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Spectrum of nutrition-specific and nutrition-sensitive determinants of child undernutrition: a multisectoral cross-sectional study in rural Mozambique

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ABSTRACT

Background Despite an increasing need for multisectoral interventions and coordinations for addressing malnutrition, evidence-based multisectoral nutrition interventions have been rarely developed and implemented in low-income and middle-income countries. To identify key determinants of undernutrition for effectively designing a multisectoral intervention package, a nutrition survey was conducted, by comprehensively covering a variety of variables across sectors, in Niassa province, Mozambique.

Methods A cross-sectional household survey was conducted in Niassa province, August–October 2019. Anthropometric measurements, anaemia tests of children under 5 years of age and structured interviews with their mothers were conducted. A total of 1498 children under 5 years of age participated in the survey. We employed 107 background variables related to possible underlying and immediate causes of undernutrition, to examine their associations with being malnourished. Both bivariate (χ^2 test and Mann-Whitney's U test) and multivariate analyses (logistic regression) were undertaken, to identify the determinants of being malnourished.

Results Prevalence rates of stunting, underweight and wasting were estimated at 46.2%, 20.0% and 7.1%, respectively. Timely introduction of solid, semi-solid or soft foods to children of 6–8 months of age was detected as a determinant of being not stunted. Mother–child cosleeping and ownership of birth certificate were a protective factor from and a promoting factor for being underweight, respectively. Similarly, availability and consumption of eggs at the household level and cough during the last 2 weeks among children were likely to be a protective factor from and a promoting factor for being wasted, respectively.

Conclusion Timely introduction of solid, semi-solid or soft foods could serve as an entry point for the three sectors to start making joint efforts, as it requires the interventions from all health, agriculture and water sectors. To enable us to make meaningful interprovincial, international and inter-seasonal comparisons, it is crucially important to develop a standard set of variables related to being malnourished.

What this paper adds?

- Despite a rapidly increasing need for multisectoral planning and implementations of nutrition-specific and nutrition-sensitive interventions, multisectoral nutrition surveys covering a spectrum of variables across sectors have been rarely conducted globally.
- Timely introduction of solid, semi-solid or soft foods should be a key intervention for childhood stunting in Niassa province, Mozambique, calling for the joint interventions from health, agriculture and water sectors.
- To ensure a better-designed package of evidence-based multisectoral interventions, it is recommended that a multi-stakeholder platform proactively work beyond respective sectoral interests in each country so that the initial step could be a joint multisectoral nutrition survey.

INTRODUCTION

Undernutrition accounts for 35% of total under-five mortalities globally.[1] Thus, malnutrition has been drawing a great deal of attention as a key global development agenda from both developed and developing nations since the launch of the Millennium Development Goals (MDGs) in 2000.[2] Under the Sustainable Development Goals, a greater emphasis continues to be placed on the critical need for addressing malnutrition as an unfinished agenda for the post MDG era.[3] One of the major reasons that malnutrition remains the unfinished agenda was a significant lack of multisectoral and multistakeholder joint efforts when addressing malnutrition.[4] It must be admitted that fragmented efforts previously made by respective sectors (eg, health and agriculture) ended up producing not

only inadequate desirable outcomes but also sometimes even intersectoral confusions and conflicts.[5] Malnutrition is not an independent issue that could be addressed and resolved by a single sector but a multifaceted complex issue that must be addressed and resolved by multiple sectors (eg, health, agriculture, environment, education, manufacturing and trading).[6 7] To encourage and accelerate better integrated or coordinated efforts towards the reduction in prevalence of malnutrition in each country, Scale Up Nutrition (SUN) was launched as a global movement to end malnutrition in 2010. SUN advocates for the importance of and need for multisectoral planning and implementations of necessary interventions, by setting 'multiple stakeholders come together' as step 1.[8]

In Mozambique, where 43%, 15% and 6% of children under 5 years of age suffer from stunting, underweight and wasting, respectively,[9 10] undernutrition has been one of the major public health concerns. The prevalence of stunting, in particular, remains extremely high around 42%–43% during the last 12 years, after its reduction from 60% in 1995 to 43% in 2008.[11] Also, 2%–3% loss of gross national product in Mozambique is estimated to be attributed to chronic undernutrition.[12] Having thoroughly understood the critical need for a multisectoral coordination in addressing high prevalence of malnutrition in the country, the Government of Mozambique (GoM) launched the Technical Secretariat for Food Security and Nutrition (SETSAN), a national multisectoral coordination mechanism for reducing undernutrition as a public health and social problem.[13] Yet, despite a series of efforts made by the SETSAN and its participating partners since 2010, the country's nutritional status has not significantly improved. One of the possible factors to which the inadequate progress in reduction in malnutrition is attributed should be a lack of detailed evidence-based multisectoral programming.

The determinants and underlying causes of malnutrition differ one country to another, and one province to another. Thus, designing a local setting-specific and context-sensitive multisectoral nutrition programme in an evidence-based manner is the key to ensuring more effective and efficient interventions.[6 14] Nevertheless, there have been few earlier studies that systematically address the variables related to both nutrition-specific and nutrition-sensitive interventions[15] and three underlying causes of undernutrition (household food insecurity, inadequate feeding and caring practices and unhealthy household environment)[16] despite its importance and needs.[17 18] While some earlier studies employed exclusively the variables related to feeding and caring practices, or water, sanitation and hygiene,[19–23] others employed exclusively those related to household food security.[24 25] Few employed the variables related to both types of interventions and three types of underlying causes of child undernutrition in a well-balanced manner. The contradiction between an emphasised need for multisectoral interventions and insufficiency of multisectoral nutrition studies is obvious.[17 26]

To design an evidence-based nutrition programme for Niassa province, the least developed province with the highest malnutrition prevalence in the country, the GoM and Japan International Cooperation Agency jointly conducted a multisectoral nutrition survey in the province. All the ministries responsible for addressing the three types of underlying causes of child undernutrition (ie, Ministry of Health, Ministry of Agriculture and Food Security and Ministry of Public Works, Housing and Water Resources) participated in the survey. No comprehensive multisectoral nutrition survey has been previously conducted in Mozambique. Therefore, the results of the survey will serve as the key foundation not only for designing an upcoming evidence-based multisectoral nutrition programme in Niassa province but also for developing the national technical standard and guidelines for multisectoral nutrition survey. This study is aimed at identifying key nutrition-specific and nutrition-sensitive determinants of child undernutrition, by employing a series of variables across three sectors (health, agriculture and water sanitation and hygiene) in Niassa province. Note that this is the first fully comprehensive multisectoral nutrition household survey in Mozambique.

METHODS

Study objectives and study design

A cross-sectional household survey was conducted in two typical rural districts of Niassa province (Majune and Muembe), Mozambique, to estimate prevalence of undernutrition among children under 5 years of age and identify its key determinants in relation to nutrition-specific and nutrition-sensitive interventions across the three sectors (ie, health, agriculture and environment).

Study areas and study group

Majune district is located in the geographic centre of Niassa province and composed of 92 enumeration areas (EAs) for the Census 2017. Muembe district is bordered with Majune district in southeast and composed of 132 EAs. The total populations were estimated at 38 453 and 44 042 in Majune and Muembe, respectively, as of 2017.[27] Ajawa is the major ethnic group in the both districts. The most commonly spoken languages in the districts are Ajawa and Macua. Agriculture accounts for the greatest proportion of local industries in the two districts. The both districts are positioned in the extremely rainy highland (annual precipitation 1171 mm and altitude 1500–1600 m). The targets of the study were children under 5 years of age living in Majune and Muembe districts.

Sample size and sampling methods

Demographic and Health Survey 2011 reported 46.8%, 18.2% and 3.7% as the prevalence of stunting, underweight and wasting among children under 5 years of age in Niassa province, respectively.[11] Assuming no significant change in those prevalence rates since 2011, the sample sizes were calculated for prevalence of the three types of

undernutrition with α (error)=0.05, 1-β (power)=0.80 and d (precision)=0.05, by applying the provincial prevalence as of 2011. This is a reasonable and realistic approach because the aforementioned prevalence rates were the only province-specific ones available and no significant changes were identified at least nationally during the last 12 years.[11] As a result, 783 494 and 148 children under 5 years of age were calculated as the sample sizes required for estimating the prevalence of stunting, underweight and wasting, respectively, in the two districts. Then, of the three sample sizes calculated, the greatest one (=783 for stunting) was selected as the common sample size as it satisfied the sample sizes for underweight and wasting, too. Then, a design effect of 1.8 was multiplied, as two-stage sampling was employed for the survey (ie, 783×1.8=1409). Assuming non-response rate of 7.5%[28] and cases of unknown child age of 2%–3%, 1556 was determined as the final sample size.

Of a total of 224 EAs (=92+132) in the two districts for the Census 2017, 94 EAs are randomly selected. Then, the number of households having children under 5 years of age to be selected in each of 94 EAs was calculated, by applying probability-proportional-to-size. The list of households for the Census 2017 was not readily available for the both districts.[27] Thus, household listing was undertaken in all the 94 selected EAs, to develop the sampling frames from which target households having children under 5 years of age were selected. Then, in proportion to the population size of each selected EA, 7–38 households having children under 5 years of age were randomly selected from the household lists. Two repeated household visits were made, when children under 5 years of age, mothers and other caregivers were either absent or not available upon the initial visits. When a household was totally unavailable despite three visits, a substitute household was adopted by mechanically sampling the next eligible household in the household lists.

By targeting those randomly selected households, anthropometric measurements and anaemia tests of children under 5 years of age and structured interviews with their mothers or other caregivers were conducted during the period from 21 August 2019 to 4 October 2019, the postharvest season in Niassa province.

Anthropometric measurements

Weight measurements were undertaken for the children to the nearest 0.1 kg, using the electronic scale for children and adults (Seca 876, Hamburg, Germany). Their heights were measured to the nearest 0.1 cm, using the stadiometer for children and adults (Seca 213, Hamburg, Germany). Children younger than 2 years of age and unable to stand properly were measured lying down (recumbent length), using the length scale for infants (Seca 416, Hamburg, Germany).

Biochemical tests

Children of 6–59 months of age were tested for anaemia by the certified nurses, using the rapid blood analyzer HemoCue 301 (Quest Diagnostics, Norrköping, Sweden). Table salt available at households was sampled and tested for iodine, by using the field test kit (MBIK001, MBI Kits International, Tamil Nadu, India).

Household interviews and observations

A total of 107 background variables were employed as the potential determinants of undernutrition among children under 5 years of age. These background variables were selected from those representative of nutrition-specific interventions, nutrition-sensitive interventions and enabling environments, which were defined in the framework for actions to achieve optimum fetal and child nutrition and development.[15] Those variables were selected so as to be in line with immediate causes and underlying causes of child undernutrition in the UNICEF's conceptual framework of the determinants of child undernutrition, too.[16]Of the 107 variables, five were derived from immediate causes in the conceptual framework (ie, disease symptoms). Thirty-eight, 28 and 8 were derived from three underlying causes of undernutrition in the conceptual framework (ie, household food insecurity, inadequate feeding and caring practices and unhealthy household environment, respectively). And, the rest (28 variables) were sociodemographic and socioeconomic variables. Moreover, we attempted to ensure that a series of these variables were consistent with the independent variables employed in earlier studies.[26 29–32]

The questions on those background variables were included in the structured questionnaire. Of them, the data on type of and travelling time to drinking water source, type of toilet, presence of soap/ash for handwashing, food storage, utensil maintenance and house building materials were collected through enumerators' direct observations and measurements. The data on other variables were collected through interviews with mothers and caregivers of children under 5 years of age. Of three locally spoken languages (ie, Ajawa, Macua and Portuguise), the most comfortable one for interviewees was selected as the language for an interview.

Data analysis

The data obtained through household interviews, observations, anthropometric measurements, anaemia tests and iodine tests were entered into a microcomputer. By using Anthro,[33] z-scores for height-for-age, weight-for-age and weight-for-height were calculated based on the 2009 WHO standard reference population under 5 years of age.[34] Those having been assumed to be under 5 years of age by parents but later found to be older by referring to the home-based records were excluded from the analysis. Wealth index was calculated for each household, by applying socioeconomic variables to principal component analysis, to categorise all the households into wealth index quintiles.[35] Household Dietary Diversity Score (HDDS) was calculated by summing up the number of 12 food groups available at and consumed by each household during last 24 hours.[36] The values for six standard

indicators for Infant and Young Child Feeding (IYCF) were calculated, by using the IYCF indicator measurement guide.[37]

The statistical analyses were conducted, by using SPSS for Windows, V.22 (IBM/SPSS, Chicago, USA).

Bivariate and multivariate analyses were undertaken to identify the determinants of and risk factors for whether being malnourished (dependent variables). While the dependent variables are dichotomous, the independent variables are composed of interval ratio variables and categorical variables. Therefore, two types of bivariate analyses were employed. First, the associations between 94 categorical variables and whether being malnourished were examined, using χ^2 test (Fisher's exact test). Note that a total of 16 dummy variables were created for the mutually exclusive categorical variables having three or more categories (ie, primary income source, primary birth attendant). The category with the greatest frequency was designated as the reference for the dummy variables. Second, the associations between 13 interval ratio variables and whether being malnourished were examined, using a non-parametric method (Mann-Whitney's U test), as it was expected and actually confirmed in Levene's test that those variables were not normally distributed.

The background variables significantly associated with being malnourished ($p<0.05$ in χ^2/Fisher's exact test or Mann-Whitney's U test) were selected as the possible independent variables for multivariate analyses. Prior to applying them to multivariate analyses, multicollinearity between those possible independent variables was systematically examined. To address possible multicollinearity between two interval ratio variables, those having a variance inflation factor (VIF) smaller than 10 were selected as the independent variables for multivariate analyses. To examine possible multicollinearity between two categorical variables, χ^2 test (Fisher's exact test) was conducted. When a statistical significance ($p<0.05$) was detected between them, one having a smaller p value with the dependent variable in χ^2 test (Fisher's exact test) was selected as an independent variable. Similarly, to examine possible multicollinearity between interval ratio and categorical variables, Mann-Whitney's U test was conducted. When a statistical significance ($p<0.05$) was detected between them, one having a smaller p value with the dependent variables in Mann-Whitney's U test was selected as an independent variable.

Ethical consideration

An informed consent to participate in the study was obtained in a written form from mothers or caregivers of children under 5 years of age. Children found to suffer from anaemia through blood tests were guided to the nearest health facilities for medical consultations and treatment. A small pack of iodised salt (approximately 5 g) was provided to households as a substitute for table salt sampled for iodine test.

RESULTS

Undernutrition prevalence

Of 1556 sampled children, 58 were excluded from data analysis since their ages were either unknown and difficult to estimate, or found to be 5 years of age or older. Thus, the data collected from 1498 (=1556–58) children under 5 years of age, their mothers and other caregivers were analysed. Of the 1498 children under 5 years of age, boys (736; 49.1%) and girls (762; 50.9%) were almost equally represented. While children of 0–11 months of age (0 year old) account for the largest proportion (25.6%), those 48–59 months of age (4 years old) account for the smallest (11.6%). The prevalence rates of stunting, underweight and wasting were 46.2% (95% CI 43.6% to 48.8%), 20.0% (95% CI 18.0% to 22.1%) and 7.1% (95% CI 5.9% to 8.6%), respectively (table 1).[10]

Bivariate analyses

Table 2 shows the results of bivariate analyses between child undernutrition and socioeconomic/demographic status.[15] Tables 3–5 show the results of bivariate analyses[15 37–39] between child undernutrition and variables related to the three types of underlying causes, that are (1) household food insecurity, (2) inappropriate parental feeding and caring practices and (3) unhealthy household environment. In addition, table 6 shows the results of bivariate analyses between child undernutrition and disease symptoms (including anaemia), as the immediate causes.[16] They are also categorised into three types of key interventions: (1) nutrition-specific interventions, (2) nutrition-sensitive interventions and (3) enabling environment in tables 3–6.[15] A total of 107 background variables examined on their bivariate relationships with child undernutrition, seven were significantly associated with whether being stunted ($p<0.05$). Similarly, 5 and 10 background variables were significantly associated with whether being underweight and whether being wasted ($p<0.05$), respectively. Of the seven variables significantly associated with whether being stunted, two were excluded from the independent variables for the logistic regression model for stunting due to their multicollinearity. For the same reason, 3 of 5 and 7 of 10 variables were excluded from the independent variables for the logistic regression models for underweight and for wasting, respectively.

Multivariate analyses

As the results of bivariate analyses and multicollinearity testing, five, two and three background variables were employed as the independent variables for the logistic regression models for stunting, underweight and wasting, respectively. Simultaneous variable entry was applied to logistic regression analyses. Table 7 shows their results. Timely introduction of solid, semi-solid or soft foods to children was the only independent variable whose OR was significant ($p<0.05$) in the logistic regression model for stunting. This implies that introduction of solid, semi-solid or soft foods to children at the age of 6–8 months is likely to have reduced the risk of becoming stunted by

Table 1 Prevalence of undernutrition among children under 5 years of age in comparison with the previous survey

	Stunting: height-for-age			Underweight: weight-for-age			Wasting weight-for-height		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Majune and Muembe district as of 2019									
(+) Severe (z-score <-3)	424	28.3	(26.0 to 30.7%)	135	9	(7.6 to 10.6%)	56	3.6	(3.7 to 4.8%)
(+) Moderate and severe (z-score <-2)	692	46.2	(43.6 to 48.8%)	300	20	(18.0 to 22.1%)	107	7.1	(5.9 to 8.6%)
(-) Non-malnourished (z-score ≥ −2)	806	53.8	(51.2 to 56.4%)	1198	80	(77.9 to 82.0%)	1391	92.9	(91.4 to 94.1%)
Niassa province as of 2011*									
(+) Severe (z-score <−3)	(n.a.)	24	(n.a.)	(n.a.)	5.1	(n.a.)	(n.a.)	1.3	(n.a.)
(+) Moderate and severe (z-score <−2)	(n.a.)	46.8	(n.a.)	(n.a.)	18.2	(n.a.)	(n.a.)	3.7	(n.a.)
(-) Non-malnourished (z-score ≥−2)	(n.a.)	53.2	(n.a.)	(n.a.)	81.8	(n.a.)	(n.a.)	96.3	(n.a.)
Mozambique as of 2011*									
(+) Severe (z-score <-3)	(n.a.)	19.7	(n.a.)	(n.a.)	4.1	(n.a.)	(n.a.)	2.1	(n.a.)
(+) Moderate and severe (z-score <-2)	(n.a.)	42.6	(n.a.)	(n.a.)	14.9	(n.a.)	(n.a.)	5.9	(n.a.)
(-) Non-malnourished (z-score ≥ −2)	(n.a.)	57.4	(n.a.)	(n.a.)	85.1	(n.a.)	(n.a.)	94.1	(n.a.)

*Mozambique Demographic and Health Survey (National Institue of Health 2011).[10]

68.3% (= (1–0.317)×100). In the logistic regression model for underweight, a significant OR (p<0.05) was detected for both two independent variables, that is, mother–child cosleeping and ownership of birth certificate. Mother–child cosleeping is likely to have reduced the risk of becoming underweight by 66.7% (= (1–0.333)×100). Those having birth certificate are 1.656 times more likely to be underweight. Of 113 birth certificate holders, 103 (91.2%) owned it as the only home-based record. A birth certificate does include not the data and information related to maternal and child health but exclusively the name, sex and date of birth of a child and his/her parents' names.[40] Thus, ownership of birth certificate implies either absence or extreme lack of opportunities for parents to practice self-monitoring and self-care of their maternal and child health. Two independent variables whose ORs were significant (p<0.05) were detected in the logistic regression model for wasting (availability and consumption of eggs generally household members and cough during the last 2 weeks). It was found availability and consumption of eggs were protective against becoming wasted, by indicating 91.6% (= (1–0.184)×100) reduction of risk of becoming wasted. Cough during the last 2 weeks was highly associated with being wasted, by producing a greater OR (ie, adjusted OR=1.713).

DISCUSSION

All the three types of undernutrition prevalence rates are at the similar level to both provincial and national prevalence as of 2011 (table 1). This implies that there has been probably neither an improvement nor a worsening in prevalence of all three forms of child undernutrition during 8 years from 2011 to 2019. In particular, very high prevalence of stunting (46.2%) we identified is in line with its Mozambique's national trend that prevalence of stunting stays around 42%–43% during the last 12 years.[11] This should be attributable not only to inadequate multisectoral coordination and fragmented efforts by relevant sectors and stakeholders but also to generally slower progress of reduction in prevalence of stunting than in those of underweight and wasting.[41]

This study identified timely introduction of solid, semi-solid or soft foods to children as the only significant determinant of or risk factors for being stunted (p<0.05) (table 7). Several studies reported that timely introduction of solid, semi-solid or soft foods at the age of 6–8 months provides children with significant protection against becoming stunted.[42–44] Thus, the results of our study are consistent to these earlier studies. Yet, giving solid, semi-solid or soft foods to children 6–8 months of age needs to be supported by mothers' previous exclusive breastfeeding practices at the age of 0–5 months. In other words, giving solid, semi-solid or soft foods not accompanied by previous exclusive breastfeeding may often involve premature introduction of those foods prior to 6 months of age. A multicountry study in Africa reported that infants suffering from diarrhoea and respiratory

Table 2 Bivariate analyses between undernutrition and sociodemographic/economic variables

Background variable	Type of intervention and conditions†			Stunting (N=1498)					Underweight(N=1498)					Wasting (N=1498)				
	Nutrition specific	Nutrition sensitive	Enabling Environment	(+) Stunted		(–) Not stunted			(+) Under weight		(–) Not underweight			(+) Wasted		(–) Not wasted		
				N	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value ‡
Categorical variables																		
Sex																		
Female	–	–	–	332	48	430	53.3	Ref.	147	49	615	51.3	Ref.	46	43	716	51.5	Ref.
v_1: male	–	–	X	360	52	376	46.7	0.038*	153	51	583	48.7	0.478	61	57	675	48.5	0.108
Total				692	100	806	100		300	100	1198	100		107	100	1391	100	
Primary income source																		
Agriculture or crop sales	–	–	–	608	87.9	700	86.8	Ref.	263	87.7	1045	87.2	Ref.	88	82.2	1220	87.7	Ref.
v_2: livestock or animal sales	–	–	X	2	0.3	2	0.2	1	1	0.3	3	0.3	1	0	0	4	0.3	1
v_3: fishing	–	–	X	3	0.4	3	0.4	1	1	0.3	5	0.4	1	1	0.9	5	0.4	0.359
v_4: unskilled wage labour	–	–	X	10	1.4	19	2.4	0.259	3	1	26	2.2	0.244	3	2.8	26	1.9	0.457
v_5: skilled wage labour	–	–	X	15	2.2	13	1.6	0.45	7	2.3	21	1.8	0.479	4	3.7	24	1.7	0.134
v_6: handicrafts, artisanal works	–	–	X	2	0.3	3	0.4	1	2	0.7	3	0.3	0.263	0	0	5	0.4	1
v_7: charcoal production	–	–	X	1	0.1	2	0.2	1	1	0.3	2	0.2	0.489	0	0	3	0.2	1
v_8: seller, trader or commercial business	–	–	X	25	3.6	25	3.1	0.666	8	2.7	42	3.5	0.59	5	4.7	45	3.2	0.398
v_9: salary wage	–	–	X	23	3.3	36	4.5	0.288	13	4.3	46	3.8	0.74	5	4.7	54	3.9	0.607
v_{10}: begging and assistance	–	–	X	0	0	1	0.1	1	0	0	1	0.1	1	0	0	1	0.1	1
v_{11}: pension and government subsidy	–	–	X	3	0.4	2	0.2	0.667	1	0.3	4	0.3	1	1	0.9	4	0.3	0.31
Total				692	100	806	100		300	100	1198	100		107	100	1391	100	
Ownership of properties																		
v_{12}: land for housing, farming or renting	–	–	X	430	62.1	507	62.9	0.789	188	62.7	749	62.5	1	73	68.2	864	62.1	0.216
v_{13}: electricity	–	–	X	109	15.8	139	17.2	0.444	44	14.7	204	17	0.341	19	17.8	229	16.5	0.687
v_{14}: radio	–	–	X	280	40.5	322	40	0.874	115	38.3	487	40.7	0.47	40	37.4	562	40.4	0.609
v_{15}: television set	–	–	X	66	9.5	94	11.7	0.208	32	10.7	128	10.7	1	15	14	145	10.4	0.255
v_{16}: mobile phone	–	–	X	290	41.9	368	45.7	0.159	118	39.3	540	45.1	0.079	45	42.1	613	44.1	0.761
v_{17}: refrigerator	–	X	X	7	1	19	2.4	0.049‡	3	1	23	1.9	0.334	6	5.6	20	1.4	0.008**
v_{18}: generator	–	–	X	4	0.6	12	1.5	0.129	1	0.3	15	1.3	0.22	2	1.9	14	1	0.319
v_{19}: air conditioner	–	–	X	4	0.6	3	0.4	0.71	1	0.3	6	0.5	1	1	0.9	6	0.4	0.405
v_{20}: house ownership	–	–	X	604	87.3	687	85.2	0.261	258	86	1033	86.2	0.926	93	86.9	1198	86.1	1
v_{21}: personal computer	–	–	X	4	0.6	8	1	0.403	2	0.7	10	0.8	1	0	0	12	0.9	1
v_{22}: bicycle	–	–	X	318	46	350	43.4	0.348	139	46.3	529	44.2	0.516	40	37.4	628	45.1	0.13
v_{23}: motorbike	–	–	X	119	17.2	149	18.5	0.543	50	16.7	218	18.2	0.557	19	17.8	249	17.9	1

Continued

Table 2 Continued

Background variable	Type of intervention and conditions†			Stunting (N=1498)					Underweight(N=1498)				Wasting (N=1498)				
	Nutrition specific	Nutrition sensitive	Enabling Environment	(+) Stunted		(–) Not stunted			(+) Under weight		(–) Not underweight			(+) Wasted		(–) Not wasted	
				N	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value ‡
v_{24}: vehicle (car, truck and tractor)	–	–	X	10	1.4	11	1.4	1	2	0.7	19	1.6	0.284	0	0	21	1.5	0.394
				Mean	SD	Mean	SD	P value§	Mean	SD	Mean	SD	P value§	Mean	SD	Mean	SD	P value§
Interval and ratio variables																		
v_{25}: age (year)	–	–	X	2.7	1.29	1.6	1.11	<0.001**	3	1.3	1.9	1.23	<0.001**	2	1.42	2.1	1.33	0.274
v_{26}: birth order in sibling (Nth child)	–	–	X	3	2.23	3.1	2.11	0.207	2.8	2.1	3.1	2.18	0.093	3.2	2.17	3	2.16	0.195
v_{27}: total number of household members (person)	–	–	X	5.7	2.74	5.7	2.35	0.556	5.7	2.41	5.7	2.57	0.67	6.1	2.46	5.7	2.54	0.064
v_{28}: wealth quintile (Nth quintile)	–	–	X	3	1.38	3.1	1.43	0.182	3	1.38	3	1.41	0.724	3.2	1.47	3	1.4	0.207

*p<0.05, **p<0.01.Categorisation based on the previous review (Black *et al*. 2013).[15]
†Categorisation based on the previous review (Black *et al*. 2013).
‡χ^2 test (Fisher's exact test)
§Mann-Whitney U test.

infections were significantly likely to be introduced solid, semi-solid or soft foods prematurely between the age of 3 and 5 months.[45] As stunting, diarrhoea and respiratory infections are mutually attributable,[46 47] the importance of timely introduction of solid, semi-solid or soft foods at the appropriate age must be rehighlighted. This is also because timely introduction of solid, semi-solid or soft foods plays a key role in smoothly responding to an additional energy requirement derived from the increase in child's activities during 6–8 months of age. In our study, of 97 children 6–8 months of age given solid, semi-solid or soft foods, 79 (81.4%) used to be exclusively breastfed during 0–5 months of age (p<0.05 in χ^2/Fisher's exact test). Thus, a majority of mothers and other caregivers giving solid, semi-solid or soft foods to their children of 6–8 months of age in Majune and Muembe districts have been continuously practising appropriate infant feeding since their childrens' births.

Mother–child cosleeping serves not just as the general proxy for desirable caring attitude, but rather as a reliable channel that ensures breastfeeding timely and frequently enough during night time and nap time. Several earlier studies indicated that mothers' physical contacts through cosleeping with their children predict feeding in response to early hunger cues.[48–50] Mother–child cosleeping, however, may increase the risks of Sudden Unexpected Death in Infancy (SUDI), through regulating infant's breathing by the rocking movement of the mother's chest while breathing.[51] Thus, while mother–child cosleeping is generally recommended not only for ensuring timely and adequate breastfeeding but also for facilitating physiological, cognitive and socioemotional development of children, efforts to minimise the risks of SUDI should be carefully made. A typical example of those efforts is to avoid cosleeping on sofa or couch which increases the likelihood of child's breathing regulation.[52] The enumerators employed for this survey rarely observed sofa and couch during household visits. Thus, the risks of SUDI to be derived from mother–infant cosleeping in the two districts should be quite limited.

The ownership of a birth certificate largely implies non-ownership of health-related home-based record (eg, child vaccination, maternal health card, child health card, maternal and child health card). Those having their children's birth certificates might think it is unnecessary to have health-related home-based records, assuming as if a birth certificate sufficed all requirements as an all-round home-based record unique to their children (eg, eligibility for school enrollment). Of 1498 children under 5 years of age, 341 (22.8%) did not have health-related home-based records (ie, either only birth certificate or no home-based record). In view of the WHO's recommendation of health-related home-based records as an effective tool for maternal and child health,[53] the recent commitment of the Mozambican Ministry of Health to developing a nationally standardised home-based record for maternal and child health is highly valued.

Table 3 Bivariate analyses between undernutrition and food security variables

Background variable	Type of intervention and conditions†			Stunting (N=1498)					Underweight (N=1498)					Wasting (N=1498)				
	Nutrition specific	Nutrition sensitive	Enabling environment	(+) Stunted		(–) Not stunted			(+) Under weight		(–) Not underweight			(+) Wasted		(-) Not wasted		
				N	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡
Categorical variables																		
Food availability and consumption																		
v_{29}: cereal	–	X	–	685	99	779	99.1	0.794	298	99.3	1186	99	0.749	107	100	1377	99	0.617
v_{30}: white roots and tubers	–	X	–	362	52.3	392	48.6	0.162	152	50.7	602	50.3	0.949	51	47.7	703	50.5	0.616
v_{31}: vegetables (vitamin A rich, leafy, and others)	–	X	–	570	82.4	670	83.1	0.732	251	83.7	989	82.6	0.732	94	87.9	1146	82.4	0.183
v_{32}: fruits (vitamin A rich and others)	–	X	–	84	12.1	71	8.8	0.041*	35	11.7	120	10	0.398	8	7.5	147	10.6	0.409
v_{33}: meats (organ and flesh)	–	X	–	82	11.8	111	13.8	0.28	32	10.7	161	13.4	0.212	16	15.9	177	12.7	0.548
v_{34}: eggs	–	X	–	75	10.8	82	10.2	0.674	28	9.3	129	10.8	0.528	4	3.7	153	11	0.014*
v_{35}: fish and seafood	–	X	–	265	38.3	285	35.4	0.259	121	40.3	429	35.8	0.16	34	31.8	516	37.1	0.299
v_{36}: legumes, nuts and seeds	–	X	–	389	56.2	409	50.7	0.038*	172	57.3	626	52.3	0.121	46	43	752	54.1	0.034*
v_{37}: milk and milk products	–	X	–	24	3.5	30	3.7	0.89	11	3.7	43	3.6	1	4	3.7	50	3.6	0.791
v_{38}: oils and fats	–	X	–	270	39	324	40.2	0.672	116	38.7	478	39.9	0.742	39	36.4	555	39.9	0.539
v_{39}: sweets	–	X	–	135	19.5	160	19.9	0.896	56	18.7	239	19.9	0.685	13	12.1	282	20.3	0.043*
v_{40}: spices, condiments and beverages	–	X	–	146	21.1	161	20	0.608	59	19.7	248	20.7	0.749	18	16.8	289	20.8	0.385
Self-production of crops																		
v_{41}: maize	–	X	–	636	98.5	726	98.5	1	278	98.9	1084	98.4	0.784	94	96.9	1268	98.6	0.178
v_{42}: rice	–	X	–	166	25.7	207	28.1	0.332	74	26.3	299	27.1	0.822	30	27	343	26.7	0.406
v_{43}: sorghum	–	X	–	135	20.9	146	19.8	0.639	68	24.2	213	19.3	0.081	25	25.8	256	19.9	0.19
v_{44}: cassava	–	X	–	271	42	287	38.9	0.272	119	42.3	439	39.8	0.454	33	34	525	40.8	0.199
v_{45}: wheat	–	X	–	1	0.2	3	0.4	0.628	0	0	4	0.4	0.588	0	0	4	0.3	1
v_{46}: yams	–	X	–	143	22.1	151	20.5	0.469	53	18.9	241	21.9	0.289	15	15.5	279	21.7	0.159
v_{47}: pumpkin	–	X	–	266	41.2	282	38.3	0.271	120	42.7	428	38.8	0.246	35	36.1	513	39.9	0.519
v_{48}: spinach and other green leafy vegetables	–	X	–	61	9.4	63	8.5	0.573	30	10.7	94	8.5	0.292	11	11.3	113	8.8	0.36
v_{49}: vitamin A rich fruits (mango, apricot, papaya and peach)	–	X	–	45	7	51	6.9	1	19	6.8	77	7	1	11	11.3	85	6.6	0.094
v_{50}: banana	–	X	–	14	2.2	20	1.7	0.603	5	1.8	29	2.6	0.52	2	2.1	32	2.5	1
v_{51}: other fruits (orange, water melon and melon)	–	X	–	12	1.9	16	2.2	0.707	7	2.5	21	1.9	0.484	3	3.1	25	1.9	0.441
v_{52}: pea and beans	–	X	–	354	54.8	382	51.8	0.28	160	56.9	576	52.3	0.18	55	56.7	881	53	0.527
v_{53}: nuts and other legumes		X		169	26.2	183	24.8	0.578	71	25.3	281	25.5	1	26	26.8	326	25.3	0.719
Ownership of agricultural assets																		
v_{54}: farmland	–	X	–	641	92.6	727	90.2	0.098	280	93.3	1088	90.8	0.206	96	89.7	1272	91.4	0.48
v_{55}: home garden	–	X	–	8	1.2	9	1.1	1	5	1.7	12	1	0.358	3	1.7	14	1	0.116
v_{56}: milk cow, cattle and bull	–	X	–	4	0.6	1	0.1	0.188	2	0.7	3	0.3	0.263	1	0.9	4	0.3	0.31

Continued

Table 3 Continued

Background variable	Type of intervention and conditions†			Stunting (N=1498)					Underweight (N=1498)					Wasting (N=1498)				
	Nutrition specific	Nutrition sensitive	Enabling environment	(+) Stunted		(–) Not stunted			(+) Under weight		(–) Not underweight			(+) Wasted		(-) Not wasted		
				N	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡
v_{57}: horse, donkey and mule	–	X	–	0	0	1	0.1	1	0	0	1	0.1	1	0	0	1	0.1	1
v_{58}: goat	–	X	–	20	2.9	26	3.2	0.765	13	4.3	33	2.8	0.188	3	2.8	43	3.1	1
v_{59}: chicken and other poultry	–	X	–	226	32.7	247	30.6	0.404	107	35.7	366	30.6	0.096	36	33.6	437	31.4	0.666
				Mean	SD	Mean	SD	P value§	Mean	SD	Mean	SD	P value§	Mean	SD	Mean	SD	P value§
Interval and ratio variables																		
v_{60}: number of months without maize during last 12 months (mo)	X	–	–	0.6	1.73	0.7	1.93	0.147	0.6	1.77	0.6	1.86	0.483	0.8	1.92	0.6	1.84	0.361
v_{61}: number of months without cassava during last 12 months (mo)	X	–	–	2.9	4.19	2.7	4.18	0.268	3.2	4.4	2.7	4.1	0.093	3.4	4.51	2.7	4.15	0.262
v_{62}: number of months without rice during last 12 months (mo)	X	–	–	2.9	4.42	3	4.39	0.464	3	4.5	2.9	4.4	0.958	3.4	4.63	2.9	4.38	0.241
v_{63}: household dietary diversity score (pt) [c]	X	–	–	4.5	2.01	4.3	2.1	0.069	4.4	1.97	4.4	2.08	0.312	4.1	1.97	4.4	2.06	0.06
v_{64}: total number of meals yesterday (meal)	X	–	–	2.7	0.53	2.7	0.5	0.873	2.7	0.48	2.7	0.52	0.353	2.7	0.5	2.7	0.51	0.806
v_{65}: farmland size (ha)	X	–	–	288	1010	352	1067	0.463	379	1352	308	949	0.939	522	1722	307	969	0.145
v_{66}: home-garden size(m^2)	X	–	–	205	363	130	162	0.306	121	212	184	295	0.364	200	259	158	279	0.407

*p<0.05, **p<0.01.
†Categorisation based on the previous review (Black *et al*. 2013).[15]
‡χ^2 test (Fisher's exact test)
§Mann-Whitney U test.

Table 4 Bivariate analyses between undernutrition and feeding/caring practice variables

Background variable	Type of intervention and conditions†			Stunting (N=1498)					Underweight(N=1498)					Wasting (N=1498)				
	Nutrition specific	Nutrition sensitive	Enabling environment	(+) Stunted		(–) Not stunted			(+) Under weight		(–) Not underweight			(+) Wasted		(–) Not wasted		
				N	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡
Categorical variables																		
Food preparation process																		
v_{67}: rinse vegetable and fruit with safe water	–	X	–	548	79.2	655	81.3	0.329	248	82.7	955	79.7	0.291	89	83.2	1114	80.1	0.528
: Cook meat thoroughly till meat juice is clear	–	X	–	409	59.1	483	59.9	0.752	181	60.3	711	59.3	0.793	75	70.1	817	58.7	0.024*
v_{69}: store leftovers in cool places§	–	X	–	127	18.4	144	17.9	0.84	51	18.8	220	18.4	0.616	17	15.9	254	18.3	0.604
v_{70}: store staple food in container(s) with cover¶	–	X	–	192	27.7	253	31.4	0.126	84	28	361	30.1	0.481	35	32.7	410	29.5	0.51
v_{71}: store utensils in cabinet after cleaning	–	X	–	95	13.7	107	13.3	0.82	48	16	154	12.9	0.157	23	21.5	1391	92.9	0.018*
v_{72}: iodised table salt	X	–		531	76.7	618	76.7	1	218	72.7	931	77.7	0.067	75	70.1	1074	77.2	0.059
Food preparation conditions																		
v_{73}: clean cooking fuel††	–	X	–	0	0	2	0.2	0.503	0	0	2	0.2	1	0	0	2	0.1	1
v_{74}: indoor cooking facility‡‡	–	X	–	368	53.2	485	60.2	0.07	161	53.7	692	57.8	0.216	68	63.6	785	56.4	0.158
Infant and young child feeding																		
v_{75}: breastfed in 1 hour after birth (n=754)§§	X	–	–	223	96.1	490	93.9	0.228	69	93.2	644	94.7	0.587	53	91.4	660	94.8	0.234
v_{76}: exclusively breastfed (n=156)¶¶	X	–	–	22	73.3	95	75.4	0.817	6	66.7	111	75.5	0.692	10	66.7	107	75.9	0.53
v_{77}: continued breastfeeding at 1 year (n=104)***	X	–	–	35	94.6	54	80.6	0.078	14	100	75	83.3	0.212	7	87.5	82	85.4	1
v_{78}: introduction of solid, semi-solid and/or soft foods (n=132)†††	X	–	–	13	54.2	84	77.8	0.023*	4	50	93	75	0.207	5	50	92	75.4	0.129
v_{79}: at least four of seven food groups consumed (n=605)‡‡‡	X	–	–	18	8.9	27	6.7	0.329	6	9.2	39	7.2	0.614	2	4.5	43	7.7	0.763
v_{80}: minimum meal frequency (n=605)§§§	X	–	–	34	16.8	68	16.9	1	9	13.8	93	17.2	0.6	9	20.5	93	16.6	0.53
Pre- and post-birth care																		
v_{81}:≥4 antenatal care visits	–	X	–	314	45.4	345	42.8	0.322	50	46.7	609	43.8	0.614	189	27.3	236	29.3	0.421
v_{82}: facility-based delivery	–	X	–	345	49.9	421	52.2	0.378	155	51.7	611	51	0.947	53	49.5	713	51.3	0.764
v_{83}: low birth weight (<2500 gram at birth)	X	–	–	89	12.9	99	11	0.262	45	15	132	11.1	0.072	18	16.8	159	11.5	0.119
v_{84}: mother–child cosleeping	X	X	–	636	91.9	777	96.4	<0.001**	265	88.3	1148	95.8	<0.001**	87	90.7	1316	94.6	0.123
Primary attendant for the child's birth																		
Skilled birth attendant (physician, nurse and midwife)	–	–	–	596	86.1	703	87.2	Ref.	254	84.7	1045	87.2	Ref.	95	88.8	1204	86.6	Ref.

Continued

Table 4 Continued

Background variable	Type of intervention and conditions†			Stunting (N=1498)					Underweight(N=1498)					Wasting (N=1498)				
	Nutrition specific	Nutrition sensitive	Enabling environment	(+) Stunted		(–) Not stunted			(+) Under weight		(–) Not underweight			(+) Wasted		(–) Not wasted		
				N	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡	n	(%)	n	(%)	P value‡
v_{85}: traditional birth attendant	–	X	–	33	5.1	35	4.7	0.709	12	4.4	56	5	0.875	1	1	67	5.2	0.084
v_{86}: no health worker attended	–	X	–	12	1.9	13	1.7	0.843	5	1.8	20	1.8	1	278	40.2	163	20.2	<0.001**
v_{87}: Do not know do not remember	–	X	–	51	7.4	55	6.8	0.687	29	9.7	77	6.4	0.059	9	8.4	97	7	0.556
Total				692	100	806	100	0.687	300	100	1198	100		107	100	1391	100	
Ownership of home-based records																		
v_{88}: child vaccination card/ handbook	X	–	–	368	53.2	436	54.1	0.755	139	46.3	665	55.5	0.005*	42	39.3	762	54.8	0.002*
v_{89}: maternal health card/ handbook	X	–	–	72	10.4	85	10.5	1	36	12	121	10.1	0.343	14	13.1	143	10.3	0.33
v_{90}:child health card/handbook	X	–	–	125	18.1	127	15.8	0.24	60	20	192	16	0.102	14	2	15	1.9	0.346
v_{91}: maternal and child health card/handbook	X	–	–	14	2	15	1.9	0.853	8	2.7	21	1.8	0.346	3	2.8	26	1.9	0.457
v_{92}: birth certificate	X	–	–	51	7.4	53	6.6	0.61	30	10	74	6.2	0.030*	13	12.1	91	6.5	0.045*
v_{93}: any home-based record(s)	X	–	–	581	84	679	84.2	0.887	247	82.3	1013	84.6	0.377	88	82.2	1172	84.3	0.583
				Mean	SD	Mean	SD	P value¶¶¶	Mean	SD	Mean	SD	P value¶¶¶	Mean	SD	Mean	SD	P value¶¶¶
Interval and ratio variables																		
v_{94}: mother's current height (cm)	X	–	–	153.7	7.02	154.2	7.5	0.020*	153.7	6.66	154.1	7.43	0.117	154.3	6.3	154	7.35	0.676

*p<0.05,
†Categorisation based on the previous review (Black *et al*. 2013).[15]
‡χ^2 test (Fisher's exact test)
§Cool places include: (i) refrigerator and (ii) under shadow.
¶Materials of containers include: (i) plastic and (ii) metal.
**p<0.01.
††Clean cooking fuel includes: (i) electricity; (ii) gas; and (iii) solar energy (WHO 2016).[38]
‡‡Indoor cooking facility includes: (i) kitchen in a house and (ii) kitchen in a separate building. (Malla and Timilsina).[39]
§§Applicable only for children 0–24 months of age (n=754) (WHO 2010).[37]
¶¶Applicable only for children 0–5 months of age (n=156) (WHO 2010).[37]
***Applicable only for children 12–15 months of age (n=104) (WHO 2010).[37]
†††Applicable only for children 6–8 months of age (n=132) (WHO 2010).[37]
‡‡‡Seven food groups are composed of: (i) grains/roots/tubers; (ii) legumes/nuts; (iii) milk products; (iv) flesh foods; (v) eggs; and (vi) other fruits and vegetables. Applicable only for children 6–23 months of age (n=605) (WHO 2010).[37]
§§§Minimum meal frequency is defined as: (i) 2 (meal/day) for breastfed children 6–8 months of age; (ii) 3 (meal/day) for breastfed children 9–23 months of age; and (iii) 4 (meal/day) for non-breastfed children 6–23 months of age. Applicable only for children 6–23 months of age (n=605) (WHO 2010).[37]
¶¶¶Mann-Whitney U test.

Table 5 Bivariate analyses between undernutrition and household environment variables

Background variable	Type of intervention and conditions†			Stunting (N=1498)					Underweight(N=1498)					Wasting (N=1498)				
	Nutrition specific	Nutrition sensitive	Enabling environment	(+) Stunted		(–) Not stunted			(+) Under-weight		(–) Not underweight			(+) Wasted		(–) Not wasted		
				N	(%)	n	(%)	P value ‡	n	(%)	n	(%)	P value ‡	n	(%)	n	(%)	P value‡
Categorical variables																		
Type of water source for drinking and cooking																		
Not improved type of source of water§	–	–	–	264	38.2	307	38.1	Ref.	108	36	463	38.6	Ref.	38	35.5	533	38.3	Ref.
v_{95}: improved type of source of water¶	–	X	–	428	61.8	499	61.9	1	192	64	735	61.4	0.425	69	64.5	858	61.7	0.606
Total				692	100	806	100		300	100	1198	100		107	100	1391	100	
Availability of water at water source																		
On and off††	–	–	–	119	17.2	166	20.6	Ref.	51	17	234	19.5	Ref.	14	13.1	271	19.5	Ref.
v_{96}: 24 hours a day ‡‡	–	X	–	573	82.8	640	79.4	0.099	249	83	964	80.5	0.366	93	86.9	1120	80.5	0.124
Total				692	100	806	100		300	100	1198	100		107	100	1391	100	
Type of sanitation facility and excreta disposal																		
Not improved type of sanitation facility §§	–	–		638	92.2	752	93.3	Ref.	269	89.7	1121	93.6	Ref.	100	93.5	1290	92.7	Ref.
v_{97}: improved type of sanitation facility ¶¶	–	X	–	54	7.8	54	6.7	0.424	31	10.3	77	6.4	0.024*	7	6.5	101	7.3	1
Total				692	100	806	100		300	100	1198	100		107	100	1391	100	
Domestic water treatment																		
Inappropriate or no water treatment	–	–	–	528	76.3	589	73.1	Ref.	226	75.3	891	74.4	Ref.	78	72.9	1039	74.7	Ref.
v_{98}: appropriate water treatment	–	X	–	164	23.7	217	26.9	0.171	74	24.7	307	25.6	0.767	29	27.1	352	25.3	0.73
Total				692	100	806	100		300	100	1198	100		107	100	1391	100	
Hand washing practices																		
v_{99}: wash hand with soap or ash after toilet	–	X	–	269	38.9	327	40.6	0.525	117	39	479	40	0.792	42	39.3	554	39.8	1

Continued

Table 5 Continued

Background variable	Type of intervention and conditions†			Stunting (N=1498)					Underweight(N=1498)					Wasting (N=1498)				
	Nutrition specific	Nutrition sensitive	Enabling environment	(+) Stunted		(–) Not stunted			(+) Under-weight		(–) Not underweight			(+) Wasted		(–) Not wasted		
				N	(%)	n	(%)	P value ‡	n	(%)	n	(%)	P value ‡	n	(%)	n	(%)	P value‡
v_{100}: wash hand with soap or ash before cooking	–	X	–	263	38	315	39.1	0.709	114	38	464	38.7	0.842	41	38.3	537	38.6	1
v_{101}: wash hand with soap or ash before eating	–	X	–	249	36	304	37.7	0.519	115	38.3	438	36.6	0.593	40	37.4	513	36.9	0.918
				Mean	SD	Mean	SD	P value ***	Mean	SD	Mean	SD	P value***	Mean	SD	Mean	SD	P value***
Interval and ratio variables																		
v_{102}: total time for water collection (min) †††	–	X	–	57.6	58.7	54.4	60.2	0.096	55	58.5	56	59.8	0.638	67.9	73.8	55	58.3	0.277

*p<0.05, **p<0.01.
†Categorisation based on the previous review (Black *et al*. 2013).[15]
‡χ^2 test (Fisher's exact test)
§Types of not improved source of water include: (i) unprotected well; (ii) unprotected spring; (iii) surface water (eg, river, lake and reservoir); (iv) vendor-provided water (eg, truck and cart); and (v) bottled water.
¶Types of improved source of water include: (i) piped private household connection indoor/in yard; (ii) public standpipe; (iii) protected well (protected hand-dug well); (iv) protected spring; and (v) rain water collection.
**p<0.01.
††For instance, water is available only when public water attendant is on duty.
‡‡Includes 37 cases of 'Do not know/do not remember'.
§§Types of not improved sanitation facilities include: (i) flush toilet not connected to sewerage system; (ii) latrine without slab; (iii) joint installation with other households; and (vi) outdoor defecation.
¶¶Types of improved sanitation facilities include: (i) flush toilet connected to sewerage system/septic tank; (ii) ventilated latrine/pit; (iii) toilet connected to pit/latrines with slab; and (iv) other non-sewered sanitation systems.
***Mann-Whitney U test.
†††The number of minutes spent reaching a water source and waiting there was measured by making enumerators physically walk.

Table 6 Bivariate analyses between undernutrition and disease symptoms (including micronutrient deficiency)

	Type of intervention and conditions†			Stunting (N=1498)					Underweight (N=1498)					Wasting (N=1498)				
				(+) Stunted		(–) Not stuntd			(+) Under weight		(–) Not underweight			(+) Wasted		(–) Not wasted		
Background variable	Nutrition specific	Nutrition sensitive	Enabling environment	N	(%)	n	(%)	P value ‡§	n	(%)	n	(%)	P value ‡	n	(%)	n	(%)	P value‡
Categorical variables																		
Low birth weight																		
(–) Not low birth weight:≥2500 [g)	–	–	–	601	67.1	714	89	Ref.	255	85	1060	88.9	Ref.	89	83.2	1226	88.5	Ref.
v_{103}: (+) Low birth weight:<2500 (g)	X	–	–	89	12.9	88	11	0.262	45	15	132	11.1	0.072	18	16.8	159	11.5	0.119
Total				660	100	773	100		283	100	1150	100		105	100	1328	100	
Anaemia§																		
(-) Without anaemia: haemoglobin concentration ≥110 (g/L)	–	–	–	291	45.5	309	49.9	Ref.	125	44.8	475	48.5	Ref.	39	44.8	561	47.9	Ref.
v_{104}: (+) With anaemia: haemoglobin concentration <110 (g/L)	X	–	–	348	54.5	310	50.1	0.128	154	55.2	504	51.5	0.278	48	55.2	610	52.1	0.657
Total				660	100	773	100		283	100	1150	100		105	100	1328	100	
Diarrhoea during the last 2 weeks																		
(–) Without diarrhoea	–	–	–	463	70.2	528	68.3	Ref.	200	70.7	791	68.8	Ref.	67	63.8	924	69.6	Ref.
v_{105}: (+) With diarrhoea	X	–	–	197	29.8	245	31.7	0.456	83	29.3	359	31.2	0.566	38	36.2	404	30.4	0.228
Total				660	100	773	100		283	100	1150	100		105	100	1328	100	
Cough during the last 2 weeks																		
(-) Without cough	–	–	–	386	58	436	55.8	Ref.	155	53.6	667	57.6	Ref.	48	45.3	774	57.8	Ref.
v_{106}: (+) with cough	X	–	–	279	42	345	44.2	0.424	134	46.4	490	42.4	0.232	58	54.7	566	42.2	0.014*
Total				665	100	781	100		289	100	1157	100		106	100	1340	100	
Fever during the last 2 weeks																		
(–) Without cough	–	–	–	386	58	436	55.8	Ref.	155	53.6	667	57.6	Ref.	48	45.3	774	57.8	Ref.
v_{107}: (+) with fever	X	–	–	270	40.7	393	59.3	0.065	116	40.6	435	37.6	0.377	45	42.5	506	37.8	0.351
Total				663	100	781	100		286	100	1158	100		106	100	1338	100	

*Categorisation based on the previous review (Black *et al*. 2013).[15]
†χ^2 test (Fisher's exact test)
‡A total of 1258 children were tested for anaemia as a result of exclusion of 240 children (=138 children under 6 months of age+102 children having rejected blood sampling).
§p<0.05, **p<0.01.

Table 7 Logistic regressions on being malnourished with background variables

Logistic regression model	Type of intervention and conditions†			Adjusted OR	95% CI	P value
	Nutrition specific	Nutrition sensitive	Enabling environment			
Logistic regression for stunting						
v_1: sex (dummy variable for 'male')	–	–	X	1.482	0.573 to 3.830	0.417
v_{17}: ownership of refrigerator	–	X	X	0	0	0.999
v_{25}: age (year)	–	–	X	6.617	0.017 to 2550.7	0.534
v_{32}: availability and consumption of fruits (vitamin A rich and other fruits)	–	X	–	1.001	0.198 to 5.055	0.999
v_{79}: introduction of solid, semi-solid and/or soft foods	X	–	–	0.317	0.124 to 0.812	0.017 *
Logistic regression for underweight						
v_{84}: mother–child cosleeping	X	X	–	0.333	0.212 to 0.524	<0.001 **
v_{92}: ownership of birth certificate	X	–	–	1.656	1.057 to 2.596	0.028 *
Logistic regression for wasting						
v_{34}: availability and consumption of eggs	–	X	–	0.184	0.045 to 0.754	0.019 *
v_{86}: delivery not attended by health workers	X	–	–	1.45	0.330 to 6.383	0.623
v_{106}: cough during the last 2 weeks	X	–	–	1.713	1.128 to 2.603	0.012 *

*p<0.05, **p<0.01.
†Categorisation based on the previous review (Black *et al*. 2013).[15]

In this study, availability of eggs at households and their consumption generally by household members was measured as a food security variable for calculating HDDS. On the other hand, consumption of eggs by each child under 5 years of age was separately measured as a feeding/caring practice variable for calculating the IYCF minimum diet diversity. Thus, availability and consumption of eggs generally at household level are defined and measured differently from child-specific consumption of eggs, in this study. There is a possibility that eggs might have been consumed exclusively by the household members other than children at some households. In view of this, of 148 studied children of 6–59 months of age whose households had readily available eggs and actually consumed them, 114 (77.0%) actually ate eggs during the last 24 hours ($p<0.05$ in χ^2/Fisher's exact test). Thus, mothers and caregivers of children of 6–59 months of age in Majune and Muembe districts tend to proactively practice introduction of eggs during complementary feeding, as far as eggs are readily available at households. Several studies reported that early introduction of eggs in complementary feeding significantly improved growth and nutritional status of young children.[54] Thus, the results of our study support those earlier studies. Yet, instability of egg production and supplies in Niassa province[55] are likely to make it generally difficult for households in Majune and Muember districts to access and consume eggs.

A significantly positive association between having cough during the last 2 weeks and being wasted (adjusted OR = 1.713) implies that appetite reduced by respiratory infections might have caused inadequate food intake and digestion, and thereby acute undernutrition. There are a number of earlier studies on the causality between cough and undernutrition.[47 56–58] Particularly, severe acute malnutrition (z-score for weight-for-height < −3) is often accompanied by cough and fever. Thus, the association between having cough and being wasted we identified not only is in line with the results of those earlier studies but also signals a certain need for therapeutic feeding.

Figure 1 shows the hypothetical process of becoming malnourished based on the findings of our study. None of the determinants of and risk factors for whether being malnourished we identified was common across three types of undernutrition (ie, stunting, underweight and wasting) (table 7). This probably does not necessarily indicate that each determinant contributes exclusively to a specific type of undernutrition. For instance, mother–child cosleeping was significantly associated with both being stunted and being underweight in bivariate analyses. Yet, due to possible multicollinearity, it was excluded

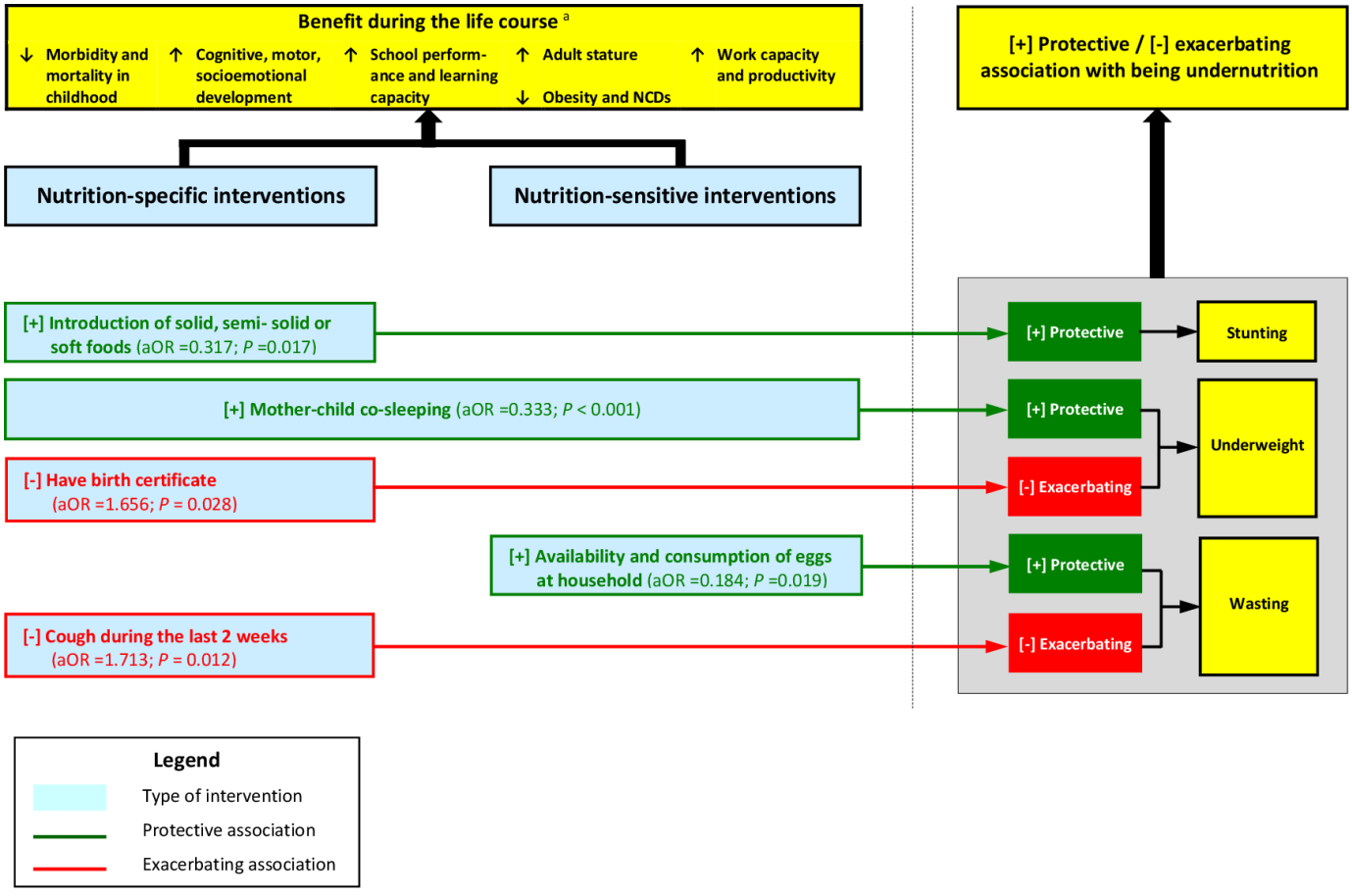

Figure 1 Hypothetical process of becoming stunting, underweight and wasted. oOR, adjusted OR. Adapted from Black *et al.* 2013

from the independent variables in the logistic regression model for stunting.

Some could be critical about adopting such a great number of independent variables. Yet, in a total absence of a standard set of variables and indicators for identifying the determinants of and risk factors for child undernutrition, taking all the possible variables, was an inevitable choice. In fact, mother–child cosleeping, a variable never employed in earlier studies, was identified as a determinant of and risk factor for whether being underweight in this study. Note that this was one of the key findings we reached by broadly screening all possible determinants.

This study has limitations in generalisability of determinants of and risk factors for child undernutrition due to employment of a cross-sectional study as the study design. We must particularly admit that possible overestimation of household food security status might have prevented this study from thoroughly identifying all the possible food-security-related determinants and risk factors. Generally, diverse food crops (including livestock products) are more available, accessible and affordable during the study period from August to October than yearly average.[59] Thus, household food security we measured may not be representative of its year-round status. A further study is necessary to more precisely estimate associations between food security variables and undernutrition, as seasonal variation of food security data is generally greater than that of feeding and caring practice data and household environment data.

CONCLUSION

This study identified that timely introduction of solid, semi-solid or soft foods to children of 6–8 months of age as a determinant of being not stunted. Mother–child cosleeping and ownership of birth certificate were a protective factor from and a promoting factor for being underweight, respectively. Similarly, availability and consumption of eggs at the household level and cough during the last 2 weeks among children were a protective factor from and a promoting factor for being wasted, respectively.

Note that the aforementioned determinants and risk factors are likely to be very applicable neither to other provinces of Mozambique and other countries nor to different seasons. This is because causality and association between undernutrition and its background factors vary according to local settings and seasons. To enable us to make meaningful interprovincial, international and interseasonal comparisons, it is crucially necessary to develop a standard set of variables and indicators related to immediate and underlying causes of child undernutrition. Yet, it is reality that the numbers and types of independent variables employed for multivariate analysis largely differ between the studies. Some studies employed less than 10 independent variables,[29 60] other employed more than 30.[26 30] Moreover, the types and definitions of those variables are not consistent and standardised enough to allow us to meaningfully compare the data between the studies. Thus, it is an urgent task to develop an internationally standardised set of variables and indicators. SUN has proposed a standard set of 79 indicators from eight technical domains.[61] Yet, they are the indicators appropriate not for identifying determinants and risk factors but rather for monitoring policy milestones and operational progress. Therefore, WHO, as the UN specialised agency responsible for health, should take responsibility for undertaking the task in collaboration with other key partners such as Food and Agriculture Organisation, UNICEF and SUN.

Conducting a multisectoral nutrition survey jointly between several key ministries (ie, typically, ministry of health, ministry of agriculture and ministry of public works) provides them with an invaluable opportunity to open a policy dialogue and further attempt to design, implement, monitor and evaluate a multisectoral nutrition programme in a joint or coordinated manner. Timely introduction of solid, semi-solid or soft foods, a possible key intervention we identified, could serve as a great entry point for the three sectors to start making joint efforts. To appropriately introduce solid, semi-solid or soft foods to a child, food production, water for cooking and feeding practising need to be undertaken by agriculture, water and health sectors, respectively. Though 54 of 61 SUN member countries (88.5%) set up national multistakeholder platform,[62] it is not clear whether those platforms facilitate conducting multisectoral nutrition surveys as the joint efforts among the stakeholders. To ensure a better-designed package of evidence-based multisectoral interventions, it is recommended that the multistakeholder platform proactively work beyond sectoral interests in each country and that its initial step be to jointly conduct a multisectoral nutrition survey.

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