Public Health Nutrition: 12(8), 1141–1149 doi:10.1017/S1368980008003716

Risk factors for stunting among under-fives in Libya

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Submitted 26 July 2007: Accepted 18 August 2008: First published online 15 September 2008

Abstract

Objective: Stunting is a chronic condition reflecting poor nutrition and health. Our aim was to ascertain major predictors of stunting in children <5 years old in Libya.
Population and methods: A nationally representative, cross-sectional, two-stage stratified cluster sample survey enrolled 4549 under-fives from 6707 households. Logistic regression was used to determine individual risk factors in bivariate and multivariate analyses.
Results: Anthropometric measurements were available for 4498 children. Among the 929 stunted children (20·7 %), 495 were boys (53·3 %) and 434 were girls (46·5 %). In multivariate analysis, risk factors were young age (1–2 years: OR = 2·32, 95 % CI 1·67, 3·22; 2–3 years: OR = 1·64, 95 % CI 1·22, 2·21), resident of Al-Akhdar (OR = 1·67, 95 % CI 1·08, 2·58), being a boy (OR = 1·28, 95 % CI 1·05, 1·55), having a less educated father (illiterate: OR = 2·10, 95 % CI 1·17, 3·77; preparatory school: OR = 1·71, 95 % CI 1·11, 2·65), poor psychosocial stimulation (no family visits or trips: OR = 1·52, 95 % CI 1·07, 2·16; father rarely/never plays with child: OR = 2·24, 95 % CI 1·20, 4·16), filtered water (OR = 8·45, 95 % CI 2·31, 30·95), throwing garbage in the street (OR = 13·81, 95 % CI 2·33, 81·72), diarrhoea (OR = 1·58, 95 % CI 1·09, 2·29) and low birth weight (OR = 1·8, 95 % CI 1·17, 2·40). Protective factors were older age of father (OR = 0·53, 95 % CI 0·32, 0·90) and water storage (OR = 0·70, 95 % CI 0·54, 0·90). These variables only explained 20 % of cases of stunting.
Conclusion: Various multilevel actions are needed to improve nutritional status of under-fives in Libya. At risk-groups include those with young age (1–3 years), resident of Al-Akhdar region, boys, father's low educational level, poor psychosocial stimulation, poor housing environment, diarrhoea and low birth weight.

Keywords
Libya
Children
Under-fives
Stunting
Risk factors

Nutritional status is a sensitive indicator of the quality of life in a given population[1,2]. Despite global improvement in the health of children aged <5 years in developing countries, undernutrition remains an important public health problem[3,4]. More than half of deaths of children in these countries are related to undernutrition[5]. Undernutrition profoundly affects human function, with both individual and transgenerational effects. Individual effects include the well-known undernutrition–infection vicious cycle, while transgenerational effects refer to a similar vicious spiral that extends to forthcoming offspring and induces permanent effects on mental, social and physical well-being. These effects occur even in mild-to-moderate cases[3]. Undernutrition also affects society at large because it leads to reduced productivity and limited ability to escape the consequences of poverty[3,6,7].

Reduction of the prevalence of undernutrition in under-fives is a top priority to reduce child mortality and morbidity. Reduction of undernutrition prevalence by 50 % between 1990 and 2015 is among the most important targets of the first Millennium Development Goal. Nevertheless, progress remains slow, and most international goals set for improving child nutrition and health were not met by 2000.

Stunting (i.e. low height-for-age) is a chronic condition that reflects poor linear growth accumulated during pre- and/or postnatal periods because of poor nutrition and/or health. It is more difficult to treat than acute forms of undernutrition such as wasting. Its relationship to micronutrient deficiencies, obesity (particularly the abdominal type) and chronic diseases makes it an important health hazard even for countries in transition. Causes of stunting

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are multifactorial with roots in many sectors of development such as education, demography, agriculture and rural development[8,9]. Identification of the causes in a particular setting implies the investigation of complex interactions between these multiple interrelated social, economic and environmental determinants. Such determinants usually occupy different positions in the dependence chain and they cannot adequately be modelled by including them all in a linear regression analysis[10,11]. They can be better understood within an integrated conceptual framework that considers these factors and their interactions[8,11,12]. One example of such a model is the UNICEF conceptual framework. This framework, which was developed in 1990 as a part of UNICEF's nutritional strategy[8], provides a holistic and pragmatic approach. It classifies the causes of undernutrition into three categories that account for the complexity of the nutritional status of children: (i) basic causes at the societal level; (ii) underlying causes at the household/family level; and (iii) immediate causes. Factors at one level influence other levels.

Libya is classified as a low-prevalence area of wasting (3·3 %) and stunting (15·1 %) using the National Center for Health Statistics/Centers for Disease Control and Prevention/WHO reference growth curves[13,14]. Stunting in Libya is more prevalent in certain geographic regions, in rural areas and in underprivileged groups[13,15]. Rates are as high as 28 % in Al-Akhdar region when the newly published growth charts from the WHO Multiple Centre Growth Reference Study[16] are used. As such, the country would be reclassified as an intermediate-level country[15].

Improvement in nutritional status needs effective planning that accounts for the underlying risk factors, identifying at-risk subgroups and permitting targeted interventions. There is a paucity of studies that would permit a fuller contextual assessment of the patterns and determinants of undernutrition in Libya. Analysis of national cross-sectional surveys can provide clues to fill this gap. The Libyan Maternal and Child Health Survey (LMCHS), undertaken as part of the Pan Arab Project for Child Development (PAPCHILD), is the first nationally representative maternal and child health survey ever undertaken in Libya[13,17]. The present study is a secondary analysis of the raw data from the LMCHS. The aim was to ascertain predictors of childhood stunting in children aged <5 years in this population.

Population and methods

Design

The design, methods and nutritional status of under-fives in Libya from the LMCHS are described in more detail elsewhere[13,15,17]. The LMCHS is a cross-sectional, nationally representative, two-stage stratified probability cluster sample of 6707 households that was undertaken during the summer of 1995. The country was divided into seven administrative regions. These regions were three costal (Benghazi, Tripoli and Al-Zaouia), two mountainous (Al-Akhdar and Al-Gharbi) and two predominantly desert areas (Sirt and Sabha). Each region was divided into urban and rural zones. In the first stage, a total of 307 sampling units, including 102 units from rural areas, were selected randomly. In the second stage, each sampling unit was divided into five segments of equal sizes. All households in one randomly selected segment were included in the sample. All children younger than 60 months at the time of the survey were eligible for recruitment.

Data and outcome measures

Data were collected in interviews with mothers during household visits using the three different standard PAPCHILD questionnaires with a few modifications to conform to local patterns of disease and determinants[17]. The child questionnaire contained items related to child health and its determinants such as vaccination, birth, nutrition, etc. The reproductive health questionnaire contained items on the mother's health and reproductive history. The third questionnaire gathered data on household characteristics and the surrounding environment such as the availability of safe water supply, sanitation facilities and garbage collection. Weight, length/height and age data were used to calculate *Z* scores of height-for-age in comparison with the newly published WHO growth curve. Stunting was defined as a length/height more than two standard deviations below the median height/length-for-age of the WHO Child Growth Standards from the WHO Multicentre Growth Reference Study[16]. The independent variables that were chosen for their possible association with stunting are shown in Table 1. These variables were organized according to the conceptual framework developed by UNICEF[8]. Socio-economic classification was based on the combination of an asset index of households with its area characteristics, and a locally validated socio-economic classification that incorporates parental occupation and education[18].

Statistical analysis

Data were analysed using WHO Anthro 2005 software (WHO, Geneva, Switzerland) and SPSS version 13 (SPSS Inc., Chicago, IL, USA) statistical software package. The WHO Anthro 2005 program considers *Z*-score values for length/height-for-age <-6 as outliers. Each independent variable was individually evaluated in bivariate analyses for possible correlation with stunting. Statistical analysis with logistic regression was performed by SPSS, determining for each of the variables the odds ratio, 95 % confidence interval and statistical significance of the association with stunting. Only statistically significant risk factors are presented here. The level of significance was set at $P<0·05$. In the final stage, in addition to the variables that were identified as significant in the bivariate analyses, some other potentially confounding variables as

https://doi.org/10.1017/S1368980008003716 Published online by Cambridge University Press

Table 1 Variables assessed for their possible association with stunting

I Basic determinants
Region of residence; urbanization; gender; age; socio-economic conditions

II Underlying determinants
Family and caregiver conditions
Main caregiver; mother's age and age at birth; living arrangements; change of residence; type of previous residence; educational state of mother; listening, watching and reading of media; currently working for cash; working for cash before or after marriage; single mother; extended family; multiple wives; poor family social life
Reproductive history of mother
Age at menarche; age at first marriage; birth order of the child; number of children; blood relation with husband; history of prematurity, stillbirth, abortion and previous sibling deaths
Father's attributes
Educational state; residence in the last 3 months; playing with the child; earning regular wages
Health services
Immunizations; check-ups during pregnancy; birth order; type, place and complications of delivery; use of Caesarean section
Household environment
Area of residence and household characteristics: dwelling type and ownership; number of rooms and bedrooms; keeping animals; kitchen location and fuel used; source, storage and treatment of drinking water; type and location of toilet facilities; collection, location and disposal of garbage; state of the area around dwelling (flooded or stagnant water)

III Immediate determinants
Diet
Feeding history of the child*: onset, duration and practices of breast-feeding, infant formula-feeding and bottle-feeding; age of introduction of powdered, animal and pasteurized bottle milk; introduction of solid foods; type of weaning; giving rice, juice, herbal drinks, preserved baby foods or family foods
Health
Diarrhoea; cough; fever; otitis; conjunctivitis; accidents or other illnesses; measles infection; weight at birth

*Optimal breast-feeding was considered if breast-feeding started early, if weaning started at 6–8 months of age and if breast-feeding continued for >12 months; whereas if weaning started between 4 and 6 months of age, breast-feeding was considered appropriate.

Table 2 Basic attributes of under-fives involved in the Libyan Maternal and Child Health Survey, 1995

Variable	*n*	%
Age of child (years)		
<1	780	17·3
1–<2	895	19·9
2–<3	968	21·5
3–<4	983	21·9
4–<5	871	19·4
Gender		
Boys	2231	49·6
Girls	2267	50·4
Socio-economic class		
Privileged	870	19·3
Intermediate	2877	64·0
Underprivileged	750	16·7
Area		
Urban	3135	69·7
Rural	1363	30·3
Region		
Al-Akhdar	553	12·3
Benghazi	604	13·4
Sirt	631	14·0
Tripoli	1513	33·6
Al-Zaouia	407	9·1
Al-Gharbi	487	10·8
Sabha	303	6·7
Degree of stunting		
Mild	1167	25·9
Moderate	591	13·1
Severe	324	7·2

indicated by $P<0{\cdot}5$ were also selected. These were all put together in a single logistic regression model to determine their net effects on stunting.

Results

Anthropometric measurements were available for 4498 children. Among the 929 stunted children (20·7 %), there were 495 boys (22·2 %) and 434 girls (19·4 %). Other basic attributes of the children participating in the survey are shown in Table 2.

In bivariate analysis, various significant factors increasing (Table 3) or decreasing (Table 4) the risk of stunting were found. Basic determinants included age 1–3 years, with the second year having the highest risk even in comparison with the first year (OR = 1·31, 95 % CI 1·04, 1·64, $P<0{\cdot}02$), being a boy, belonging to less privileged groups, living in rural areas and being a resident of Al-Akhdar, Sirt, Al-Zaouia or Al-Gharbi regions. Underlying determinants found included family and caregiver conditions such as consanguinity, large family size (having ≥4 siblings in the family), low paternal and/or maternal education and limited psychosocial stimulation (absent or rare interaction between the child and father, absence of external social contact, absence of media contact). Meanwhile, being a first or a single child decreased the risk for stunting. Other underlying determinants included poor utilization of health services (absence or poor follow-up during pregnancy, incomplete immunization). Delivery in a private health establishment decreased the risk. Housing environment such as type of dwelling, lack of safe water supply, inadequate sanitation and garbage collection were among the underlying determinants that increased the risk of stunting. Many immediate factors related to feeding practices and health status such as low birth weight and diarrhoea were found also to increase the risk of stunting. Onset of weaning at 4–6 months of age rather than 6–8 months and a large birth weight decreased the risk for stunting.

The logistic regression model for multivariate analysis included the factors reported above in addition to some other potentially confounding variables such as father's age, father's education and using water from wells without pumps. Overall, the model was significantly associated with stunting, but it explained only 20 % of the variance as indicated by its R^2 value (Table 5).

https://doi.org/10.1017/S1368980008003716 Published online by Cambridge University Press

Table 3 Bivariate analysis of factors associated with increased risk for stunting in under-fives in Libya: secondary analysis of data from the Libyan Maternal and Child Health Survey, 1995

Risk factor	*n*/*N*	OR	95 % CI	*P*
I Basic determinants				
Living in a rural area	316/1363	1·24	1·07, 1·45	0·006
Age (ref: 4–<5 years)	138/871	1·00	–	
<1 year	172/780	1·50	1·17, 1·92	0·001
1–<2 years	242/896	1·96	1·55, 2·47	0·000
2–<3 years	204/968	1·42	1·12, 1·80	0·004
Region (ref: Benghazi)	89/604	1·00	–	
Al-Akhdar	154/552	2·24	1·67, 3·00	0·000
Sirt	157/631	1·92	1·44, 2·56	0·000
Al-Zaouia	86/407	1·55	1·12, 2·15	0·01
Al-Gharbi	122/488	1·92	1·42, 2·61	0·000
Boys	495/2230	1·21	1·05, 1·40	0·01
Socio-economic class (ref: Privileged)	150/870	1·00	–	
Intermediate	591/2877	1·24	1·02, 1·51	0·03
Underprivileged	188/750	1·61	1·27, 2·05	0·000
II Underlying determinants				
Family and caregiver conditions				
Consanguinity (ref: No relation)	452/2381	1·00	–	
Husband is a paternal cousin	328/1461	1·24	1·05, 1·45	0·01
Husband is a maternal cousin	122/523	1·30	1·03, 1·63	0·03
Family goes on no trips or visits	144/482	1·77	1·42, 2·20	0·000
Educational status of mother (ref: University)	39/301	1·00	–	
Illiterate	345/1507	2·02	1·41, 2·89	0·000
Read and/or write	106/504	1·81	1·22, 2·70	0·004
Primary	184/839	1·91	1·31, 2·78	0·001
Preparatory	128/666	1·62	1·10, 2·39	0·02
Secondary	112/614	1·51	1·02, 2·24	0·04
Family does not watch television	94/323	1·75	1·35, 2·26	0·000
Family does not listen to radio	461/2100	1·17	1·01, 1·35	0·04
Number of siblings (ref: 2–4)	302/1494	1·00	–	
>5	391/1743	1·18	1·00, 1·40	0·05
Father plays with child (ref: Almost every day)	585/3011	1·00	–	
Rarely/never	31/90	2·20	1·41, 3·42	0·001
Sometimes	291/1277	1·22	1·04, 1·43	0·013
Educational status of father (ref: University)	79/550	1·00		
Illiterate	122/487	2·00	1·46, 2·73	0·000
Read and/or write	89/455	1·47	1·05, 2·04	0·02
Primary	174/921	1·39	1·04, 1·86	0·03
Preparatory	207/910	1·76	1·33, 2·34	0·000
Secondary	210/944	1·72	1·29, 2·28	0·000
Health services				
Mother had no check-ups during pregnancy	209/868	1·29	1·08, 1·53	0·005
Place of delivery (ref: Public health establishment)	815/4022	1·00	–	
Home	79/267	1·65	1·26, 2·17	0·000
Others	4/6	7·87	1·43, 43·45	0·02
Incomplete immunization	175/717	1·28	1·06, 1·55	0·009
Household environment				
Dwelling type (ref: Apartment)	88/578	1·00	–	
Popular	252/1216	1·45	1·11, 1·89	0·006
Traditional	198/797	1·82	1·38, 2·41	0·000
Modern	342/1789	1·31	1·01, 1·69	0·04
Hut and house made from fur	22/91	1·79	1·06, 3·04	0·03
Others	27/28	149·48	19·83, 1126·81	0·000
Kitchen location (ref: Inside dwelling)	873/4296	1·00	–	
Outside dwelling	49/185	1·41	1·01, 1·97	0·04
No kitchen	7/17	2·80	1·09, 7·21	0·03
Source of drinking water (ref: Pipe system)	521/2522	1·00	–	
Wells without pump	88/318	1·46	1·12, 1·90	0·005
Rainwater catchment	23/70	1·84	1·11, 3·06	0·02
Water storage (ref: No water storage)	231/1068	1·00	–	
Tin container	25/76	1·80	1·09, 2·96	0·02
Other	49/155	1·69	1·17, 2·44	0·005
Water treatment (ref: No treatment)	885/4305	1·00	–	
Treatment by filtering	7/11	6·01	1·82, 19·82	0·003
Type of toilet facilities (ref: Flush toilet with sewer)	438/2372	1·00	–	
Latrine with container	165/612	1·63	1·32, 2·00	0·000
Pit	17/35	4·06	2·08, 7·93	0·000
Open air	17/53	2·09	1·16, 3·76	0·02

Table 3 *Continued*

Risk factor	n/N	OR	95 % CI	P
Garbage disposal method (ref: Plastic bags)	288/1609	1·00	–	
Container without lid	434/1871	1·38	1·17, 1·63	0·000
Thrown in street	14/44	2·18	1·15, 4·14	0·02
Others	9/15	7·26	2·58, 20·44	0·000
Garbage container located outside dwelling	276/1182	1·38	1·13, 1·70	0·002
III Immediate determinants				
Dietary intake				
Sudden weaning	399/1899	1·29	1·08, 1·54	0·004
Health conditions of the child				
Diarrhoea	94/339	1·53	1·19, 1·96	0·001
Weight at birth (ref: Normal)	758/3750	1·00	–	
Low birth weight	88/289	1·74	1·34, 2·26	0·000

n, number of stunted children in the category; *N*, total number of children in the category.

Table 4 Bivariate analysis of factors associated with decreased risk for stunting in under-fives in Libya: secondary analysis of data from the Libyan Maternal and Child Health Survey, 1995

Risk factor	n/N	OR	95 % CI	P
II Underlying determinants				
Family and caregiver conditions				
Birth order (ref: 2nd–4th child)	302/1494	1·00	–	
First child	88/608	0·67	0·52, 0·87	0·002
Number of children (ref: 2–4)	316/1610	1·00	–	
Single child	35/267	0·61	0·42, 0·89	0·01
Health services				
Place of delivery (ref: Public health establishment)	815/4022	1·00	–	
Private establishment	12/122	0·42	0·23, 0·77	0·005
III Immediate determinants				
Dietary intake				
Time after birth breast-feeding started (ref: <1 h)	220/919	1·00	–	
Between 1 and 3 h	315/1585	0·79	0·65, 0·96	0·02
More than 6 h	211/1120	0·74	0·60, 0·92	0·006
Age when animal milk was given (ref: Not given)	806/3815	1·00	–	
Delayed introduction (>12 months)	73/470	0·69	0·53, 0·89	0·005
Breast-feeding practices (ref: Optimal)	300/1248	1·00	–	
Appropriate	50/299	0·63	0·46, 0·88	0·007
Acceptable	93/507	0·71	0·55, 0·92	0·009
Inappropriate	458/2342	0·77	0·65, 0·91	0·002
Age when powdered milk was given (ref: Not given)	309/1354	1·00	–	
<4 months	449/2257	0·84	0·71, 0·99	0·04
4–6 months	98/547	0·74	0·57, 0·95	0·02
Feeding practices (ref: Optimal)	103/426	1·00	–	
Acceptable	60/339	0·68	0·47, 0·97	0·03
Given pasteurized bottled milk	404/2195	0·77	0·66, 0·89	0·000
Given infant powdered milk	438/2268	0·85	0·74, 0·98	0·03
Given juices	700/3547	0·77	0·65, 0·92	0·004
Given preserved baby food	269/1480	0·80	0·68, 0·93	0·005
Ever fed from infant bottle	604/3152	0·74	0·64, 0·87	0·000
Health conditions of the child				
Weight at birth (ref: Normal)	758/3750	1·00	–	
Large-for-age at birth	44/329	0·62	0·44, 0·85	0·004

n, number of stunted children in the category; *N*, total number of children in the category.

Discussion

Libya is a country with an intermediate level of income, with a per capita gross domestic product of $US 6418 in 1995[19]. A number of programmes were implemented to improve the nutritional status of the population in the second half of the last century. Large amounts of resources were spent on food subsidy programmes and also on food distribution activities for women and children[15]. A nutritional surveillance system was introduced in maternal and child health centres. There have been marked improvements over the past few decades in the nutritional status of children[15,20]. However, much work remains to be done[15].

Table 5 Multivariate analysis of risk factors associated with stunting in under-fives in Libya: secondary analysis of data from the Libyan Maternal and Child Health Survey, 1995

	Risk factor	OR	95 % CI	*P*
I	Basic determinants			
	Resident of Al-Akhdar (ref: Benghazi)	1·67	1·08, 2·58	0·02
	Age (ref: 4–<5 years)			
	1–<2 years	2·32	1·67, 3·22	0·0001
	2–<3 years	1·64	1·22, 2·21	0·001
	Boys	1·28	1·05, 1·55	0·02
II	Underlying determinants			
	Family and care giver conditions			
	Father's educational status (ref: University)			
	Illiterate	2·10	1·17, 3·77	0·01
	Preparatory	1·71	1·11, 2·65	0·02
	Family goes on no trips or visits	1·52	1·07, 2·16	0·02
	Father rarely/never plays with child (ref: Almost every day)	2·24	1·20, 4·16	0·01
	Father's age >50 years at birth (ref: >30–50 years)	0·53	0·32, 0·90	0·02
	Household environment			
	Water storage in tanks (ref: No water storage)	0·70	0·54, 0·90	0·006
	Water treatment by filtering (ref: No treatment)	8·45	2·31, 30·95	0·001
	Garbage is thrown in the street (ref: Plastic bags)	13·81	2·33, 81·72	0·004
III	Immediate determinants			
	Health conditions of the child			
	Diarrhoea	1·58	1·09, 2·29	0·02
	Low birth weight	1·68	1·17, 2·40	0·005

This is the first time that data have been exploited to formulate a hypothesis on possible factors determining the problem of undernutrition among under-fives in Libya. One of the important aspects of this survey is that it was performed during the peak of political and economic difficulties that faced the country in the 1990s following UN sanctions and the counteracting measures that were taken. The result was a many-fold rise in the price of most food items.

We did not find any evidence of significant collinearity in our model. However, certain inherent limitations may arise in the study such as the difficulty to examine temporal relationships, differences in seasonal distribution of risk factors, recall bias, absence of data on maternal nutrition and food practices of the family, absence of data on parasitic infections, absence of comprehensive data on mental health of the family including different psychosocial stimulation and/or interaction between family members, and the possibility that respondents would answer in more socially desirable ways. Standard national cross-sectional studies such as PAPCHILD, the Pan Arab Project for Family Health and Multiple Indicator Cluster Surveys do not evaluate measures taken by different authorities to combat undernutrition.

The complex interrelated factors associated with stunting that we found in the current study are represented according to the UNICEF conceptual framework (Fig. 1). The results of our study show the importance of the UNICEF model incorporating parental and socioeconomic characteristics in understanding the prevalence of stunting in Libya. However, such models should be interpreted only from an exploratory point of view(11). Models constitute a platform for better comprehension of potential dynamics and possible sites of intervention(21). The paths indicated by the arrows in the UNICEF framework are meant to suggest distal *v.* proximal relationships, and do not necessarily mean that distal factors cannot have direct effects on stunting.

In the current study, being from the less privileged groups was a risk factor initially but disappeared in subsequent multivariate analysis. The effects of income are known to be mediated through other underlying determinants(4,12). These factors determine the ability of the family to combine their knowledge, resources and patterns of behaviour, to promote, recover or maintain health status and to cope with a difficult environment(4,11,12). Such factors include parental education, psychosocial stimulation and household environment(4,12,22–24).

In spite of equity-driven health and education service expansion in Libya during the 1970s, stunting was related to living in rural areas as well as in certain geographical regions. Stunting is known to be more prevalent in rural areas(22). People living in urban areas are provided with better access to health services, education and other social support systems which are either not available or not easily accessible to residents in rural areas. The two regions with the highest risk for stunting were the two mountainous areas. A strong inverse association between child height and altitude has been noticed previously. Possible explanations could include access to food, dietary habits, living practices, environmental conditions such as cold climate, hygienic measures such as water supply, and parasitic infections(7,25). These findings may also reflect the absence of vertical expansion that

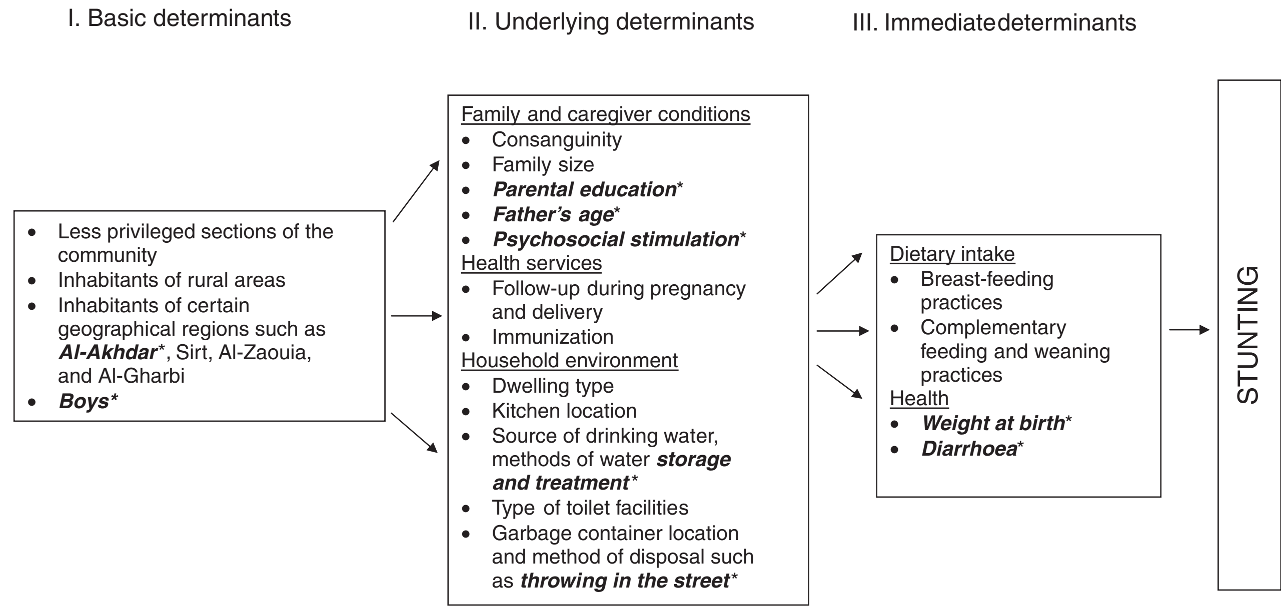

Fig. 1 Explanatory model and possible interactions of different risk factors associated with stunting among under-five children in Libya based on the UNICEF conceptual framework[8] of the determinants of nutritional status (*bold italic font indicates those factors that persisted in the multivariate model)

should have followed the horizontal expansion which occurred in the country during the 1970s. Further studies are needed to verify the exact role of these factors in this population.

Gender is an important aspect of equity. Equal degree of undernutrition between under-five boys and girls by the year 2020 is accepted as a mean for evaluating gender equity in different societies[11,26]. There is no evidence of gender bias in stunting in Libya based on the current study.

On occasions, children may be born undernourished due to growth retardation *in utero* and their growth may improve exponentially over time[11,12,22,23]. On other occasions, the anthropometric status of children worsens considerably only when they are weaned and particularly if low-quality solid foods are introduced. In the current study, stunting was associated with age period of 1–3 years. Other factors increasing the risk of stunting in this age period include loss of passive immunity, exposure to unsanitary conditions increasing the risk of infections that suppress appetite and directly affect nutrient metabolism, and return of the mother to work[11,23,27].

In the current study, paternal education and age were significant factors associated with stunting in the final model. Higher education could reflect higher income and more paternal interest in child nutrition. More educated fathers are more likely to have educated wives. Educated mothers are known to be older at their first birth and are more knowledgeable about care practices. Educated families live in smaller households, in better houses, they are better able to use health-care facilities, and are more adept at keeping their environment clean[11,12,28].

Parental consanguinity was a significant factor associated with stunting in bivariate analysis in the current study, but it disappeared in multivariate analysis indicating that it was a confounding variable. Studies have shown conflicting results on the impact of consanguineous marriages on child health[29].

Indicators for health services utilization such as incomplete immunization, poor check-up during pregnancy and non-supervised deliveries were all risk factors for stunting. These factors are known to influence stunting both directly and indirectly. Health knowledge and access to health care could also explain regional differences in undernutrition[11,23], as in Libya.

Environmental factors refer to the availability of safe water, sanitation and environmental safety, including shelter. Environmental factors such as poor housing and exposure to untreated water are known to be associated with stunting[30,31]. In fact, most of the positive effect of income on child height could be mediated by the quality of family housing[7,12]. In the current study, household quality was an important risk factor in the multivariate model. In some regions of Libya and in spite of major drinking water projects, many people have to use variable methods to obtain a continuous water supply or more palatable water. Examples include boiling of water from superficial wells and the use of desalinated or filtered water from near-by factories. Such water may be either contaminated, thereby predisposing children to repeated bouts of infection, or lacking in some micronutrients, which might compromise growth. Having piped water in the home also reflects higher income levels and/or that the environmental sanitation in these homes is better.

When water is not readily available, food hygiene is frequently poor, which increases the risk of pathogen contamination and exposure to illnesses. However, the fact that storing water in tanks protects against infections in comparison to publicly supplied piped water calls for better quality control of this system.

Diarrhoea is a known risk factor for stunting[11,23,30]. The current survey was conducted during the summer. The prevalence of diarrhoea from our data was found to be 17·3 % (779/4498). Diarrhoea could be related to food preparation and feeding practices and to increased exposure to pathogens as children become increasingly mobile throughout the first three years of life. As children get older, they may become more immune to infections due to a gradual increase in the colonization of various bacteria and viruses in the gut. Targeting health education messages to mothers with children younger than 3 years old may be an important option to consider.

Breast milk contains the mix of nutrients that is best suited to the infant's metabolism. An initial period of exclusive breast-feeding is essential to lower the risk of stunting, after which supplementary foods should be introduced appropriately into the child's diet[24]. The use of bottle feeding predisposes to infections and may be associated with diluted non-nutritive formula preparation[24]. Early introduction of complementary foods is a known predictor of undernutrition[23], but there is a debate as to the most suitable age that supplements should be first given[32]. In the current study, breast-feeding was considered optimal if it started early, if it was continued for >12 months and if weaning started at 6–8 months. It was considered appropriate if weaning started earlier (between 4 and 6 months). In the current study, optimal breast-feeding was not as protective as appropriate breast-feeding. In addition, there was a protective effect of bottle feeding and early introduction of breast milk substitutes such as powder milk or pasteurized bottled milk. Previous studies reported a similar observation where, for example, longer breast-feeding was associated with both higher stunting and severe stunting risk[24]. This should be viewed as failure of optimal complementary feeding and the inability of the household to provide supplemental foods, and should not be an argument for advertising of these substitutes[11]. In other cases, when a child is severely stunted, mothers may respond by a decision to continue breast-feeding[24,33]. Moreover, none of the dietary intake factors in the current study persisted in the multivariate model.

Low birth weight is a known correlate of stunting[12,28]. In the current study, it had a potent effect on stunting that persisted in the single multivariate analysis. The known effect of low birth weight on child health makes it the most relevant single factor for children's survival[34].

To fight undernutrition sustainably, changes in many of the underlying factors are necessary[11]. In spite of the existence of food security programmes in Libya, the broader concept of nutritional security should be implemented. This is achieved for a household when secure access to food is coupled with a sanitary environment, adequate health services and knowledgeable care. As in other studies, the risk factors of stunting that we found were diverse, complex, difficult to manage, and their effects started even before birth[35]. The current study provides relevant information for determining courses of action to be taken at the meso and micro level to improve the nutrition and health of children in Libya. Policy frameworks must be established that incorporate short-, medium- and long-term strategies to solve nutritional problems in Libya. Corresponding intervention strategies should be comprehensive, culturally sensitive and addressed at various levels. Programmes should specifically target higher-risk groups such as young children (1–3 years), residents of Al-Akhdar, boys, less educated fathers, poor family social life, low-quality household environment, diarrhoea and low birth weight. Particular attention should be given to the particularly brief window of intervention from the mother's pregnancy through the child's first two years of life. Further research, particularly on regional differences, is required to design relevant and effective intervention programmes.

Acknowledgements

There are no conflicts of Interest and no sources of funding.

Authors' contributions: A.E.T. was responsible for data analysis and interpretation, performed statistical analysis and drafted the paper. O.G. and S.M.M. supervised data analyses and contributed to interpretation of data. P.G. and S.H. contributed to drafting the paper. A.A.M. and I.B. were responsible for study design and coordinated the supply of the data. All contributors were involved in critical revision of the paper.

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