004).

In addition to anthropometrics information, DHS surveys give a range of information on health and population indicators. Three questionnaires were administrated in each household: household questionnaire, a woman's questionnaire and a man's questionnaire. The eligibility age for women and men to participate is ranged from 15 to 45 years. Additional detail on survey methodology is available (https://dhsprogram.com/data). We included data from children aged 6-59 months.

Anthropometric indicators

The primary analysis was the pooled prevalence of children 6-59 months who were stunted defined as those with height-for-age, z-score(HAZ)<-2SD, children wasted defined as those with weight-for-height or length, z-score(WHZ)<-2 SD, children underweight defined as those with weight-for-age, z-score(WAZ)<-2 SD based on the WHO growth standards (Mercedes *et al* 2004). The prevalence stunting, wasting and underweight by country were computed with SPSS version23.(College station, Texas IBM SPSS).

Statistical analysis

To overcome the issue of confidence intervals limits and variable instability in meta-analysis of prevalence a double arcsine transformation was used to generate the pooled prevalence by country, gender and age group for each indicator (Barendregt JJ *et al* 2013).The random effect model (Der Simonian and Laird method) which evaluate the variability within and between studies was used. It assumes each study included in the meta-analysis represent a specific effects size. The global effect size is the mean of the effects size of studies included in the meta-analysis. Heterogeneity was explored with Cochran's Q chi-square meaningful at p value ($p < 0.01$) which verifies the presence of variability among studies. The statistic I^2 or Higgins I^2estimate inconsistency measure of heterogeneity between studies from the formula: $I^2 = 100$ X (Cochran Q- degree of freedom)/Cochran Q (Matheus S *et al* 2015). I^2gives the percentage of variability due to the heterogeneity, then due to sampling error or chance. I^2 is range from 0 to 100%. If$I^2 > 50\%$ the heterogeneity is high (Heidi I *et al* 2011, Nikolaos A *et al* 2014).

Sensitivity analyses were conducted by comparing the pooled prevalence before and after removing one by one studies to appreciate the study which is determinant in pooled prevalence and which is responsible for heterogeneity (Nikolaos A *et al* 2014).The publication bias was assessed using Doi plot and the Luis Furuya-Kanamori asymmetry index (LFK index). In the presence of symmetry we conclude that there is no publication bias but in the absence of symmetry we can expect publication bias. Therefore, an LFK between +1 and -1 means that there is no asymmetry. LKF exceeds ± 1 but within ± 2 presence of minor asymmetry and LFK index exceeds ± 2 presence of major asymmetry. The forest plot shows the prevalence of an indicator for individual countries and its corresponding weight, as well as the pooled G5 Sahel estimate and associated with 95% Confidence Intervals (CI). Data were entered and analysed using Meta XL version 5.3 software (www.epigear.com) for meta-analysis linked to excel (Barendregt .JJ *et al* 2016).

Inclusion criteria

Only countries with a DHS survey conducted between 2006 and 2016 data with anthropometric indicators for children 6 to 59 months were included. The choice of this inclusion period to estimate the pooled prevalence is warranted because we want to stay in 10 years after the occurrence of revolution in the management of severe acute malnutrition in the Sahel with the introduction of community management of acute malnutrition, and after 2005 nutritional crisis in Niger. It's also a period of ten - year after implementing WHO references. Some countries conducted many DHS surveys in the inclusion period, in this case the most recent datasets was chosen.

Ethical Considerations

Access to datasets was obtained after online registration on the DHS program website (https://dhsprogram.com/data). Ethical approval for the analyses presented here was obtained from the Niger National Ethical and research in health Committee number 047/2018/CNERS.

RESULTS

A total of 07 DHS surveys were conducted between 2006 and 2016 with anthropometrics data. Two (02) countries (Mali and Niger) had beyond one DHS survey during the inclusion period and the most recent one was included. Four (04) DHS surveys from four (04) countries of the G5 Sahel met the inclusion criteria. No surveys from Mauritania were available. (Figure 1).

Heterogeneity and publication bias

The four studies included were assessed for heterogeneity and publication bias. The result showed a substantial heterogeneity ($P<0,001$) and I^2 of Higgins ($I^2>50\%$).

The Doi Plot analysis showed no symmetry. The verification of asymmetry showed a minor asymmetry (LFKindex-1, 09) (figure 2)

Sensitivity analysis

Sensitivity analysis was done for stunting pooled prevalence to test the effect of each study in the pooled prevalence of stunting by excluding studies one by one. The result showed two studies (Niger 2012 and Burkina Faso 2010) were relatively determinant in pooled prevalence while heterogeneity remain high (I^2>50%)(table I).

Pooled prevalence

The pooled prevalence in G5 Sahel countries was 41.8% (95% CI: 37.8%-46.0%), for stunting among children from 6 to 59 months, 14.0% (95% CI: 11.8-16.5%), for wasting and 30.4% (95% CI: 25.4%- 35.6%), for underweight. (Table II)

The pooled prevalence of stunting was 41.8 % (95% CI: 37.8%- 46.0%). Niger (2012) had the highest prevalence of 47.4% (95% CI: 46.0%-48.8%), followed by Chad (2014-2015) with 43.2% (95% CI: 42.2%-44.2%), Mali (2012-2013) with 39.8% (95% CI:38.8%- 41.2%). Burkina Faso (2010) had the lowest prevalence of 37.2% (95% CI: 36.1-38.4%). (Figure3).

The pooled prevalence of wasting (global acute malnutrition) was 14.0% (95%CI: 11.8%-16.4%) (Figure 4). The pooled prevalence of wasting in Niger (2012) was 17.8% (95%CI: 19.7%- 18.9%), followed by Burkina Faso (2010) with14.2%(95% CI: 13.3%-15.0%), Mali(2012-2013) with 12.2% (95% CI: 11.3%-13.2%) and Chad (2014-2015) with12.4% (95% CI: 11.8%-13.1%).

The pooled prevalence of underweight among children 6 to 59 months in the G5 Sahel was 30.4% (95%CI: 25.5%- 35.8%). The highest prevalence was found in Niger (2012)with 38.8% (95% CI: 37.4%-40.2%), followed by Chad (2014-2015) with30.5%(95%CI: 29.4%-31.4%), Burkina Faso (2010) with 26.6% (95%CI:25.5%-27.5%), and Mali (2012-2013) with 26.2% (95%CI: 25.0%-27.6%).(Figure5)

To determine those who are the most at risk of malnutrition among children 6-59months, we computed a pooled prevalence by sex and age group.

The study revealed the male children were at higher risk of under nutrition than female children. The pooled prevalence of stunting among male children was higher with 43.7% (95%CI: 42.5%-44.2%) versus 40.0% (95% CI: 39.1%-40.9%) for female children. Similar to stunting, the pooled prevalence of wasting was higher for male children with 17.9% (95%CI: 14.3%-15.5%) and 12.3% (95% CI: 12.0%-13.2%) for females. The pooled prevalence of underweight by sex was 31.4 % (95% CI: 30.8%-32.4%) for males and 28.9% (95% CI:28.1%-29.7%) for females (Table3).

We generated the pooled prevalence by age group from 6 to 23 months and 24 to 59 months. The pooled prevalence of stunting was 31.9% (95% CI: 30.9%-32.9 %) for the 6-23 months age group and 46.5 % (95%CI: 45.8%-47.3%) for the 24-59months age group. The pooled prevalence of wasting was 21.5% (95% CI: 20.6%-22.4%) for the 6-23 months age group while 10.2% (95%CI: 9.7%-10.6%) of 24-59months age group were wasted. The pooled prevalence of underweight were similar among the two age groups. 30.3 % (95%CI: 29.3%-31.3%), for the 6-23 age versus 30.2% (95%CI: 29.6%-30.9%), for the 24-59months age group.(Table III)

DISCUSSION

We report a pooled prevalence estimate of stunting, wasting and underweight in children aged 6 -59 months in G5 Sahel countries derived from data from DHS surveys. Based on the World Health Organization classification to assess the severity of the prevalence of malnutrition among children from 0 to 5 years of age, the pooled prevalence of the stunting and underweight among children 6-59 months aged was very high (stunting >=40% and underweight >=30%) in G5 Sahel countries. The pooled prevalence of wasting is high (10-14%) (WHO 1986).The pooled prevalence of stunting is higher than what Akombi *et al*, found in a meta-analysis of child under five in Sub-Sahara Africa: 33.2%, (95%CI: 30.4%-36.1%) in 32 countries and 31.8% (95%CI: 28.1%-35.5%) in West Africa. We found the highest prevalence of the three-under nutrition indicators in Niger.

The highly pooled prevalence of stunting could be the consequence of suboptimal nutrition of women during the conception through a pregnancy and childhood up to 2 years. There is strong evidence that adequate complementary feeding practices reduces the incidence of stunting in this age group (Black R *et al* 2013). Adopting optimal feeding practices is fundamental to child survival, growth and development. In G5 Sahel countries few children benefit of optimal Infant and young child feeding. The rate of minimum required acceptable, quality and the frequency of meals in G5 Sahel countries is very low among children 6-23months. Estimates report this to be 5.6% in Niger (2012), 3.1% in Burkina Faso(2010), 5.7% in Chad(2013), 3.4% in Mali(2015) and 14.3% in Mauritania(2015).(UNICEF 2018). The low rates of minimum required acceptable, quality and frequency of meals in G5 Sahel countries could contribute to the high estimate prevalence among 24-59 months age group with 46.5 %(95% CI :45.8%-47.3%)) and high estimate prevalence of wasting among the 6-23 months age group with 21.5% (95% CI: 20.6%-22.4%).

Each year a deterioration in the food and nutrition security is expected in July, August and September corresponding to the depletion of food stocks during the lean season in most Sahel countries (FAO 2017 b). The lean season, or hunger gap, has multifactorial causes, but one of these is climate change. The Sahel is one of the most vulnerable regions to climate change in the world due to the poverty and dependence of the population on natural resources, lack of technology and insufficient of infrastructure (Hubert N *et al* 2009). The consequences of climate change lead to a reduction of food production thereby increasing food insecurity in households, and levels are insufficient to cover at least 80% of household needs during the year. Frequency of floods and droughts is increasing which leads to lower food production and food insecurity. Food insecurity is also known to influence growth.(Saxena.NC and 2011, Mutisya M *et al* 2015). The link between drought and nutrition is well recognized, it's often indirect and complex. The quality and quantity of nutrient intake is affected by depletion of the food production as a result of drought (Stanke C *et al* 2013). Tefera D *et al* 2016 in a meta-analysis in Ethiopia found that the pooled prevalence of wasting was 13.1% in areas affected by moderate drought, higher than in areas with no drought (10.0%).Food insecurity could be a result of poor physical and economic access to food and inadequate food exchange between abundant and deficit

harvest places. There is a need to ensure the four dimensions of food security and nutrition: availability, access, stability, and utilization are effectively addressed (FAO, 2015).The demographic, socioeconomic, and agro-ecological characteristics of Sahel countries also negatively affect the nutritional status of children. Rapid population growth, increasing cost living, desertification, insecurity, and migration also affect food access, availability and production. This situation is exacerbated by insecurity problems linked to instability in Libya and terrorist attacks.

In 2010, the prevalence of the three forms of malnutrition (stunting, wasting and underweight) reported in Niger was very high with half of children affected (National Institute of statistic (INS) (Niger, 2010). Despite a robust community integrated management of acute malnutrition with a large network of outpatient and in-patient centres, Niger has always reported the highest rate of stunting, acute malnutrition and underweight in the region due to several food and humanitarian crises 2005 and 2010 (INS, 2010, PAM, 2005).Niger has also one of the highest birth rates (3.3%) and fecundity index (7.6 child per woman) in the world (INS Niger 2012).

Severe infectious diseases occurred in the early childhood, can cause wasting and influence linear growth. Studies have consistently shown that diarrhea is the most important infectious diseases determinant of stunting of linear growth (Black *et al* 2013).Wasting can be due to an important loss of nutrients during diarrhea which can get worse with increasing of duration and episodes. (Tebeje NB *et al* 2017) Studies found a link between high prevalence of Plasmodium falciparum and stunting. Blood parasite like Plasmodium falciparum can also cause loss of appetite leading to oral ingestion difficulties and increased vulnerability to various infectious diseases that could endanger the nutritional status of children. (Custodio E *et al* 2009)

To reach the 2012 World Health Assembly targets in 2025 and achieve the Sustainable Development Goals (SDG) particularly SDG1, target 2.2, a holistic intervention should be considered. According to the Lancet journal (2013), Nutrition specific interventions addresses the immediate causes of malnutrition while nutrition- sensitive interventions addresses the underlying determinants of malnutrition. They two nutrition interventions have a key role in addressing under-five malnutrition.(Mercedes D, *et al* 2013, PNUD 2015, Marie .T *et al* 2013).These programs are relevant to address the intermediate and underlying causes of child malnutrition during the opportunity window of 1000 days from preconception to age of two years extended to adolescent through intervention such maternal health and nutrition, micronutrient supplementation, maternal dietary, and promotion of optimum breastfeeding (Marie .T *et al* 2013). Action on nutrition is necessary to achieve goals across the SDGs, and also action throughout the SDGs is necessary to address the causes of malnutrition.(FAO 2017a)

In line with the recurrent food crisis and a high prevalence rate of under nutrition among children under five, the government of Niger developed a holistic program called the Nigeriens feed Nigeriens Initiative (NNN). The NNN initiative aims to overcome famine and reduce the high level of under nutrition among children under five. Nutrition specifics interventions and nutrition-sensitive program are implemented (I3N).

Gender may also be an important factor. Compared by gender, female children were less vulnerable to malnutrition than Male children (Pushpa L *et al* 2015). It may be linked to energy expenditure during activities and health problems (Custodio E *et al* 2009).As reported by the previous studies, our study shows that the boys were at higher risk of malnutrition than the girls. In India among under five children in rural areas of Bijapur district, Shashank *et al*, reported the prevalence of wasting of 36.5% male and 21.2% female, stunting 41.1% male and 35.9% female, underweight 49.8% male and 36.7% female. (Shashank K *et al* 2015). However, Edna , H *et al* found in Pangani District in Tanzania that female children are more stunted (14.6%) than male children(13.2%).

Our study is based on the DHS dataset, which have nationally representative and comparable across the country. Four of the five countries of G5 Sahel were included and can reasonably be generalized to all G5 Sahel countries. All the studies included cover a period of five years from 2010 to 2014.

The key limitation of this study is the exclusion of countries without recent DHS. The results presented here mask local differences and do not reflect the current childhood nutrition status in G5 Sahel countries but rather the nutritional situation between 2010 and 2014.Further, this analysis does not aim to address causality, but rather to provide pooled prevalence estimates which could be used by relevant stakeholders to program more appropriately in the region. Any suggestions concerning the causes of malnutrition are hypothesis generating.

CONCLUSION

Ours study reveals a high prevalence of under nutrition among children aged 6-59 months in G5 Sahel countries. The pooled prevalence of the three under nutrition indicators was above the level of intervention threshold according to World Health Organization. The study is an opportunity to obtain pooled prevalence for the G5 Sahel and results will be helpful for planning program across the borders to tackle childhood under nutrition.

Declarations

Funding: The study did not receive any specific funding.

Ethic approval and consent to participate

Ethical approval for the analyses presented here was obtained from the Niger National Ethical for research in Health Committee number 047/2018/CNERS.

Availability of data and materials*:* The datasets generated and analysed during the current study are available at: https://dhsprogram.com/data

Competing Interests: All authors declare no conflicts interests

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Table I Summary of sensitivity analysis of studies included

Excluded studies	Stunting pooled (95% CI)	I^2 (95%CI)	P Value
Niger 2012	40.1% (36.4,40.8)	96.6%(92.9, 98.4)	P<0.001
Burkina Faso 2010	43.5% (39.6,47.3)	96.5 (92.6 , 98.3)	P<0.001

Mali2013	42.6%(37.3,48.0)	98.4% (97.1, 99.1)	P<0.001
Chad2014	41,4% (35.4,47.5)	98.3%(97.0 , 99.1)	P<0.001

Table II G5 Sahel countries with the anthropometric indicators for children aged from 6 to 59 months

Type of malnutrition	Countries	Year of DHS	N children	N prevalence	LCI 95%	HCI 95%	Weight (%)
Stunting	Niger	2012	4854	2302 (47. 4%)	46.0%	48.8%	24.88
	Burkina Faso	2010	6256	2331 (37. 2%)	36.1%	38.4%	25.04
	Mali	1013	4531	1802 (39. 8%)	38.3%	41.2%	24.83
	Chad	2014	9736	4209 (43. 2%)	42.2%	44.2%	25.24
	Pooled			**41.8%**	**37.8%**	**46.0%**	
underweight	Niger	2012	4845	1882 (38. 8%)	37.5%	40.2%	24.93
	Burkina Faso	2010	6263	1670 (26. 6%)	25.6%	27.8%	25.02
	Mali	1013	4535	1192 (26.2%)	25.0%	27.6%	24.91
	Chad	2014	9715	2963 (30. 5%)	29.6%	31.4%	25.14
	Pooled			**30.4%**	**25.4%**	**35.6%**	
Wasting	Niger	2012	4853	863 (17. 8%)	16.7%	18.9%	24.81
	Burkina Faso	2010	6255	888 (14. 2%)	13.3%	15.1%	25.07
	Mali	1013	4541	558 (12. 2%)	11.3%	13.3%	24,.4
	Chad	2014	9734	1213 (12. 4%)	11.8%	13.1%	25.9
	Pooled			**14.0%**	**11.9%**	**16.4%**	

Table III pooled prevalence of under nutrition by gender and age group in G5 Sahel countries among children 6-59 months

pooled prevalence of under nutrition among children 6-59 months by gender and age group in G5 Sahel countries				
Under nutrition	gender		age group	
	females: CI: 95%	Males CI: 95%	6-23 months CI: 95%	24-59months CI: 95%
Stunting: pooled prevalence	40.0% (39.1%-40.9%)	43.7% (42.5%-44.2%)	31.9% (30.9%-32.9 %)	46.5 %(45.8%-47.3%)
Wasting: pooled prevalence	12.3% (12.0%-13.2%)	17.9% (14.3%-15.5%)	21.5% (20.6%-22.4%)	10.2% (9.7%-10.6%)
Underweight: pooled prevalence	28.9% (28.1%-29.7%)	31.4 % (30.8%-32.4%)	30.3 % (29.3%-31.3%)	30.2% (29.6%-30.9%),

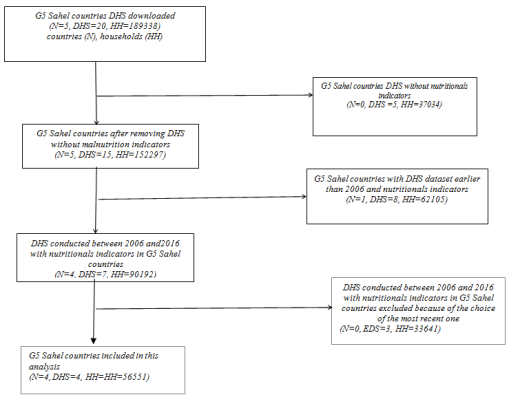

Figure 1 Flow diagram of studies included (Legend: N: number of countries, HH: household, DHS: Demographic Health Survey)

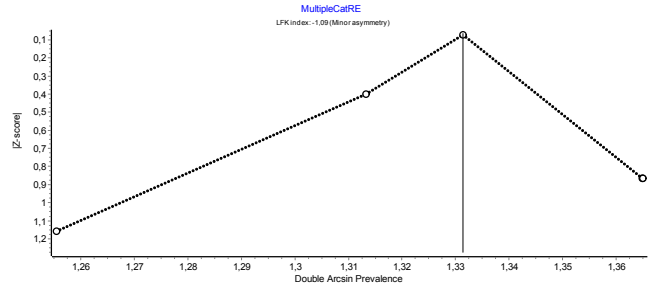

Figure 2 Doi plot Analysis and LFK index of publication bias

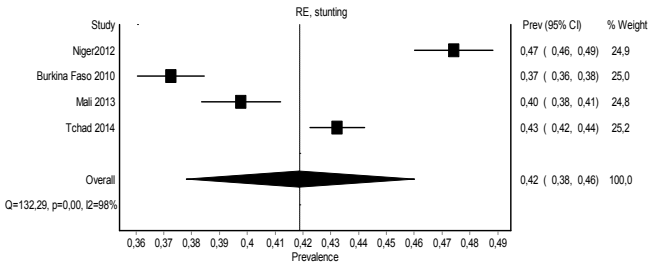

Figure 3 Forest plots showing the pooled prevalence of global stunting among children 6 to 59 months

(Legend: Horizontal lines represent 95% of confidence intervals (CI). Each box represents the prevalence point estimate and the area is proportional to the weight of study)

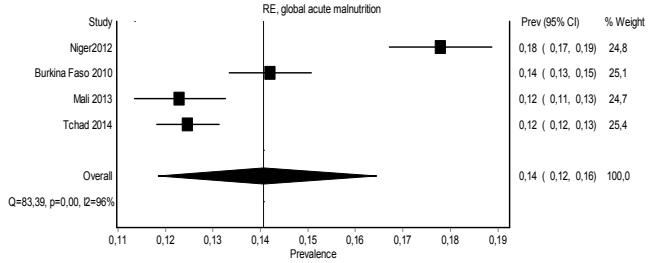

Figure 4 Forest plots showing pooled prevalence of global acute malnutrition among children 6 to 59 months

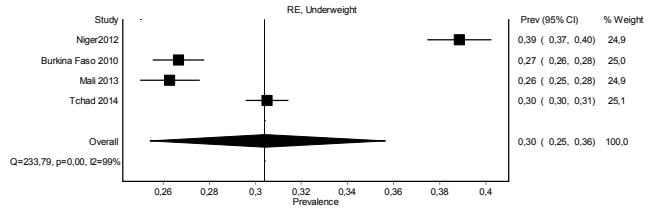

Figure 5 Forest plots showing pooled prevalence of global underweight among children 6 to 59 months

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