


BMJ Open Undernutrition in children aged 0–59 months by region and over time: secondary analysis of the Burkina Faso 2012–2018 National Nutrition Surveys

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ABSTRACT

The global burden of undernutrition remains high, responsible for significant under-five mortality in resource-limited settings. Numerous sustainable development goals (SDGs) are linked to nutrition, and nationally representative nutrition surveillance is a key activity to track progress towards SDGs and guide efficient programmes.

Objectives The aim of this study is to look at spatial and temporal trends in undernutrition in children under 5 years age in Burkina Faso.

Setting We used data from annual National Nutrition Surveys using Standardised Monitoring and Assessment of Relief and Transitions methodology (anthropometry, morbidity) over 7 years (2012–2018) in Burkina Faso.

Participants Children of under 5 years from households selected through systemic sampling at countrywide level.

Main outcome measures Prevalence of stunting (height-for-age z-score, <−2), underweight (weight-for-age z-score, <−2) and wasting (weight-for-height z-score, <−2) at regional and national. We used general linear mixed models, adjusted by age, survey year, sex, presence of fever and/or diarrhoea, and poverty index to quantify the risk of undernutrition over time and by region of residence.

Results Between 2012 and 2018, decreases were observed overall in the prevalence of growth retardation (stunting) decreased from 33.0% (95% CI 32.3 to 33.8) in 2012 to 26.7% (95% CI 26.2 to 27.3) in 2018. Underweight reduced from 24.4% (95% CI 23.7 to 25.1) to 18.7% (95% CI 18.2 to 19.2) for the same period and wasting decreased from 10.8% (95% CI 10.3 to 11.3) in 2012 to 8.4% (95% CI 8.1 to 8.8) in 2018. However, there was substantial variation across the country, with increased risk of undernutrition in the regions of Sahel, East and Cascades primarily. High-risk regions were characterised by a lower poverty index and limited access to healthcare services.

Conclusions Our findings could inform national policymakers in refining and optimising resource allocation based on the identification of high-risk areas.

BACKGROUND

Globally, undernutrition (eg, wasting as a sign of acute undernutrition, and stunting

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Children morbidity is associated with all forms of undernutrition.
- ⇒ Poverty index is associated with chronic undernutrition but not with acute undernutrition.
- ⇒ Under-five boys are at higher risk of experiencing undernutrition compared with girls.
- ⇒ Sahel region children are at higher risk of stunting and underweight.
- ⇒ Our study did not cover all the National Nutrition Surveys from 2009 to 2021, due to data unavailability, therefore our finding is only relevant for the studied period. The analysis relies on survey data but not a cohort, hence causality cannot be inferred.

as a sign of chronic undernutrition) remains an important public health issue, affecting the growth and mortality of children, especially in low-income and middle-income countries.^{1–3} Globally, in 2020, wasting and stunting affected an estimated 45.4 and 149.2 million children under 5 years of age, respectively.^{4,5,6} Undernourished children have a higher risk of death from common childhood illness such as diarrhoea, pneumonia and malaria,^{5,7,8} and longer-term are likely to experience poorer physical and cognitive development, increased risk of chronic disease in older age, with undernourished women at increased risk of delivering low birth weight babies.^{9–11}

In Burkina Faso, like most low-income countries, improvements in nutrition through better diet quality and access to food, continues to be a major health, socio-economic and political challenge, and is one of the main public health priorities towards achieving sustainable development goals (SDGs) 1, 2 and 3.¹² In Burkina Faso, more than one-third of deaths among children

under 5 years of age are directly or indirectly attributable to undernutrition. Despite the development and implementation by successive governments of numerous policies and programmes to deal with undernutrition, the prevalence of undernutrition (stunting, underweight and wasting) remains high. Factors such as recurrent drought, sociocultural practices (poor dietary practices), poverty, diarrhoeal and febrile diseases and insufficient access to basic health services negatively affect the nutritional status of children.^{3 8 13–15} In addition, there is the problem of insecurity that the country has been experiencing since 2015, leading to massive internal displacement of the population, aggravating the already very limited access to basic livelihoods, healthcare and nutrition services in a context of poverty in these localities.^{16–20} Food insecurity (lack of consistent access to enough food for every person in a household to live an active, healthy life) has been highly prevalent in the country (bulletin special FSC).

The government, supported by its financial and technical partners, has put in place a system to monitor the nutritional situation through the implementation of yearly national nutritional surveys according to the SMART (Standardised Monitoring and Assessment of Relief and Transitions) methodology. This methodology is widely used by governments and humanitarian partners to conduct timely nutrition surveys in all contexts (emergency, development, displaced populations). SMART surveys are conducted on a regular basis, often in connection with seasonal malnutrition, and can be conducted at the national or regional level, and even on a smaller scale. This paper follows a secondary analysis of the survey databases from 2012 to 2018 to have an overview of temporal trends and overall spatial risk of undernutrition and identify the areas to prioritise for resource allocation according to the risk of areas.

METHODS

Study setting

Burkina Faso is a landlocked country in West Africa divided into 13 regions, 45 provinces, 351 communes (49 urban and 302 rural) and 8228 villages. According to the latest census, the country has 20.5 million inhabitants, 45.3% of whom are under 15 years old and children aged 0–4 years represent 16.2% of the total population.²¹ The country is ranked 182nd out of 189 according to the Human Development Index report with more than 41.4% of its population living below the poverty line.²²

The country's epidemiological profile is marked by the persistence of a high burden of disease due to infectious disease, and by the progressive increase in the burden of non-communicable diseases. Besides infectious and non-communicable diseases, undernutrition is one of the major diseases of public health importance.²³ The food security situation is also of concern. It is estimated that approximately 3.28 million people are food insecure and in need of immediate humanitarian assistance, representing 15% of the country's total population.²⁴

Patient and public involvement

Because we used data from National Nutrition Surveys (NNSs), it was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

Data sources

The Directorate of the Nutrition of Burkina Faso provided data (accessible through on request). The data are from annual cross-sectional NNSs using the SMART methodology. This consists of a rapid assessment survey of the food and nutrition situation among children under 5 years of age, women of childbearing age and households. For this study, we focus on anthropometric measurements collected between 2012 and 2018 (seven surveys) among the population aged 0–59 months.

We examined trends in three crude indices of nutritional problems in Burkina Faso over a 7-year period, namely stunting (height/length-for-age), underweight (weight-for-age) and wasting (weight-for-height/length). Anthropometric measurements were converted into weight-for-age z-score (WAZ), height-for-age z-score (HAZ) and weight-for-height z-score (WHZ), using the 2006 WHO child growth standards.²⁵ Children with oedema, which can be a sign of acute undernutrition) were excluded as recommended for this analysis (table 1).

For 2012 and 2014, the SMART survey was provincially representative for six regions (Cascades, Centre West, East, North, Sahel and South West) and regionally representative for the other seven (Boucle du Mouhoun, Centre-South, Centre, Centre-North, Centre-East, Central Plateau and Hauts-Bassins). For 2013 and 2015, the SMART survey had provincial representativeness for seven regions (Boucle du Mouhoun, Centre-South, Centre, Centre-North, Centre-East, Central Plateau and Hauts-Bassins) and regional representativeness for the other six (Cascades, Centre-West, East, North, Sahel and South-West). For 2016, the SMART survey had regional representativeness for 13 regions (resulting in smaller sample) and from 2017 onwards, the SMART survey had provincial representativeness for the 45 provinces across the 13 regions.

Each level of representativeness constituted strata.

Outcome variables

Stunting was determined if $HAZ < -2$ SD, underweight as $WAZ < -2$ SD and wasting as $WHZ < -2$ SD (table 1). We excluded z-scores with extreme values from the observed mean, the following WHO indicators were used in the final analysis: WHZ -5 to 5 ; HAZ -6 to 6 ; WAZ -6 to 5 .

The independent variables were individual-level characteristics mainly age in months and gender, diarrhoea and fever during the 2 weeks preceding the survey, year of the survey and cluster-level characteristics constituted by the poverty index for each province.²⁶

Table 1 Definition of anthropometric measurements and indices in children under-five

Index	Nutritional problem measured	Indicator
Height/length-for-age	Severe stunting	HAZ<-3 SD
	Moderate stunting	HAZ<-2 SD and HAZ≥-3 SD
	Global stunting	HAZ<-2 SD
Weight-for-age	Severe underweight	WAZ<-3 SD
	Moderate underweight	WAZ<-2 SD and WAZ≥-3 SD
	Global underweight	WAZ<-2 SD
Weight-for-height/length	Severe wasting	WHZ<-3 SD
	Moderate wasting	WHZ<-2 SD and WHZ≥-3 SD
	Global wasting	WHZ<-2 SD

HAZ, length/height-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-length/height z-score.

Statistical analysis

For descriptive statistics at the individual and strata levels, estimates account for the complex survey design and the sampling weights provided by *survey*. Descriptive analysis of the study population was presented using means and SE for continuous variables and frequencies and proportions for categorical variables. These descriptive analyses were performed to estimate the crude temporal trend of prevalence nationwide and provide a yearly map for the regional disparities of undernutrition index.

Considering that the data have a hierarchical structure, and we would need to account for the cluster (province and region) variability as well as the individual-to-individual variability, we used general linear mixed models (GLMMs, multilevel models). GLMM (multilevel models) with binomial distribution were used to quantify the association of independent variables with each study outcome variable (stunting, underweight and wasting). We assume that the outcome variables were drawn from a binomial distribution and the residual are independent and normally distributed. The GLMM contains fixed and random effects and was formulated as follows:

$$Y_{ij} \sim \text{Bernoulli}(\pi_{ij})$$

$$\text{logit}(\pi_{ij}) = \log\left[\frac{\pi_{ij}}{1 - \pi_{ij}}\right] = \beta_0 + \sum_{p=1}^P \beta_p x_{ij} + \sum_{q=1}^Q \beta_q z_j + \omega_j + \varepsilon_i$$

$$\varepsilon_i \sim N(0, 1)$$

The random effects are also, independent and normally distributed.

In this general linear model, Y_{ij} represents stunting, underweight or wasting for a child i in a cluster j . The logit (π_{ij}) was used to model the probability of success (ie, occurrence of undernutrition) as a linear combination of observed individual characteristics (x_{ij}) and contextual characteristics (z_j) associated with an unobserved specific effect (random effect) of the province and region (ω_j). The model contains a random error for child i (ε_i) that does not depend on the province/region or year. The fixed effect is composed of β_0 (intercept), β_p (vector of regression coefficients associated with the individual-level

variables) and β_q (vector of regression coefficients associated with the cluster-level variables). The unobserved specific effect or random effect (ω_j) has two components, province specific effect and region-specific effect. These cluster specific effects were considered as province and region-specific risk.

Since we intended to quantify the association between the outcomes and dependent variables by avoiding the coefficient being affected by the individual weight, survey weights were not used to adjust the regressions and a complete case analysis was used. The model diagnostics were checked by generating a diagnostic that plots the fitted or predicted values against the residuals. All statistical analyses were performed with R statistical software (R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria). The descriptive statistics that accounted for the complex survey design and sampling weights were performed using 'survey' package, regression models were fitted using the 'lme' package.

RESULTS

Demographic characteristics and anthropometrical measures of children

The overall number of children under-five assessed for their nutritional status using anthropometric measurement and included in the present analysis is shown in [table 2](#). Since the survey in 2016 was set up to have regionally representative estimates, 9434 children were surveyed. Gender was equally distributed through the surveys and varied between 51.6% and 51.1% for the proportion of male children. The average age of the children during the period of 2012–2018 ranged from 27 to 29 months.

The distribution of anthropometric measures such as weight, height and the z-scores with WHO as reference population (HAZ, WAZ and WHZ) from 2012 to 2018 are presented in [table 2](#). All z-scores had a mean value below the WHO standard. HAZ values ranged from -1.50 to -1.27; WHZ values ranged from -0.70 to -0.53; WAZ values ranged from -1.33 to -1.11.

Table 2 Characteristic of children under-five surveyed at household in Burkina Faso, 2012–2018

Index	Weighted mean (SE)						
	2012 N=19049	2013 N=19170	2014 N=15835	2015 N=20408	2016* N=9434	2017 N=19409	2018 N=23939
Age	27.80 (0.11)	27.15 (0.12)	27.82 (0.13)	27.47 (0.11)	28.59 (0.16)	28.53 (0.11)	29.04 (0.10)
Weight	10.46 (0.02)	10.39 (0.02)	10.72 (0.03)	10.41 (0.02)	10.85 (0.03)	10.8 (0.02)	10.92 (0.02)
Height	82.08 (0.09)	81.54 (0.1)	82.68 (0.11)	81.97 (0.09)	83.38 (0.13)	83.31 (0.09)	83.75 (0.08)
HAZ	1.49 (0.01)	1.50 (0.01)	1.30 (0.01)	1.47 (0.01)	1.30 (0.01)	1.28 (0.01)	1.27 (0.01)
WHZ	0.67 (0.01)	0.61 (0.01)	0.53 (0.01)	0.70 (0.01)	0.55 (0.01)	0.60 (0.01)	0.56 (0.01)
WAZ	1.31 (0.01)	1.28 (0.01)	1.11 (0.01)	1.33 (0.01)	1.12 (0.01)	1.15 (0.01)	1.11 (0.01)

*In 2016 the sampling framework was regional and national (without provincial), hence impacting the sample size. This choice by the Ministry of Health was guided by limited resources to run the national survey.
HAZ, length/height-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-length/height z-score.

Prevalence of undernutrition

The annual prevalence of chronic undernutrition (stunting) using HAZ ranged from 33.0% (95% CI 32.3 to 33.8) in 2012 to 26.7% (95% CI 26.2 to 27.3) in 2018, with a maximum of 34.2% (95% CI 33.4 to 34.9) in 2013. In other words, between 2013 and 2018, stunting prevalence declined among children under-five from 33.4% to 26.7%, a decline of 19.1% (online supplemental figure 1A).

The annual prevalence of underweight (WAZ) ranged from 24.4% (95% CI 23.7 to 25.1) in 2012 to 18.7% (95% CI 18.2 to 19.2) in 2018, with a maximum of 25.3% (95% CI 24.6 to 25.9) in 2015 (online supplemental figure 1B). This meant that nationally, underweight decreased by 23.3% between 2012 and 2018.

The annual prevalence of wasting (WHZ) (online supplemental figure 1C) ranged from 10.8% (95% CI 10.3 to 11.3) in 2012 to 8.4% (95% CI 8.1 to 8.8) in 2018, with a maximum of 11.7% (95% CI 10.7 to 11.6) in 2015. In other words, between 2013 and 2018, global wasting prevalence declined among children under-five from 33.4% to 26.7%, corresponding to a decline of 22.2%.

Overall, there was a reduction in prevalence of undernutrition over the years, but this was not seen in all areas. In other words, there was a spatial heterogeneity of undernutrition index through the country. During the 7 years, the analysis showed a permanent high prevalence (>30%) of stunting in Sahel, and East regions (online supplemental figure 2), whereas the stable high prevalence of underweight (>30%) was mainly noted in the Sahel region (online supplemental figure 3). The high prevalence of wasting was mainly noted in the Sahel and North region (online supplemental figure 4).

The predicted probabilities of stunting, underweight, wasting by child's age at survey and stratified by gender for the year 2012 to 2017 are shown in online supplemental figures 5–7. The probability of being stunted increased with age, and was higher for male than female children, but decreased over time, that is, between 2012 and 2018 (online supplemental figure 5). Similarly, predicted prevalence of underweight decreased with children's age, was

greater among male children and declined over the study period, that is, from 2012 to 2018 (online supplemental figure 6). For wasting, the probability decreased with child's age and was more marked among males, but the trend over time was stable (online supplemental figure 7).

Potential risk factors associated with stunting, underweight and wasting from 2012 to 2017 in Burkina Faso

In multivariable analysis, allowing for adjustment (table 3) males had a significantly increased risk of stunting (adjusted OR (aOR)=1.47, 95% CI 1.43 to 1.52), underweight (aOR=1.39, 95% CI 1.34 to 1.43) and wasting (aOR=1.38, 95% CI 1.31 to 1.44) than females. Compared with children aged less than 5 months, older children had higher risks of stunting and underweight, but the odds of wasting decreased significantly over the age of 24 months. Compared with the year 2012, the analysis showed that the risk of stunting, underweight and wasting in the subsequent years, that is, 2013–2018, decreased significantly overall, except for the year 2015 for wasting. Furthermore, diarrhoea was associated with high odds of stunting (aOR=1.08, 95% CI 1.05 to 1.12), underweight (aOR=1.32, 95% CI 1.27 to 1.37) and wasting (aOR=1.46, 95% CI 1.39 to 1.54). This association was similar with the fever. There was no significant association between wasting and poverty index (aOR=1.03, 95% CI 0.96 to 1.10), whereas stunting and underweight were significantly associated with the poverty index. The model diagnostics plots were presented in supplementary materials (online supplemental text and figures 8–10).

Estimation of province and region-specific risk

The province spatial risk of stunting, underweight and wasting was shown to be heterogeneous throughout the country. Online supplemental figure 5 displays the specific risks (or odds) of each province compared with the national mean odds ratio (aOR=1).

For stunting, the provinces with high odds were located in eight provinces namely Gourma, Ioba, Kenedougou, Kossi, Lorum, Seno and Yagha provinces, whereas the

Table 3 Potential risk factors associated with stunting, underweight and wasting from 2012 to 2017 in Burkina Faso

Predictors	Stunting aOR (95% CI)	P value	Underweight aOR (95% CI)	P value	Wasting aOR (95% CI)	P value
Gender						
Female	1		1		1	
Male	1.39 (1.35 to 1.43)	<0.001	1.31 (0.27 to 1.35)	<0.001	1.37 (1.31 to 1.43)	<0.001
Age in months						
0–5	1		1		1	
6–11	1.51 (1.39 to 1.63)	<0.001	1.96 (1.82 to 2.11)	<0.001	1.67 (1.53 to 1.82)	<0.001
12–23	3.74 (3.49 to 4.00)	<0.001	2.56 (2.39 to 2.73)	<0.001	1.53 (1.41 to 1.65)	<0.001
24–35	4.94 (4.62 to 5.28)	<0.001	2.28 (0.13 to 2.44)	<0.001	0.83 (0.76 to 0.90)	<0.001
36–47	4.57 (4.27 to 4.89)	<0.001	1.67 (1.56 to 1.79)	<0.001	0.46 (0.41 to 0.50)	<0.001
48–59	3.44 (3.20 to 3.68)	<0.001	1.58 (1.47 to 1.69)	<0.001	0.49 (0.44 to 0.54)	<0.001
Year of survey						
2012	1		1		1	
2013	0.89 (0.85 to 0.94)	<0.001	0.79 (0.75 to 0.84)	<0.001	0.72 (0.66 to 0.78)	<0.001
2014	0.78 (0.75 to 0.82)	<0.001	0.72 (0.69 to 0.76)	<0.001	0.73 (0.68 to 0.79)	<0.001
2015	0.87 (0.82 to 0.91)	<0.001	0.95 (0.90 to 1.00)	0.063	1.00 (0.92 to 1.08)	0.902
2016	0.73 (0.69 to 0.78)	<0.001	0.74 (0.69 to 0.79)	<0.001	0.70 (0.63 to 0.77)	<0.001
2017	0.67 (0.64 to 0.71)	<0.001	0.71 (0.68 to 0.75)	<0.001	0.86 (0.80 to 0.93)	<0.001
Diarrhoea						
No	1		1		1	
Yes	1.19 (1.14 to 1.23)	<0.001	1.36 (1.31 to 1.42)	<0.001	1.39 (1.32 to 1.47)	<0.001
Fever						
No	1		1		1	
Yes	1.08 (1.05 to 1.12)	<0.001	1.31 (1.27 to 1.35)	<0.001	1.48 (1.41 to 1.55)	<0.001
Poverty index in %	1.17 (1.09 to 1.26)	<0.001	1.15 (1.08 to 1.22)	<0.001	1.03 (0.96 to 1.10)	0.456
Random effects						
σ^2	3.29		3.29		3.29	
τ_{00}						
Provinces	0.03		0.03		0.04	
Region	0.03		0.01		0.00	
ICC	0.02		0.01		0.01	
N region	13		13		13	
N provinces	45		45		45	
Observations	83 161		83 161		83 161	

aOR, adjusted OR.

provinces with lower odds were located in four provinces namely, Bales, Passore, Tuy and Zounweogo provinces (figure 1A).

Regarding underweight, the provinces with high odds were located in nine provinces namely Gourma, Ioba, Kossi, Kourweogo, Lorum, Oudalan, Seno, Tapoa, Yagha provinces, whereas the provinces with lower odds were located in four provinces namely, Passore, Poni, Sourou and Zounweogo provinces (figure 1B).

Regarding wasting, the provinces with high odds were located in 11 provinces namely, Bam, Ioba, Kossi,

Kourweogo, Lorum, Nayala, Oudalan, Sanguie, Seno, Tapoa and Yatenga provinces whereas, the provinces with lower odds were located in eight provinces namely, Boulgou, Comoe, Houet, Koulpelgo, Leraba, Poni, Sourou and Zounweogo province (figure 1C).

Further, the analysis also indicated some regions where the odds were statistically significant higher (Sahel and Cascades) or lower (Centre-Sud, Centre-Ouest and Boucle de Bouhoun) for stunting (figure 2A). For underweight, only the region of the Sahel exhibited higher

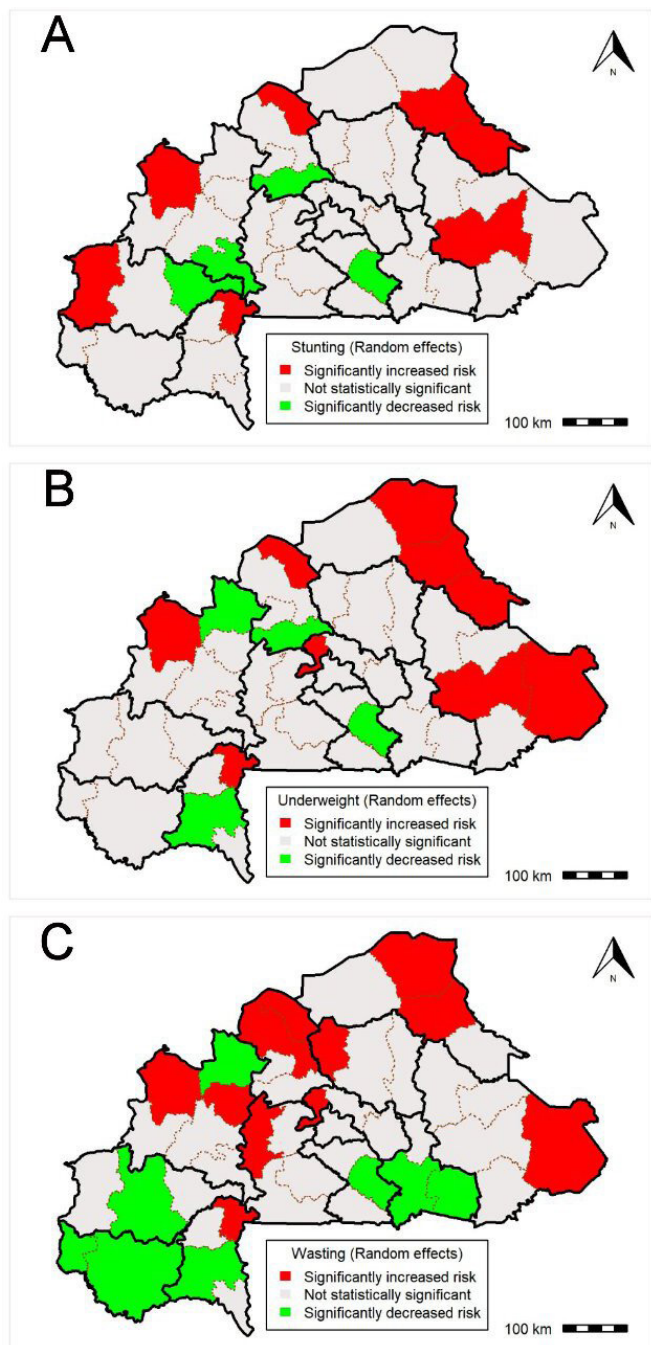


Figure 1 Overall province-specific ORs (province random effect) of stunting (A), underweight (B) and wasting (C) among study population. Maps created by Boua *et al.*

odds (figure 2B). Finally, regarding wasting, no region exhibited a higher or lower risk (figure 2C).

DISCUSSION

This study undertook a secondary analysis using data from annual cross-sectional NNS using SMART methodology to generate estimates that could help national policymakers in refining and optimising resource allocation based on identification of high-risk areas. The analysis found that undernutrition remains very high in certain

part of the country, although there was an overall decrease in prevalence and risk over the years in the country; the geospatial risk to experience an undernutrition event is not uniform throughout the country. This decrease in all undernutrition prevalence has been observed in other sub-Saharan Africa countries despite predicted stagnation in the region for stunting until 2020.^{27–29}

In previous analysis, de Onis and collaborators predicted that in Africa, the prevalence of stunting was going to stagnate in the next coming decade from 2010, and specifically in Western Africa.²⁹ Our results showed a decrease in stunting prevalence of 6.7 between 2012 and 2018. de Onis prediction were based on poor data from some countries with lag time of about 10 years between them (namely Demographic and Health Survey), and the landscape of interventions in nutrition was poor. From 2009, a nutrition surveillance system has been implemented with yearly national surveys, additionally more effective nutrition programmes to improve nutritional status across the whole population have been implemented.

Sex of child (male), 2 weeks morbidity (fever, diarrhoea) were factors associated with the three forms of undernutrition; whereas poverty measured through wealth index was associated with stunting and underweight but not wasting. In their analysis of Nigeria Demographic and Health Survey, Akombi *et al* found the same factors associated to stunting.³⁰ Biological and social mechanism or both has been proposed to explain the differences between boys and girls.³¹ Even though 2 weeks morbidity might not be causal to chronic undernutrition, it translates the effect of morbidity and or repeated morbidity on growth retardation and underweight.

Living in certain provinces and/or regions of the country confers higher risk of suffering from undernutrition. Similar findings were reported in Côte d'Ivoire, Uganda and Nigeria.^{28 30 32} In Burkina Faso, these areas were the one with the highest proportion of the population living more than 10 km away from the primary health centre (first level of referral).²³ This means that access to healthcare could be associated with nutritional status. The persistent prevalence of undernutrition translates a need, not just for the community management of wasting programmes which have been shown to be effective, but for effective prevention programmes as well as structural changes allowing reduction of inequalities.^{33–36}

Sahel region had the highest risk of stunting and underweight. Prior to the recent threats from terrorism, Burkina Faso had already endured a decade of a fragile food security situation due to droughts and floods, affecting food security and nutrition, especially in the northern part of the country. Restrictions on the movement of people and goods, as well as limited access to natural resources and regional or international markets, had placed a heavy burden on local food systems and people's livelihoods. The food insecurity situation in Burkina Faso is currently aggravated by a high level of insecurity. The populations of the Sahel zone are the most affected. Undernutrition is chronic and its causes are structural and complex.

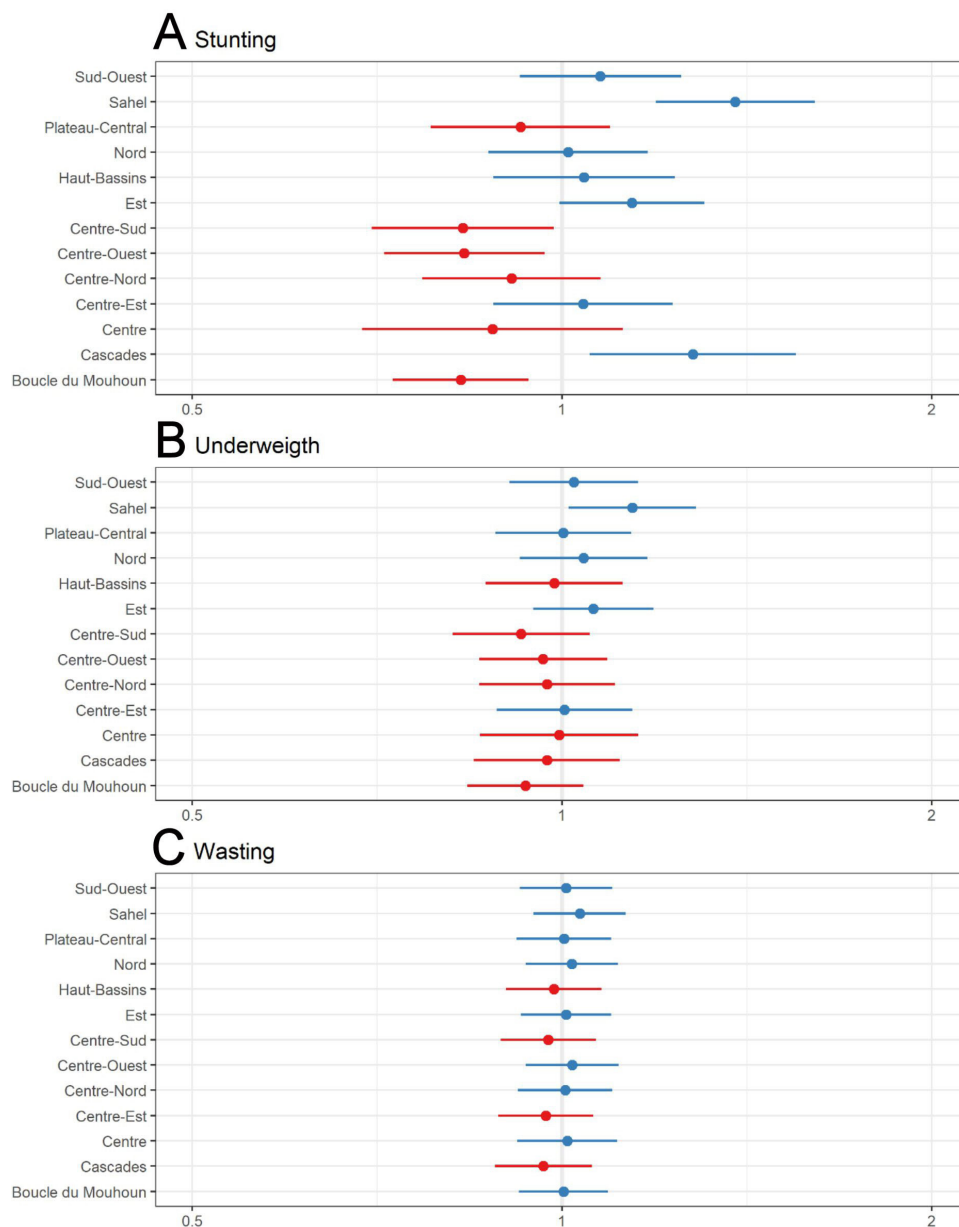


Figure 2 Overall region-specific ORs (region random effect) of stunting (A), underweight (B) and wasting (C) among study population.

They are the result of a combination of several factors, including a short agricultural production season lasting 4 months of the year, climatic vulnerability, the depletion of natural resources, a chronic shortage of agricultural production and very little access to basic social services due to the weak state presence.

Insecurity marked by attacks from terrorist groups and the increase in inter-community conflicts exacerbate food and nutrition insecurity in the Sahel and North Central regions by reducing the already fragile livelihoods of populations that depend mainly on agriculture and pastoralism. Insecurity limits access to fields and agricultural production. The resulting road closures affect the supply of agricultural products to markets, reduce the availability of agricultural products, limit access due to price fluctuations, and hinder transhumance and access of animals to

pasture within Burkina and to Mali and Niger. The looting of food reserves and livestock reduces the resilience of communities affected by this insecurity. In addition, many health facilities are closed or operating at minimal capacity in areas affected by insecurity, reducing access to health services, including those for severely malnourished children. This has forced people to move to other parts of the country (almost 1 million internally displaced persons (IDPs) according to the United Nations Office for the Coordination of Humanitarian Affairs), resulting in overcrowding in host towns. While some IDPs reside in camps, more than 80% of IDPs are staying with host families whose food supplies are rapidly running out.

In our study, we found that poverty index is not associated with wasting, that mean acute undernutrition is due to an underlying disease causing abnormal nutrient loss,



increased energy expenditure or decreased food intake. Based on its aetiology, undernutrition is either illness related (one or more diseases or injuries directly result in nutrient imbalance) or caused by environmental/behavioural factors associated with decreased nutrient intake and/or delivery.^{11 37 38} Therefore, primary acute undernutrition is mostly social rather than biomedical in origin, but it is also multifactorial. For example, poor water quality, sanitation and hygiene practices are increasingly believed to be the cause of the condition called ‘environmental enteropathy’ that contributes to acute undernutrition in childhood.³⁸

Although this study provided insight on the temporal trends and overall spatial risk in undernutrition among children under-five between 2012 and 2018 in Burkina Faso, this study is influenced by several limitations. Our study did not cover all the NNSs from 2009 to 2021, due to data unavailability, therefore our finding is only relevant for the studied period. The analysis relies on survey data but not a cohort, hence causality cannot be inferred.

Conclusion

The study found that undernutrition prevalence remains high and marked spatial disparities. Overall, there is a decrease in prevalence over the year. It is important to note that we found low-risk area where the control efforts need to be maintained and reinforced. The high-risk area, need to be allocated more resources and reinforce the control effort. Morbidity (fever and diarrhoea) constitutes important associated factors and need prompt and effective management with particular focus on children over 6 months. Further research should include birth cohort to allow causality inference for undernutrition in Burkina Faso. Additionally, surveillance system should be implemented towards IDPs. Our study showed that secondary analysis of national surveillance data has the potential to inform public health action and refinement of intervention.

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REFERENCES

- 1 FAO, IFAD, UNICEF, and WFP. The state of food security and nutrition in the world 2021. transforming food systems for food security, improved nutrition and affordable healthy diets for all, Rome. 2021.
- 2 Development Initiatives. The burden of malnutrition - global nutrition report, Bristol. 2018.
- 3 Myatt M, Khara T, Schoenbuchner S, *et al*. Children who are both wasted and stunted are also Underweight and have a high risk of death: A descriptive epidemiology of multiple Anthropometric deficits using data from 51 countries. *Arch Public Health* 2018;76:28.
- 4 UNICEF / WHO / World Bank Group. UNICEF-WHO-the world bank: joint child malnutrition estimates – levels and trends – 2021 edition - UNICEF DATA. 2021.
- 5 Brown M, Backer D, Billing T, *et al*. Children: improving survival and well-being. *Food Secur* 2020;12:1241–52.
- 6 Pelletier DL, Frongillo EA, Habicht JP. Epidemiologic evidence for a Potentiating effect of malnutrition on child mortality. *Am J Public Health* 1993;83:1130–3.
- 7 Black RE, Allen LH, Bhutta ZA, *et al*. Maternal and child Undernutrition: global and regional exposures and health consequences. *Lancet* 2008;371:243–60.

- 8 Black RE, Victora CG, Walker SP, *et al.* Maternal and child Undernutrition and overweight in low-income and middle-income countries. *The Lancet* 2013;382:427–51.
- 9 McFie J, Welbourn HF. Effect of malnutrition in infancy on the development of bone, muscle and fat. *The Journal of Nutrition* 1962;76:97–105.
- 10 Darsene H, Geleto A, Gebeyehu A, *et al.* Magnitude and predictors of Undernutrition among children aged six to fifty nine months in Ethiopia: A cross sectional study. *Arch Public Health* 2017;75.
- 11 Shahrin L, Chisti MJ, Ahmed T. 3.1 primary and secondary malnutrition. *World Rev Nutr Diet* 2015;113:139–46.
- 12 United Nations sustainable development goals (SDGS).
- 13 McDonald CM, Olofin I, Flaxman S, *et al.* The effect of multiple Anthropometric deficits on child mortality: meta-analysis of individual data in 10 prospective studies from developing countries. *Am J Clin Nutr* 2013;97:896–901.
- 14 Khara T, Mwangome M, Ngari M, *et al.* Children concurrently wasted and stunted: A meta-analysis of prevalence data of children 6–59 months from 84 countries. *Matern Child Nutr* 2018;14:e12516.
- 15 Garenne M, Willie D, Maire B, *et al.* Incidence and duration of severe wasting in two African populations. *Public Health Nutr* 2009;12:1974–82.
- 16 Davycas, UNICEF, WFP, and Ministry of Health. Nutrition survey in communities and sites with internally displaced persons (Idps) in Burkina Faso, Ouagadougou. 2020.
- 17 Ridde V, Lechat L, Meda IB. Terrorist attack of 15 January 2016 in Ouagadougou: how resilient was Burkina Faso's health system *BMJ Glob Health* 2016;1:e000056.
- 18 International Crisis Group. The social roots of Jihadist violence in Burkina Faso's North | crisis group. *Africa Report N°254* 2017.
- 19 Save the Children, DS/DRS de Kaya, and Lionella Fieschi. Prise en charge Communautaire de la malnutrition Aiguë (PCMA): Évaluation semi-quantitative de L'Accessibilité et de la Couverture (SQUEAC), Kaya, Burkina Faso. 2010.
- 20 Ministry of Health. Guide pour le Suivi et La Gestion de la Prise en charge de la malnutrition Aiguë, Ouagadougou, Burkina Faso. 2009.
- 21 Institut National de la statistique et de la démographie. *Cinquième Recensement Général de la Population et de l'Habitation du Burkina Faso, no.aouÛt.* 2022: 400.
- 22 The World Factbook. *Burkina Faso population projection.* The World Factbook — Central Intelligence Agency,
- 23 Ministère de la Santé Burkina Faso (DGESS). *Annuaire Statistique 2020, Ouagadougou, Apr.* 2020.
- 24 Ministère de la Santé. *Enquête Nutritionnelle Nationale (SMART-2020), Ouagadougou, Burkina Faso.* 2020.
- 25 World Health Organization. *Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age Methods and development.* 2006.
- 26 Zida Y, Kambou SH. Cartographie de la Pauvreté et des Inégalités au Burkina Faso. 2014.
- 27 Masibo PK, Makoka D. Trends and determinants of Undernutrition among young Kenyan children: Kenya demographic and health survey. *Public Health Nutr* 2012;15:1715–27.
- 28 Barankanira E, Molinari N, Msellati P, *et al.* Stunting among children under 3 years of age in Côte D'Ivoire: spatial and temporal variations between 1994 and 2011. *Public Health Nutr* 2017;20:1627–39.
- 29 de Onis M, Blössner M, Borghi E. Prevalence and trends of Stunting among pre-school children, 1990–2020. *Public Health Nutr* 2012;15:142–8.
- 30 Akombi BJ, Agho KE, Hall JJ, *et al.* Stunting and severe Stunting among children Under-5 years in Nigeria: A Multilevel analysis. *BMC Pediatr* 2017;17:15.
- 31 Thurstans S, Opondo C, Seal A, *et al.* Boys are more likely to be Undernourished than girls: A systematic review and meta-analysis of sex differences in Undernutrition. *BMJ Glob Health* 2020;5:e004030.
- 32 Yang YY, Kaddu G, Ngendahimana D, *et al.* Trends and determinants of Stunting among Under-5S: evidence from the 1995, 2001, 2006 and 2011 Uganda demographic and health surveys. *Public Health Nutr* 2018;21:2915–28.
- 33 Ruel MT, Menon P, Habicht J-P, *et al.* Age-based preventive targeting of food assistance and behaviour change and communication for reduction of childhood Undernutrition in Haiti: a cluster randomised trial. *Lancet* 2008;371:588–95.
- 34 Desmond C, Watt K, Boua PR, *et al.* Investing in human development and building state resilience in fragile contexts: A case study of early nutrition investments in Burkina Faso. *PLOS Glob PUBLIC Health* 2023;3:e0001737.
- 35 Sanoussi Y, Ahinkorah BO, Banke-Thomas A, *et al.* Assessing and decomposing inequality of opportunity in access to child health and nutrition in sub-Saharan Africa: evidence from three countries with low human development index. *Int J Equity Health* 2020;19:143:143:..
- 36 Bradshaw CJA, Otto SP, Mehrabi Z, *et al.* Testing the socioeconomic and environmental determinants of better child-health outcomes in Africa: A cross-sectional study among nations. *BMJ Open* 2019;9:e029968.
- 37 Dipasquale V, Cucinotta U, Romano C. Acute malnutrition in children: pathophysiology, clinical effects and treatment. *Nutrients* 2020;12:2413.
- 38 Gelli A, Becquey E, Ganaba R, *et al.* Improving diets and nutrition through an integrated poultry value chain and nutrition intervention (SELEVER) in Burkina Faso: study protocol for a randomized trial. *Trials* 2017;18:412.