Hubert *et al. BMC Nutrition* (2025) 11:106
https://doi.org/10.1186/s40795-025-01096-0

BMC Nutrition

RESEARCH

Open Access

Food insecurity, feeding practices and associated factors of acute malnutrition among children under 5 years of age in a post-conflict context in the Kasai region, Democratic Republic of Congo: a community-based case-control study

Victoire Hubert[1,3*], K. Phelan[3], L. I. Bozama[4], H. Boubacar[1], G. Tshibangu Sakubu[5], B. Tshiala[4], Mathilde Savy[6], R. Becquet[2] and C. Cazes[2]

Abstract

Background The Kasai region in the Democratic Republic of Congo suffered a violent conflict in 2016-17 and has been facing high household food insecurity and acute malnutrition (AM) in under 5 children ever since. This study aims to describe food security and feeding practices in a rural health district of this region in which the clinical randomised control trial OptiMA was implemented, and to assess the associated factors of AM among children aged 6 to 59 months in the aftermath of the conflict.

Methods A community-based matched case-control study was nested in the OptiMA trial. Cases ($n = 91$) were children aged 6 to 59 months suffering from AM enrolled in the trial. Two neighbourhood controls ($n = 181$) were randomly selected per case, matched on age. The required sample size, based on the Household Hunger Score (HHS) in the area, was 81 pairs of cases and controls. Of the 282 heads of households interviewed, 272 were included in the analyses. The heads of household and the children's caregivers were interviewed on household, caregiver, and child acute malnutrition risk factors. A conditional logistic regression was used to fit a model of wasting risk factors.

Results A total of 91% of households faced severe food insecurity and 33% severe hunger. Dietary diversity of both children and mothers was low with no mothers and only 5 children in the controls group reaching minimum dietary diversity. The mean diet diversity of mothers and children in both groups was only comprised between 2 and 2.5 out of 10 and 8 food groups, respectively in the classification. The HHS (AOR 2.9, 95% CI 1.6 to 5.6) and both moderate and severe stunting (AOR 10.2, 95% CI 3.2 to 32.2 and AOR 11.0, 95% CI 3.5 to 34.9, respectively) were strongly associated with acute malnutrition in the adjusted model.

*Correspondence:
Victoire Hubert
hubert.victoire@gmail.com
Full list of author information is available at the end of the article

Conclusions The dire food security and hunger described in this study calls for multi-sectoral actions to improve food access and evidence-based preventive actions for all types of undernutrition in the area.

Trial registration The trial in which this ancillary study is embedded was registered on clinicaltrials.gov under the number NCT03751475 on November, 23rd 2018.

Keywords Child, Democratic republic of congo, Post-conflict, Hunger, Malnutrition, Food insecurity, Growth disorders, Risk factors, case-control studies

Background

According to the 2023 Joint Malnutrition Estimate (UNICEF/WHO/World Bank), 45 million of the world's children under 5, or 6.8%, are severely or moderately wasted [1]. The risk of mortality for severely wasted children has been shown to be 11.6 times higher than for non-wasted children (95% IC 9.8–13.8). An estimated 27% of all children affected by wasting worldwide live in Africa [2].

The Democratic Republic of Congo remains one of the 15 countries most affected by acute malnutrition [3]. National wasting prevalence among under 5 children in 2017 was initially estimated by the World Health Organization at 6.4%, or approximately 1 million cases [1]. The Kasai region, which is home to many diamond extraction activities, has regularly been singled out as one of the areas of the country with a high burden of acute malnutrition, even though it is far from the decades-long conflict in the Eastern regions [4]. In 2016–2017, violent conflict came to Kasai, leading to a massive internal displacement of around 1.4 million people [5] and high food insecurity [6]. Additionally, thousands of Congolese workers and their families have been forced out of neighbouring Angola since 2018 into Kasai [5]. Despite the end of armed conflict, Kasai was classified as being in an "emergency" food insecurity phase [7]. The National Nutrition Department of the Ministry of Health (PRONANUT) identified 14 out of 18 health districts in Kasai as having concerning ($n = 13$) or alarming ($n = 1$) levels of acute malnutrition from January to March 2020. In most of these health districts, more than 20% of under 5 children and more than 15% of pregnant and lactating women had a Mid-Upper Arm Circumference (MUAC) below the thresholds used for determining acute malnutrition (< 125 mm for under 5 children and < 230 mm for pregnant and lactating women) [8].

We conducted a case-control study in the post-conflict Kasai region with the first purpose to document the context in which the Optimizing Treatment of Acute Malnutrition (OptiMA) randomized control trial was implemented [9]. This ancillary study is key to the analysis of the trial's results due to the lack of literature on the topic in the area. We described and compared the food security status and feeding practices of households of wasted children to households of non-malnourished children. The study also aimed to identify the main associated factors for episodes of acute malnutrition for young children in this rural area. The main hypothesis of our study was that the household living conditions and feeding practices of children suffering from acute malnourished children differed from the ones of non-malnourished children. Our results will contribute to the existing body of evidence on the immediate and underlying associated factors of acute malnutrition in a rural, post-conflict context of the Democratic Republic of Congo affected by emergency levels of food insecurity and high prevalence of wasting. We also hope our results can serve as a call for action for national and local actors in the prioritization of effective actions to improve the food security and nutrition situation.

Methods

Study design and setting

This study was an age-matched, case control-study. It took place in the Kamwesha health zone, Kasai Province in the Democratic Republic of Congo. Kamwesha is a rural district of 500,000 people with 26 health areas and one district hospital. In 2017 the prevalence rate of acute malnutrition was estimated at 19.7% (95% CI 14.4–26.3%) based on MUAC and at 11.0% (95% CI 7.4–26.3%) based on weight-for-height z-score (WHZ) [10]. In May 2018, The Alliance for International Medical Action (ALIMA), a non-governmental organisation (NGO), launched a nutritional paediatric emergency project in support of the Democratic Republic of Congo Ministry of Health (MoH). It consisted of implementing the national Democratic Republic of Congo protocol for severe acute malnutrition (SAM) treatment for the first time and supporting paediatric care in nine health centres and the district hospital in this landlocked rural health zone that had experienced two years of armed conflict. Nested in this emergency project, ALIMA, the French National Institute of Health and Medical Research (Inserm) and the PRONANUT in the Democratic Republic of Congo conducted a randomised control trial, the OptiMA trial, in four out of the nine health areas supported by ALIMA from July 2019 to July 2020. The OptiMA strategy aims to simplify and improve acute malnutrition management by treating children aged 6 to 59 months old with a MUAC < 125 mm or oedema with a single product–Ready-to-Use Therapeutic Food– at a tapered dose. The trial protocol and the findings have been published [9, 11, 12].

This case-control study was nested in the OptiMA trial and conducted in the same 4 health areas, at the end of March 2020, i.e. right after the harvest of the region's two main staple foods, i.e. corn and cassava. The lean season, or when food insecurity is supposedly at its highest, is between October and December (Fig. 1). As shown on the graph, staple crops in the area have two harvesting seasons. There are two rainy seasons: one from February to May and one from September to December.

Selection of cases

Cases were selected among children enrolled in the OptiMA trial. Inclusion criteria for the OptiMA trial were being aged between 6 and 59 months old with a MUAC < 125 mm or a WHZ<-3 or oedema without signs of complications or another underlying chronic condition. We kept the inclusion criteria as our definition of acute malnutrition as this study is ancillary to the trial [9]. Children were followed up for 6 months after their inclusion in the trial. To be selected as cases, children had to be enrolled in the trial and either receive nutritional treatment at an ambulatory therapeutic feeding centre at the time of the interview or be discharged less than a month prior to the interview. Children with a live twin were excluded.

Selection of controls

Two neighbourhood controls were randomly sampled for each case. Interviewers started from a case's house and then randomly selected a direction. They then picked the first households on their path that fitted the selection criteria for controls. Controls were children aged between 6 and 59 months who were MUAC ≥ 125 mm and WHZ≥-3 and no oedema (i.e. did not suffer from acute malnutrition according to the definition used in the trial). Controls were matched to cases based on age with two strata: 6–23 months old and 24–59 months old. Controls were not selected if any of the children between 6 and 59 months old in the household was receiving nutritional treatment, had been discharged from a nutritional program less than a month before, or had participated in the OptiMA trial. Children with a live twin were excluded. Only one control per household was selected, choosing the child with the age closest to the case.

Sample size calculation

The sample size was calculated using the formula for matched case-control studies [13, 14]. We selected the Household Hunger Score (HHS) as the main risk factor. A proportion of 75% of exposed controls was selected as, according to the Integrated Food Security Phase Classification analysis of August 2019, 75% of households in the Kasai region suffered from moderate to severe hunger [7]. We selected a power of 80% and a significance of 5% with a control to case ratio of 2 to 1 and an odds ratio to detect of 3. The required sample size was 73 cases and 146 controls. We considered 10% of missing data with a final required sample size of 81 pairs.

Data collection

The enumerators were 4 nurses who also collected data for the OptiMA trial with the help of each village's community health worker. They were trained for 3 days by the deputy project leader and the trial monitor with the contribution of Kamwesha health zone management team and the regional PRONANUT officer. Data were collected on tablets using ODK software [15]. Anthropometric measurements of children included in the study were taken by nurses who were assisted by community health workers following Democratic Republic of Congo national Integrated Management of Acute Malnutrition (IMAM) guidelines [16]. Salter weighting scales were used to measure weight to the nearest 100 g, height boards to measure height/length to the nearest 0.1 cm and MUAC tapes to measure MUAC to the nearest 1 mm. MUAC was measured on the child's left arm. For children measuring less than 87 cm, height was measured with the child lying down on the scale whereas children measuring 87 cm or more stood up, according to the OptiMA and the national acute malnutrition management protocols [12]. Nurses and community health workers were trained and supervised on anthropometric measurements for the OptiMA trial.

Crop	Jan	feb	march	april	may	june	july	aug	sept	oct	nov	dec
Corn	S/H	S/H	S/H			H	H		S	S	S	S
Groundnuts	S/H	S/H				H			S			
Cassava			H						S/H			
Beans	S/H	S	S			H	H	H	S			

Fig. 1 Seasonal agriculture calendar of the Kamwesha area (Kasai, Democratic Republic of Congo). S = Sowing season; H = Harvest season

Variables included in the study

Household risk factors

The first part of the questionnaire was answered by the head of the household and regarded socioeconomic characteristics of the household: household composition, age, gender, occupation, education level, marital status of the head of household. The different types of occupation of the head of household were grouped in 3 categories: agriculture as it is the main occupation in the area; education sector/health sector/civil service as it could mean a higher level of education; and other (trade, craftsmanship, employee, diamond extraction, unemployment). Further questions detailed agricultural activities. Questions were asked about the household's main assets, type of housing, household's hygiene. Several questions were asked on whether the household had encountered any shock during the past year and what type (financial, linked to farming activities…), and whether they had received any food distribution in the month prior to the interview. Indeed, the World Food Program (WFP) organised a blanket distribution of flour and beans for all households in the area near the end of our data collection period, and another NGO distributed corn soy blend flour to pregnant and lactating women. Households also assessed how much time their current food stocks could feed their household.

The Household Food Insecurity Access Scale (HFIAS) was assessed through the 9 questions designed by the Food and Nutrition Technical Project of the United States Agency for International Development over a recall period of 4 weeks [17]. To better illustrate the high food insecurity in the area, we chose to show the proportion of households in a situation of severe food insecurity as well [17]. The questions were asked to the head of the household. The HHS was constructed from the HFIAS last three questions to further differentiate households who suffered from hunger versus others [18]. The HHS score was classified in the 3 HHS categories: little to no hunger in the household, moderate hunger in the household, severe hunger in the household. The household wealth index was constructed using a principal components' analysis ([19]. It was based on the household possessions variables, the type of house, the number of rooms, livestock farming. Based on the wealth index, households were categorised in terciles.

Child and caregiver risk factors

The second part of the questionnaire was preferentially administered to the child's mother, when available, or to the child's caregiver. Collected data included the mothers' age, education level, occupation, status (present in the household, absent for the day or permanently absent). If the caregiver was a woman aged between 15 and 49 years old, dietary diversity was assessed through the Women Dietary Diversity Score (WDDS) computed from a qualitative 24 h recall. The WDDS was based on 10 food groups as recommended: grains, white roots, tubers and plantains; pulses; nuts and seeds; dairy; meat, poultry and fish; eggs; dark green leafy vegetables; other vitamin A-rich fruits and vegetables; other vegetables; other fruits. Due to the specifics of the diet in the region, we also asked mothers about their consumption of red palm oil and insects. The minimum dietary diversity for women indicator is a dichotomous indicator derived from the WDDS, which equals 1 (minimum dietary diversity is reached) when women had consumed 5 food groups or more over the previous 24 h, and 0 otherwise [20]. Dietary diversity of children was assessed using the Individual Dietary Diversity Score (IDDS) recommended by the WHO with a recall period of 24 h. The WHO score, based on 8 food groups (breast milk; grain, roots and tubers; pulses, legumes and nuts; dairy products; flesh foods; eggs: vitamin-A rich fruits and vegetables; other fruits and vegetables), was initially defined for children aged from 6 to 23 months, however it was extended here to children aged 6 to 59 months [21]. Questions on feeding practices were based on WHO Indicators for Assessing Infant and Young Child Feeding Practices (IYCFP) [21]. Both the Minimum Meal Frequency and Minimum Dietary Diversity indicators were then calculated based on WHO guidelines for children aged 6 to 23 months old. The Minimum Dietary Diversity (MDD) indicator is calculated as children having consumed 5 food groups out of 8 during the previous day. The Minimum Meal Frequency indicator was only calculated for children aged 6 to 23 months old according to the WHO guidelines: 2 feedings for breastfed children aged 6–8 months, 3 feedings for breastfed children aged 9–23 months and 4 feedings for non-breastfed children aged 6–23 months. Additional questions were asked on the child's morbidity history in the past month.

Anthropometric indicators

Height-for-age z score to define stunting (i.e. height-for-age z-score<-2) was calculated using the WHO anthropometry package for R [22]. Extreme, biologically implausible observations (<-6 z-score/>6 z-score) were considered as missing following WHO guidelines [23].

Data analysis

Data was analysed using R software [24]. First, we compared characteristics between cases and controls. Descriptive statistics were expressed as percentages and frequencies for categorical variables and as median, interquartile range, minimum and maximum values for continuous variables. The WDDS and IDDS were expressed as means and standard deviation. Several continuous variables were transformed to categorical variables using standard cut-off points when available, or the variable's distribution.

The outcome used in the bivariate and multivariate analysis was to be a case, i.e. to currently suffer or have suffered less than a month ago from an episode of acute malnutrition. Conditional logistic regression was used to assess independent association with the outcome and to obtain crude odds ratios. If significant ($p < 0.1$), the variables were selected for the multivariate model. In case of collinearity between some variables in the multivariate model, we chose the one we found the most appropriate to present regarding the rationale and based on literature relevant to this study. A conditional logistic regression was used to fit the multivariate model. All explicative variables were entered in the model and were then removed following a stepwise backwards approach until only significant variables remained in the final model ($p < 0.05$). All variables were assessed for multicollinearity by using the variance inflation factor in the final model thanks to the "performance" package of R. The goodness of fit of the model was tested thanks to a generalized linear model using the "glm" package of R.

Ethics

Ethical approval with annual renewal was granted by the Democratic Republic of the Congo National Ethics Committee (approval number 94/CNES/BN/PMMF/2018) and the Ethics Evaluation Committee of the French National Institute for Health and Medical Research (INSERM, approval number 18–545).

The case-control study was nested in the OptiMA trial and mentioned as an ancillary study in the protocol approved by ethic committees. Before conducting the interview, enumerators explained the study to the participants in Tshiluba and answered their questions before giving them an information sheet. All participants signed a consent form. If the participant was unable to read and write, he chose a witness that could sign for him/her (usually the village community health worker). All collected data were anonymised with an identifying number. Before the start of the trial, community leaders were consulted on the study. Community health workers of each village were fully implicated in the study implementation.

Results

Between March, 4th and April, 23rd 2020, 282 households were interviewed, and of these, 272 were included in the analysis (91 cases; 181 controls) (Fig. 2).

Table 2 shows the household characteristics of cases and controls. The heads of household were mainly males (85.7%). Case households were more likely to have 3 or 4 children under 5 years (24.2%) than controls (12.1%). Agriculture was the main occupation of the heads of households in both cases (86.8%) and controls (76.2%), regardless of gender. Although almost all case and control households grew crops (93.4%), controls were more likely to farm livestock (52.5%) compared to cases (36.3%). Control households were more frequently in the highest wealth tercile than case ones (37.6% versus 20.9%). Nearly all case households (98.9%) and most control households (86.7%) were in a situation of severe food insecurity, according to the HFIAS. As many as 38.5% of case households suffered from severe hunger, compared to 29.8% of control ones. We found more declaration of pregnant or lactating women treated for malnutrition during the past year among the case households (12.4% versus 5.6%).

Table 3 shows the characteristics of mothers and children. Mothers had almost the same median age in both groups (27–28 years). Mothers of cases were more frequently illiterate (84.9% against 77.9%) and more likely to have more than 6 children (23.1% against 11.6%). In both groups, 62% of children were between 6 and 23 months old and around 70% of children were breastfed at the time of the interview. Food and beverages were integrated in most children's diet before 6 months of age, for both cases and controls (84.2% and 82.9%, respectively). We found a higher proportion of both moderate and severe stunting among the cases (33.7% and 44.2% respectively) versus controls (18.9% and 25.0%).

Regarding meal and diet diversity, we found 3 female caregivers who had not eaten the day before the interview. Among those who had eaten, no caregiver in the sample reached the minimum dietary diversity for women (at least 5 food groups out of 10) with scores ranging from 1 to 4 food groups. However, having eaten 3 or 4 meals the day before the interview was less frequent among the cases (3.6%) versus the controls (14.8%); they were also fewer to have consumed nutrient-rich foods. In total 22 children had not eaten a single meal the day before the interview. For those who ate, the median IDDS was 3 out of 8 food groups. Similar to their female caregivers, fewer children in the cases had 3 to 4 meals the day before the interview (13.4%) compared to controls (30.4%), however no difference was observed in nutrient-rich foods intakes. Finally, we found more caregivers reporting that their child was sick during the past month in the control group (47.5% versus 37.4%).

In the crude analysis, HFIAS and HHS scores were both associated with the AM episode (OR 1.3, 95% CI 1.2 to 1.5 and OR 2.5, 95% CI 1.7 to 3.7, respectively) (Table 1). In the multivariate analysis, only HHS was kept as a variable. Only one variable could be kept as HHS is calculated from HFIAS. We selected HHS as it was more strongly associated to the occurrence of an episode of acute malnutrition and discriminated better between the two groups. Having experienced an unexpected hardship during the past year such as the loss of crops or livestock

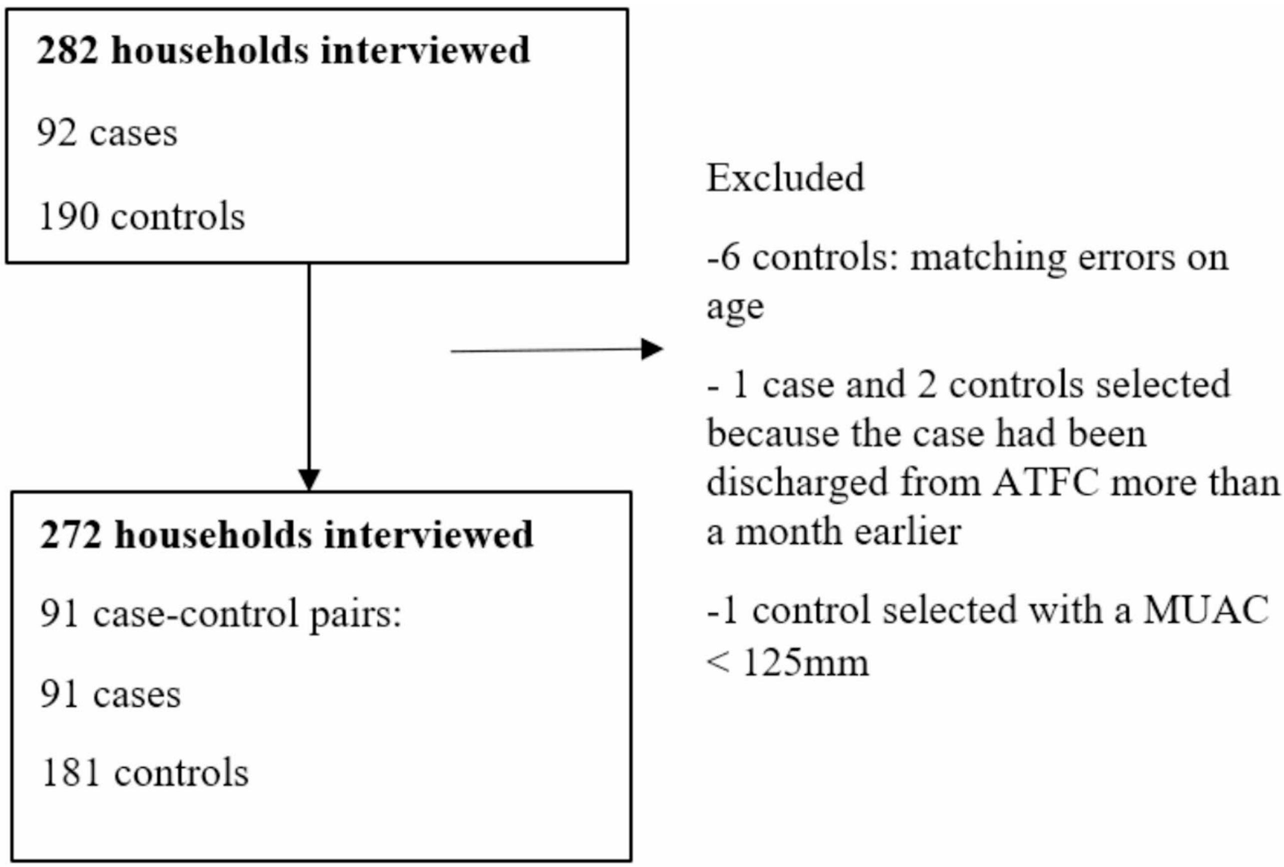

Fig. 2 Flow chart of children included in the case-control study. ATFC = Ambulatory Therapeutic Feeding Center; MUAC = Mid-Upper Arm Circumference

or the death of an adult member of the household, was associated with a 2.6 times increased risk of the child developing an AM episode (OR 2.6, 95% CI 1.02 to 6.6). Low household wealth was a risk factor for the outcome as well ($p = 0.02$). On the contrary, a higher dietary diversity in women (OR 0.5, 95% CI 0.3 to 0.8) and in children (OR 0.5, 95% CI 0.3 to 0.8) lowered the risk of AM (Table 1).

In the multivariate analysis (Table 1), more than two children under 5 at home, an illiterate head of household, a high HHS, the presence of a woman of the household having been treated for AM in the past year, a low child IDDS and stunting were risk factors for an AM episode. One additional point of the HHS increased the risk of an AM episode by 2.9 (AOR 2.9, 95% CI 1.6 to 5.3). Adjusting for hunger score in the household, children with a higher dietary diversity score had a 60% lower chance of developing an AM episode (AOR 0.5, 95% CI 0.3 to 0.8) (Table 1). All other variables of the final model had a variance inflation factor < 2. Using a generalized linear model shows a good predictability of the model ($p < 0.005$).

Discussion

This study was conducted one year after the end of an armed conflict that has caused large population displacements and high food insecurity in the Kasai region of the Democratic Republic of Congo. Globally, 91% of all households interviewed faced severe food insecurity and 33% were affected by severe hunger. We found significant differences between cases and controls regarding household food security, mean diet diversity scores and number of meals eaten at the child and mother/caregiver levels. However, both cases and controls households faced dire levels of food security and hunger. Dietary diversity of both children and mothers remained low with a diet mainly based on cereals, tubers, and dark green leaves vegetables. Most mothers and children had only eaten 1 or 2 meals the day before the interview, and none or only a few individuals reached the minimum dietary diversity. These results provide additional context for the interpretation of OptiMA-trial results.

Our results bring additional evidence to the existing literature on the factors associated with acute malnutrition in Sub-Saharan Africa, especially as very few studies have been conducted in the Democratic Republic of Congo. A systematic review [25] on the determinants of acute

Table 1 Risk factors associated with an episode of acute malnutrition

Characteristics	Cases		Bivariate model		Multivariate model (*N* = 244)	
	n	(%)	OR (95% CI)	*P*-value	AOR (95% CI)	*P*-value
Number of children under 5 (*N* = 272)				**0.005**		**0.02**
1–2	69	(75.8)	1	Ref	4.9	Ref
3–4	22	(24.2)	3.6 (1.5–8.9)	0.005	(1.3–18.2)	0.02
Fishing/Hunting households (*N* = 272)				**0.02**		
yes	8	(8.8)	0.4 (0.2–0.9)	0.02		
Households having experienced at least 1 hardship in the past year (*N* = 272)				**0.04**		
yes	82	(90.1)	2.6 (1.0-6.6)	0.04		
Household wealth index (*N* = 272)				**0.007**		
Median [IQR]	-0.1 [-0.4-0.2]		0.3 (0.2–0.7)	0.007		
Min-Max	-0.5-1.1					
Access to a well/borehole (*N* = 272)				**0.08**		
Yes	72	(79.1)	0.2 (0.1–1.2)	0.08		
Head of household literacy (*N* = 272)				**0.02**		**0.005**
Illiterate	22	(24.2)	2.4 (1.2–4.9)	0.02	6.4 (1.7–23.4)	0.005
HHS (*N* = 272)				**< 0.001**		**< 0.001**
Median [IQR]	3.0 [2.5–3.5]		2.5 (1.7–3.7)		2.9 (1.6–5.3)	< 0.001
HFIAS (*N* = 272)				**< 0.001**		
Median [IQR]	14.0 [11.0–25.00]		1.3 (1.2 -1. 5)			
Mother literacy (*N* = 258)				**0.09**		
Illiterate	73	(84.9)	2.1 (0.9–5.2)	0.09		
WDDS (*N* = 254)				**0.003**		
Median [IQR]	2 [2–3]		0.5 (0.3–0.8)	0.003		
min - max	1–4					
Number of meals of the caregiver* (*N* = 252)				**0.008**		
[1,2]	80	(96.4)	1	[1,2]		
[3,4]	3	(3.6)	0.2 (0.1–0.6)	[3,4]		
Animal-source food eaten by the caregiver* (*N* = 254)				**0.03**		
yes	5	(5.9)	0.4 (0.1–0.9)	0.03		
Fruits and vegetables eaten by the caregiver* (*N* = 254)				**0.06**		
yes	71	(83.5)	0.2 (0.1–0.6)	0.06		
Number of children of the child's mother (*N* = 272)				**0.006**		
[1,6]	70	(83.5)	(reference)			
]6,11]	21	(16.5)	3.1 (1.4–7.1)	0.006		
Stunting (*N* = 266)				**< 0.001**		**< 0.001**
HAZ [-3;-2]	29	(33.7)	5.7 (2.5–13.4)	< 0.001	10.2 (3.2–32.2)	< 0.001
HAZ <-3	38	(44.2)	7.5 (3.2–17.5)	< 0.001	11.0 (3.5–34.9)	< 0.001
IDDS score (*N* = 250)				**0.002**		**0.01**
Median [IQR]	3 [2–3]		0.5 (0.3–0.8)	0.002	0.4 (0.2–0.8)	0.01
Min - max	1–4					

Data are n (%) or mean (standard deviation); odd ratio (OR) or adjusted odd ratio (AOR) with 95% confidence interval; HHS = Household Hunger Score, PLW = Pregnant and Lactating Women; IDDS = Individual Dietary Diversity Score, WDDS = Women Dietary Diversity Score; * The day before the interview; § Stunting is defined by a height-for-age z-score <-2. Underlined variables are the ones selected in the final multivariate model

malnutrition episodes in sub-Saharan Africa found only one cross-sectional study of medium quality, conducted in the Democratic Republic of Congo, and it was carried out in a health area with low under 5 children wasting prevalence (3.8%). It identified low appetite, diarrhoea, and age as the 3 predictive factors of wasting [26]. An additional case-control study aiming to develop a predictive score for severe acute malnutrition (SAM) was conducted in the same area among hospitalised children. The model identified 9 individual and household-level predictive factors of malnutrition (such as the mother's age), then translated to a system of points that can be used to identify children at a high risk of SAM [27].

A literature review examining the associations between food insecurity and malnutrition found mixed results regarding wasting, with only 3 out of 15 studies finding such an association. The mixed results can be explained by the fact that studies used different methodologies

Table 2 Household characteristics of cases and controls

Characteristics	**Cases** *N* = 91		**Controls** *N* = 181		***p*-value**
	n	**(%)**	**n**	**(%)**	
HOUSEHOLD CHARACTERISTICS					
Head of household gender					**0.2**
Male	75	(82.4)	158	(87.3)	-
Female	16	(17.6)	23	(12.7)	0.2
Number of household members					**0.03**
[0–3]	7	(7.7)	29	(16.0)	-
]3–14]	84	(92.3)	152	(84.0)	0.03
Number of children under 5					**0.005**
1–2	69	(75.8)	159	(87.9)	-
3–4	22	(24.2)	22	(12.1)	0.005
Head of household age (years)					**0.5**
Median [IQR]	36 [31–41]		36 [30–40]		0.5
Min-max	18–62		18–62		
Head of household literacy					**0.02**
Illiterate	22	(24.2)	24	(13.3)	0.02
Head of household main occupation					**0.1**
Agriculture	79	(86.8)	138	(76.2)	-
Health, education, civil service	6	(6.6)	23	(12.7)	0.1
Other	6	(6.6)	20	(11.1)	0.2
FARMING					
Type of farming activity					
Crops	85	(93.4)	169	(93.4)	-
Livestock	33	(36.3)	95	(52.5)	0.01
Fishing/hunting	8	(8.8)	34	(18.8)	0.02
Gathering leaves, fruits…	35	(38.5)	72	(39.8)	0.7
No farming activity	3	(3.3)	8	(4.4)	0.7
STOCKS					
Households who have food stocks at the time of the survey					**0.3**
Yes	73	(80.2)	154	(85.1)	0.3
Duration of stocks					**0.6**
[1,3] months	38	(52.1)	69	(44.8)	-
]3,6] months	29	(39.7)	75	(48.7)	0.5
]6,12] months	6	(8.2)	10	(6.5)	0.6
Households benefitting from food distribution (WFP/NGO) during the previous month					**0.4**
yes	10	(11.0)	16	(8.8)	0.4
HARDSHIPS					
Households having experienced at least 1 hardship during the past year					**0.04**
yes	82	(90.1)	149	(82.3)	0.04
HOUSEHOLD WEALTH INDEX					**0.003**
1st tercile - Poorest	34	(37.4)	64	(35.4)	-
2nd tercile - Medium	38	(41.8)	49	(27.1)	0.6
3rd tercile - Wealthiest	19	(20.9)	68	(37.6)	0.02
HOUSEHOLD FOOD INSECURITY					
HFIAS					**< 0.001**
Median [IQR]	14 [11–25]		12 [7–24]		< 0.001
Min - max	1–27		0–27		
Severely food insecure					**0.006**
yes	90	(98.9)	157	(86.7)	0.006
Household Hunger Score					**< 0.001**
Median [IQR]	3.0 [2.5–3.5]		3.0 [1.0–4.0]		< 0.001
Min - max	0–6		0–6		

Table 2 (continued)

Characteristics	Cases N = 91		Controls N = 181		p-value
	n	(%)	n	(%)	
Household Hunger Score Categorical Indicator					**< 0.001**
Little to no hunger in the household	12	(13.2)	52	(28.7)	-
Moderate hunger in the household	44	(48.3)	75	(41.5)	< 0.001
Severe hunger in the household	35	(38.5)	54	(29.8)	< 0.001
WATER AND HYGIENE					
Access to a well/borehole					**0.08**
yes	72	(79.1)	151	(83.4)	0.08
Soap use for hand washing					**0.6**
yes	61	(67.0)	124	(68.5)	0.6
Type of latrine					**0.5**
Open defecation	12	(13.2)	17	(9.4)	-
Household latrine	19	(21.0)	35	(19.3)	0.6
Village latrine	60	(65.9)	129	(71.3)	0.6
Waste management					**0.4**
Thrown away	36	(34.0)	86	(29.3)	-
Buried	22	(24.2)	39	(21.5)	0.5
Open pit	31	(39.6)	53	(47.5)	0.2
Burnt	2	(2.2)	3	(1.7)	1
HISTORY OF MALNUTRITION IN THE HOUSEHOLD					
A PLW in the household has been treated for acute malnutrition during the past year					**0.04**
Yes	11	(12.4)	10	(5.6)	0.04
Missing data	2	-	2	-	

Data are n (%) or mean (standard deviation); P values are based on Wald tests; HFIAS = Household Food Insecurity Access Scale; WFP = World Food Programme; NGO = Non-Governmental Organisation; PLW = Pregnant or Lactating Women

(cross-sectional versus longitudinal) and studied various age groups [28].

Our findings are in line with those from the United Nations' Office for the Coordination of Humanitarian Affairs from 2020 which found that communities in the Kasai were still affected by the aftermath of the 2017 conflict [5]. An earlier food security assessment by WFP in 2017 highlighted several structural and social factors that caused high food insecurity: lack of access to agricultural land and seeds, especially for displaced populations, poor road access to most areas, lack of investment in farming activities, limited farming workforce as people favour diamond extraction activities, and pests causing crop damage [6]. We found that an unexpected hardship (e.g. the death of an adult in the household or the loss of crops or animals) in this context of structural food insecurity increased the risk of developing an episode of acute malnutrition among under 5 children. Kismul and al. documented in the Equateur region of the Democratic Republic of Congo how children who live in households with a high pressure on productive adults are at higher risk of malnutrition [29].

In this study, we used both the HFIAS and the HHS to measure food insecurity and hunger and both were significantly associated with a child's wasting episode ($p < 0.001$). Research from other countries reported mixed results on such an association [28]. Disha Ali et al. investigated the association between food insecurity measured through HFIAS and stunting, wasting and underweight in 3 countries [30]. In this study, HHS was more strongly associated with a child's wasting episode, showing the relevance of this indicator for severe food insecurity context, as recommended by the guidelines [18].

Household food insecurity, however, is not enough to explain child wasting. The percentage of stunted children was the largest difference between cases and controls groups. This study showed a strong link between stunting and wasting in accordance with several longitudinal studies showing the association between stunting and wasting and vice versa. Wasting episodes were found to be predicted by prior episodes of both wasting and stunting as well as concurrent wasting and stunting [31].

Disha Ali et al. found that diet diversity of the child did mediate the association with food insecurity but not entirely [30], which is in line with our results. In our final model, a higher child diet diversity was significantly protective against wasting, once adjusted for the level of household hunger (HHS).

Apart from diet diversity, feeding practices were not significantly associated with the outcome in the final model. Even when looking at crude associations,

Table 3 Mother and child characteristics

Characteristics	Cases N = 91		Controls N = 181		*p*-value
	n	(%)	n	(%)	
MOTHER/CAREGIVER CHARACTERISTICS					
Mother's status on the day of the interview					**0.2**
Interviewee	84	(93.3)	170	(93.9)	
Temporarily absent (travel…)	2	(2.2)	9	(5.0)	0.3
Permanently absent (dead or moved out)	4	(4.4)	2	(1.1)	0.1
Missing data	1	-	-	-	
Mother's age					**0.6**
Median [IQR]	27 [22–33]		28 [24–32]		0.6
Min– max	18–48		16–43		
Missing data	21		42		
Mother literacy					**0.09**
Illiterate	73	(84.9)	134	(77.9)	
Missing data	5		9		
Mother occupation					**0.3**
Housewife	8	(9.2)	11	(6.4)	
Agriculture	77	(88.5)	149	(86.6)	0.5
Other sectors	2	(2.3)	12	(7.0)	0.1
Missing data	4		9	-	
Number of children					0.02
[1–3]	42	(46.2)	86	(47.5)	
]3–6]	28	(30.8)	74	(40.9)	0.5
]6–11]	21	(23.1)	21	(11.6)	0.01
Mother/caregiver aged 15–49 years old					**0.8**
Yes	86	(94.5)	172	(95.10)	0.8
Mother/caregiver had eaten the day before					**0.6**
Yes	85/86	(98.84)	169/172	(98.26)	0.6
Dietary diversity (WDDS) among mother/caregiver who had eaten the day before					**0.003**
Mean (sd)	2.2 (0.7)		2.5 (0.7)		0.003
min– max	1–4		1–4		
MDD-W among mother/caregiver who had eaten the day before					
Yes	0/85	-	0/169	-	-
Types of nutrient-rich foods eaten the day before					
Animal-source food	5/85	(5.9)	26/169	(15.4)	0.03
Pulses, nuts and seeds	13/85	(15.3)	28/169	(16.6)	0.8
Fruits and vegetables	71/85	(83.5)	162/169	(95.9)	0.006
Women who had eaten red palm oil the day before					**0.6**
Yes	35/85	(41.2)	77/169	(45.6)	0.6
Women who had eaten insects the day before					**0.8**
Yes	26/85	(30.6)	53/169	(31.4)	0.8
Number of meals in the previous 24 h					**0.008**
[1,2]	80/85	(94.1)	144/169	(85.2)	
[3,4]	3/85	(3.5)	25/169	(14.8)	0.008
Missing data	2/85	(2.4)	0/169		
Pregnant women among mothers/caregivers aged 15–49 years old					**0.4**
Yes	16/86	(18.6)	25/172	(14.5)	0.4
Missing data	3/86	(3.5)	9/172	(5.2)	
Lactating women among mothers/caregivers aged 15–49 years old					**0.3**
Yes	72/86	(83.7)	152/172	(88.4)	0.3
Pregnant and lactating women among mothers/caregivers aged 15–49 years old					**0.3**
Yes	9/86	(10.5)	13/172	(7.6)	0.3
CHILD CHARACTERISTICS	*N* = 91		*N* = 181		

Table 3 (continued)

Characteristics	Cases *N* = 91		Controls *N* = 181		*p*-value
	n	(%)	n	(%)	
Child's age					**0.8**
[6–23] months	56	(61.5)	112	(62.0)	
[24–61] months	35	(38.5)	69	(38.0)	0.8
Child's sex					**0.8**
Male	46	(50.5)	94	(51.9)	
Female	45	(49.5)	87	(48.1)	0.8
Child's height-for-age z score					**< 0.001**
[-2, 6[	19	(20.1)	101	(55.8)	< 0.001
[-3, -2[	29	(31.9)	34	(18.8)	
]-6, -3[	38	(41.8)	45	(24.9)	< 0.001
Missing data	5	(5.5)	1	(0.05)	**-**
Birth order					**0.6**
First born	16	(17.6)	34	(18.7)	
2nd and more	66	(72.5)	129	(71.3)	0.6
Missing data	9	(9.9)	18	(10.0)	-
HEALTH					
Children sleeping under a bed net					**0.7**
yes	20	(21.9)	44	(24.3)	**0.7**
Children sick during the past month					**0.05**
yes	34	(37.4)	86	(47.5)	0.05
Type of disease					
Febrile	21/34	(61.8)	61/86	(70.9)	0.7
Diarrhoeal	14/34	(41.2)	34/86	(39.5)	0.9
BREASTFEEDING					
Children who were ever breastfed					0.5
yes	89	(97.8)	181	(100)	0.5
Breastfeeding initiation					**0.3**
1 h or less	47/89	(52.8)	110/181	(60.8)	-
After 1 h	23/89	(25.8)	39/181	(21.5)	0.3
Missing data	19/89	(21.3)	32/181	(17.7)	-
Breastfed at the time of the interview					**0.5**
yes	61/89	(68.5)	126/181	(70.2)	0.5
Age of cessation of breastfeeding among children no breastfed at the time of the interview, months					**0.3**
Median [IQR]	16 [13.5–24]		20 [14.3–24]		0.3
Min - max	5–26		3–36		
Age of introduction of other food & beverage among children who were ever breastfed, months					**0.8**
[0,6[	75/89	(84.2)	150/181	(82.9)	-
[6,26]	14/89	(15.7)	31/181	(17.1)	0.8
MEAL CONSUMPTION (semi solid or solid food)					
Children who ate a meal the day before					**0.5**
yes	85	(93.4)	165	(91.2)	0.5
Number of meals among children who ate a meal the day before					**0.02**
[1–2]	71/85	(83.5)	110/165	(66.7)	-
[3–4]	11/85	(12.9)	48/165	(29.1)	0.02
Missing data	3/85	(3.5)	7/165	(4.2)	-
IDDS (number of food groups) among children who ate a meal the day before					**0.002**
Mean (sd)		2.7 (0.7)	3.0 (0.8)		
Min-max		1–4	1–5		
Types of nutrient-rich foods eaten the day before					
Animal-source food	7/85	(8.2)	25/165	(15.2)	0.1
Pulses, nuts and seeds	8/85	(9.4)	18/165	(10.9)	0.7

Table 3 (continued)

Characteristics	Cases *N* = 91		Controls *N* = 181		*p*-value
	n	(%)	n	(%)	
Fruits and vegetables	71/85	(83.5)	154/165	(93.3)	0.1
Children who had eaten red palm oil the day before					**0.9**
yes	37/85	(43.6)	78/165	(47.0)	0.9
Children who had eaten insects the day before					**0.6**
yes	26/85	(30.6)	55/165	(33.3)	0.6
WHO IYCFP indicators among children aged 6–23 months old and who ate a meal the day before					
Minimum meal frequency					0.01
Yes	7/50	(14.0)	31/96	(32.3)	0.01
Minimum diet diversity	*				
yes	0/50	(0.0)	4/96	(3.9)	*

Data are n (%) or n/N (%) or mean (standard deviation); *P* values are based on Wald tests; WDDS = Women Dietary Diversity Score, MDD-W = Minimum Dietary Diversity for Women, PLW = Pregnant and Lactating Women, IDDS = Individual Dietary Diversity Score, IYCFP = Infant and Young Child Feeding Practices, WHO = World Health Organization. * The *p*-value couldn't be calculated as one of the values is 0

perinatal feeding practices, such as breastfeeding or the age of introduction of a complementary diet, were not different between cases and controls. However, control children and their mothers were more likely to have eaten 3 to 4 meals the day before. In another region of the Democratic Republic of Congo, Mukuku et al. [27] found a strong association between perinatal feeding and wasting whereas in Chad Dodos et al. did not [32]. Other factors that were significantly associated with wasting in our final model included: the number of children under 5 in the household, which is in line with Mukuku et al. [27], and the illiteracy of the head of household, which could have an impact on the household's wealth and access to a more diverse diet [33]. The household wealth index was associated to wasting in the bivariate but not the multivariate model. It may be mediated entirely by the HHS. A relationship between household wealth and wasting is well documented in the literature in Sub-Saharan countries [25] and globally [34].

There are several limitations to this study. First, it was carried out only once and did not capture wasting episode risk factors at repeated intervals. Second, it did not allow us to identify recent child morbidity episodes as wasting risk factors. Questions were asked on health in the month leading up to the interview to reduce recall bias, but cases ranged from children very recently admitted to an ambulatory therapeutic feeding centre to children who had already been discharged for a month. Although this was not an obstacle for food security, which changes slowly, we could not identify if diarrhoea or febrile episodes had led to the wasting episode or were posterior to it. One must note that studies mentioned here all considered WHZ<-2 as the definition of wasting while our study considered both a MUAC < 125 mm and/or WHZ <-3 and/or the presence of oedema, which could have an impact on the association [28]. Not all variables impacting wasting could be properly captured. The questionnaire was entirely based on the head of household and caregiver's answers, with a risk of recall bias. WFP was distributing food concurrently in some areas, so we cannot exclude the possibility ALIMA interviewers were mistaken for WFP ones, leading respondents to appear more vulnerable than they actually were. However, having anticipated this risk and to mitigate it, we emphasised to the participants that ALIMA was completely separate from the WFP and did not take part in the decision of food distributions in the area.

This study's strongest point is to have been conducted in a post-conflict area with little literature available on food security and malnutrition causes in this context. The use of established indicators such as HFIAS, HHS, diet diversity indicators allow for comparability with other studies and adds to the literature on the link between these indicators and acute malnutrition. It was conducted as an ancillary study of a randomized controlled trial with already the infrastructure in place for a good quality of data collection such as trained investigators with a relation of trust with the community, the involvement of local authorities, an onsite data monitoring system. This study also confirms the results of the OptiMA-Democratic Republic of Congo clinical trial, contributing to the revision of the WHO guideline on acute malnutrition in 2023 [35], were shown in a severely food insecure context.

These findings show how most families in this area of the Democratic Republic of Congo face a daunting food insecurity situation, with the southern part of the Kasai province (Kamonia territory) still in phase 3 (Crisis) according to the acute food insecurity Integrated Phase Classification established by the Famine Early Warning System Network (FEWS-NET) as of May 2024 [36]. As food insecurity and lack of diet diversity were both associated with wasting in under 5 children, multi-sectoral actions are needed for a better availability of and access to foods and nutrients with appropriate child-adapted practices. Proven preventive cost-efficient interventions against stunting and wasting such as a blanket distribution of Small Quantity-Lipid Nutrient Supplementation should be considered in such areas of high prevalence of stunting, wasting and a combination of both [37]. As confirmed in this study, stunting remains one of the strongest associated factors of wasting. A 1000 Days program which would encompass both mothers and children's health and nutritional needs would be very relevant since mothers also showed poor nutrition indicators, such as diet diversity.

Conclusions

In this post-conflict context in the Kasai region of the Democratic Republic of Congo, the food security and nutritional situation remains dire for most of the population, calling for multi-sectoral actions to foster availability and access to foods in good quantity and sufficient quality with child-adapted practices. Evidence-based and integrated nutrition-specific actions are needed to cut both stunting and wasting rates.

Abbreviations

ALIMA	The alliance for international medical action
AM	Acute malnutrition
HFIAS	Household food insecurity access scale
HHS	Household hunger score
IDDS	Individual diet diversity score
INSERM	French national institute for health research
MUAC	Mid-upper arm circumference
NGO	Non-governmental organization
OptiMA	Optimizing treatment of acute malnutrition
PRONANUT	National nutrition programme of the democratic republic of congo
SAM	Severe acute malnutrition
WDDS	Women diet diversity score
WHO	World health organization
WFP	World food programme
WHZ	Weight-for-height z-score

Acknowledgements
We are indebted to the women and children who participate in the study. The authors wish to particularly acknowledge the ALIMA operational team on the ground who managed the study and the nutrition program on a day-to-day basis. The authors also acknowledge the Ministry of Health of the Democratic Republic of Congo through the commitment of key representatives from the Kamwesha health zone and the National Nutrition Programme. This study was developed as part of the Clinical and Operational Research Alliance (CORAL). This research platform aims at developing high-quality innovative and transformative research programs within a partnership between scientists from the research institute Inserm (Institut National de la Santé et la Recherche Médicale, Bordeaux and Abidjan) and the humanitarian organization ALIMA (Alliance for International Medical Action), primarily on improving maternal and child health outcomes. A board of directors defines the scientific policy of the CORAL partnership alongside with the supervision of research projects and dissemination of results. It consists of senior representatives from both ALIMA and Inserm: Renaud Becquet (Inserm Bordeaux, methodological co-chair), Susan Shepherd (ALIMA, medical co-chair), Moumouni Kinda (ALIMA), Marie Jaspard (ALIMA), Béatrice Sera (ALIMA), and Xavier Anglaret (Inserm Bordeaux & Abidjan). The CORAL research platform meets annually with an external scientific advisory board to review projects and strategic orientation.

Author contributions
RB and CC developed the rational (CC) and methodological (RB) study concept. VH, CC, MS and RB designed the study methodology and wrote the protocol. CC, VH and HB coordinated the study teams. LIB, GTS and BT coordinated the Ministry of Health staff working in the trial. VH and HB organized and supervised data collection. VH developed the database. VH, CC, MS and RB developed the statistical analysis strategy. VH wrote the first draft of the manuscript with substantial inputs from CC, MS and KP. CC was primarily responsible for the final content of the manuscript. All authors critically reviewed the first draft and had a substantial writing contribution to the development of the final manuscript.

Funding
The study was supported by the Innocent Foundation (London, UK), grant number ALIMA-2018-DRC. The Innocent Foundation had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data availability
The data will be available in our University's data warehouse and in co-investigators (Programme National Nutrition of DRC) data warehouse upon request from researchers who provide a methodologically sound proposal and whose proposed use of the data has been approved by an independent review committee.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki. The study was nested in a trial whose protocol was approved by the DRC national ethics committee (CNES) (94/CNES/BN/PMMF/2018) and by the Ethics Evaluation Committee of Inserm, the French National Institute for Health and Medical Research (Comité d'Evaluation Ethique de l'Inserm) (18–545). In November 2019, the CNES performed a field visit at each of the study sites and then renewed approval (152/CNES/BN/PMMF/2019) for the continuation of the trial. After an initial explanation by the enumerator in Tshiluba, asking questions and receiving an information sheet, all participants gave written consent. If the participant was unable to read and write, he chose a witness that could sign for him/her (usually the village community health worker).

Consent for publication
Not required.

Competing interests
The authors declare no competing interests.

Author details
[1]The Alliance for International Medical Action (ALIMA), Kamwesha, Democratic Republic of Congo
[2]University of Bordeaux, National Institute for Health and Medical Research (INSERM), UMR 1219, Research Institute for Sustainable Development (IRD), Bordeaux Population Health Research Centre, EMR 271, Bordeaux, France
[3]The Alliance for International Medical Action (ALIMA), 1 rue Philidor, 75020 Paris, France
[4]National Nutrition Programme (PRONANUT), Ministry of Health, Kinshasa, Democratic Republic of Congo
[5]Kamwesha Health Zone in the Kasaï Province, Ministry of Health, Kamwesha, Democratic Republic of Congo
[6]Univ Montpellier, CIRAD, CIHEAM-IAMM, INRAE, Institut Agro, IRD, MoISA, Montpellier, France

Received: 3 July 2024 / Accepted: 20 May 2025
Published online: 30 May 2025

References

1. WHO/World Bank Group Joint Child Malnutrition Estimates. Levels and trends in child malnutrition: UNICEF/. Key findings of the 2023 edition. Volume 24. UNICEF, World Health Organization and World Bank Group. 2023;32:2.
2. Khara T, Dolan C. The relationship between wasting and stunting, policy, programming and research implications. Emergency Nutrition Network. 2014. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0306374796904674
3. Unicef. Urgent action needed as acute malnutrition threatens the lives of millions of vulnerable children. 2023.
4. Kismul H, Acharya P, Mapatano MA, Hatløy A. Determinants of childhood stunting in the Democratic Republic of congo: further analysis of demographic and health survey 2013-14. BMC Public Health. 2017;18(1):1–14.
5. UN Office for the Coordination of Humanitarian Affairs. Plan Opérationnel 2020 - Région Kasaï, Kwango et Kwilu (Deuxième semestre 2020) [Operational Plan 2020 - Kasai region, Kwango and Kwilu (2nd semester 2020)]. 2020.
6. World Food Programme. Evaluation approfondie de la sécurité alimentaire en situation d'urgence dans les provinces du Kasaï, Kasaï central, Kasaï oriental, Lomami et du Sankuru, RDC [Assessment of food security in an emergency context]. Available from: https://www.wfp.org/publications/republique-democratique-congo-evaluation-approfondie-securite-alimentaire-urgence-octobre-2017
7. Ngonde R, Vangu D, Milandu M, Aguba T, Lero P, Busambo P, Analyse. IPC de l'insécurité alimentaire aiguë en RDC - Juillet 2019 - Mai 2020 (17e cycle) [IPC analysis of acute food insecurity in DRC - July 2019-May 2020 (17th cycle)]. 2020.
8. PRONANUT (RDC). INS, SNSA. Bulletin n°39 du SNSAP (Surveillance Nutritionnelle, Sécurité Alimentaire et Alerte Précoce) [39th Bulleting of SNSAP (Nutritional Surveillance, Food security and Early Warning)]. 2020.
9. Cazes C, Phelan K, Hubert V, Boubacar H, Bozama LI, Sakubu GT, et al. Simplifying and optimising the management of uncomplicated acute malnutrition in children aged 6–59 months in the Democratic Republic of the congo (OptiMA-DRC): a non-inferiority, randomised controlled trial. Lancet Glob Health. 2022;10(4):e510–20.
10. Action against Hunger. Résumé enquête SMART des AS affectés par la crise humanitaire ZS Kalonda Ouest et, Kamuesha. RDC 25 Février au 13 mars 2017 [Summary of the SMART survey conducted in the health zones of Kalonda Ouest and Kamwesha, DRC Feb 23rd to March 15th 2017]. 2017.
11. Cazes C, Phelan K, Hubert V, Boubacar H, Bozama LI, Sakubu GT, et al. Optimising the dosage of ready-to-use therapeutic food in children with uncomplicated severe acute malnutrition in the Democratic Republic of the congo: a non-inferiority, randomised controlled trial. EClinicalMedicine. 2023;58:101878.
12. Cazes C, Phelan K, Hubert V, Alitanou R, Boubacar H, Izie Bozama L, et al. Simplifying and optimising management of acute malnutrition in children aged 6 to 59 months: study protocol for a community-based individually randomised controlled trial in Kasaï, Democratic Republic of congo. BMJ Open. 2020;10(12):e041213.
13. Rosner B. Fundamentals of biostatistics, eighth edition. Cengage Learning 2013.
14. Kirkwood BR, Sterne JAC. Essential Medical Statistics. Medical statistics. 2003.
15. Hartung C, Lerer A, Anokwa Y, Tseng C, Brunette W, Borriello G. Open data kit. In: Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development. New York, NY, USA: ACM 2010;1–12.
16. Democratic Republic of Congo Nutrition Programme. Protocole national de prise en charge intégrée de la malnutrition aiguë de la RDC (DRC Integrated Management of Acute Malnutrition). 2016.
17. Coates J, Bilinsky P, Coates J. Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide Version 3. 2007.
18. Ballard T, Coates J, Swindale A, Deitchler M. Household Hunger Scale: Indicator Definition and Measurement Guide. 2011.
19. Hjelm L, Mathiassen A, Miller D, Wadhwa A. Creation of a Wealth Index. 2017.
20. FAO, Minimum Dietary. 2021;1–176. Available from: https://doi.org/10.4060/cb3434en
21. WHO & Unicef. Indicators for assessing infant and young child feeding practices. 2008.
22. Dirk S. WHO anthro package for R. 2020. Available from: https://cran.r-project.org/web/packages/anthro/index.html
23. Blössner M, Borghi E, de Onis M, Onyango A, Siyam A, Yang H. WHO Anthro 2005 for Personal Computers. 2005;56. Available from: http://www.who.int/entity/childgrowth/software/anthro_pc_manual_v322.pdf
24. Team RC. R: A language and environment for statistical computing. MSOR connections. 2014;1. Available from: https://api.semanticscholar.org/CorpusID:215755663
25. Akombi BJ, Agho KE, Hall JJ, Wali N, Renzaho AMN, Merom D. Stunting, wasting and underweight in Sub-Saharan Africa: A systematic review. Int J Environ Res Public Health. 2017;14(8):1–18.
26. Mukalay AWM, Kalenga PMK, Dramaix M, Hennart P, Schirvel C, Kabamba LM, et al. Factors associated with malnutrition in children aged under five years in Lubumbashi (DRC). Sante Publique (Paris). 2010;22(5):541–50.
27. Mukuku O, Mutombo AM, Kamona LK, Lubala TK, Mawaw PM, Aloni MN et al. Predictive Model for the Risk of Severe Acute Malnutrition in Children. J Nutr Metab. 2019 [cited 2019 Oct 27];2019. Available from: https://doi.org/10.1155/2019/4740825
28. Maitra C. A review of studies examining the link between food insecurity and malnutrition. 2018;70. Available from: http://www.fao.org/3/CA1447EN/ca1447en.pdf
29. Kismul H, Hatløy A, Andersen P, Mapatano M, Van Den Broeck J, Moland KM. The social context of severe child malnutrition: A qualitative household case study from a rural area of the Democratic Republic of congo. Int J Equity Health. 2015;14(1):1–14.
30. Ali D, Saha KK, Nguyen PH, Diressie MT, Ruel MT, Menon P, et al. Household food insecurity is associated with higher child undernutrition in Bangladesh, Ethiopia, and Vietnam, but the effect is not mediated by child dietary diversity. J Nutr. 2013;143(12):2015–21.
31. Motbainor A, Worku A, Kumie A. Stunting is associated with food diversity while wasting with food insecurity among underfive children in East and West Gojjam zones of Amhara region, Ethiopia. PLoS ONE. 2015;10(8):1–14.
32. Dodos J, Altare C, Bechir M, Myatt M, Pedro B, Bellet F, et al. Individual and household risk factors of severe acute malnutrition among under-five children in Mao, Chad: A matched case-control study. Archives Public Health. 2018;76(1):1–9.
33. Drammeh W, Hamid NA, Rohana AJ. Determinants of household food insecurity and its association with child malnutrition in Sub-Saharan Africa: A review of the literature. Curr Res Nutr Food Sci. 2019;7(3):610–23.
34. Victora CG, Christian P, Vidaletti LP, Gatica-Domínguez G, Menon P, Black RE. Revisiting maternal and child undernutrition in low-income and middle-income countries: variable progress towards an unfinished agenda. Lancet. 2021;397(10282):1388–99.
35. World Health Organization. WHO guideline on the prevention and management of wasting and nutritional oedema (acute malnutrition) in infants and children under 5 years. Geneva 2023.
36. FEWS NET. Crisis (IPC Phase 3) outcomes in conflict zones during the lean season| FEWS NET. 2024. Acute food insecurity classification - Democratic Republic of the Congo 2024.
37. United Nations Children's Fund. Small Supplements for the Prevention of Malnutrition in Early Childhood (Small Quantity Lipid Nutrient Supplement). Brief Guidance Note. Version 1.0. New York 2023.

Publisher's note