BMJ Open

Malnutrition and contributing factors among newborns delivered at the University of Gondar Hospital, Northwest Ethiopia: a cross-sectional study

Almaz Tefera Gonete ![ORCID],[1] Tewodros Getaneh Alemu,[1] Eskedar Getie Mekonnen ![ORCID],[2] Wubet Worku Takele ![ORCID] [3]

¹Department of Pediatrics and Child Health Nursing, University of Gondar, Gondar, Ethiopia
²Reproductive Health, University of Gondar College of Medicine and Health Sciences, Gondar, Amhara Regional State, Ethiopia
³Department of Community Health Nursing, University of Gondar, Gondar, Ethiopia

Correspondence to
Wubet Worku Takele;
wubetakele380@gmail.com

ABSTRACT

Objectives To estimate the prevalence of various indicators of malnutrition (stunting, wasting, low birth weight, concurrent stunting and wasting, overweight/obesity and double burden malnutrition) among newborns and to investigate factors associated with these nutritional disorders.

Methods A hospital-based cross-sectional study was conducted from 10 March through to May 2020. A total of 419 newborns were recruited into the study to estimate the prevalence of low birth weight and stunting. After excluding 28 newborns whose length was less than 45 cm, 394 newborn–mother dyads were approached to estimate wasting and overweight/obesity. A systematic random sampling technique was used to select participants. All independent variables were entered into the multivariable logistic regression model and variables that had significant associations were identified based on a p value.

Results A very small proportion of the newborns 2.5% (0.9% to 4.1%) were concurrently wasted and stunted. The prevalence rates of low birth weight and wasting were 20.8% (16.8% to 24.6%) and 10.9% (7.82% to 14.01%), respectively. The magnitude of overweight/obesity was 12.7% (9.3% to 15.9%) where 2.8% (1.1% to 4.4%) of newborns have the double burden of malnutrition. Having a father with a primary level of education 2.82 (1.19 to 6.65) and being stunted at birth 3.17 (1.6 to 6.0) were variables that were associated with increased odds of low birth weight. The odds of being overweight/obese are significantly higher among newborns born to mothers who are urban dwellers 0.35 (0.12 to 0.99).

Conclusions The study underscores that malnutrition is a pressing public health concern that demands due emphasis. Fathers' educational status (low level) and being stunted are associated with a high burden of low birth weight. Mothers' residency (being urban) is associated with an elevated risk of overweight/obesity among newborns. Thus, improving the health literacy of fathers and preventing stunting at birth are recommended to mitigate low birth weight.

INTRODUCTION

Stunting, wasting and low birth weight (LBW) are the predominant forms of undernutrition that usually occurred in children of developing countries, where the socioeconomic status, literacy level and dietary practices are poor.[1 2] Multiple nutritional disorders (concurrent/double burden of malnutrition (DBM)) would also happen to a child that further increases the likelihood of developing short-term and long-term untoward consequences.[2] Concurrent wasting and stunting (WaSt) at birth, for instance, is the most common concomitant nutritional disorder, which is characterised by being thin for weight and short for age at a time. Similarly, the occurrence of overweight/obesity with stunting simultaneously is termed as the DBM, which is an emerging nutritional problem.[3 4] Following the swift nutrition transition, DBM is becoming an increasing problem in different countries of the world that largely compromises the growth and development of children.[5 6] The emergence of DBM and WaSt has ruined the lives of millions of young children across the globe.[2]

Globally, malnutrition is a threat to the lives of one-third (33.8%) of children younger than 5 years, of which Africa contributes the

Strengths and limitations of this study

► The prevalence of various forms of malnutrition (both overnutrition and undernutrition) is estimated which yields a piece of comprehensive evidence.
► This is the only study in Ethiopia that reported the concurrent and double burden of malnutrition among newborns.
► The anthropometric measurements reported are adjusted for the gestational age.
► Paternal-related variables such as height that would have an impact on the nutritional status of newborns were not included because of the inaccessibility of fathers during delivery.
► Maternal mental health status that is presumed to be a contributing factor for malnutrition has not been considered as a factor and tested for association.

biggest share of the burden at 98%.[5] About 8 million (2%) of children younger than 5 years are suffering from DBM.[7] Similarly, the overall burden of concurrent WaSt in this segment of the population ranged between 2.35% and 3%.[8 9] In children younger than 5 years, wasting and stunting have contributed to 64.6 and 54.9 million disability-adjusted life years, respectively, which accounted for 14.8% and 12.6% of the total global disability-adjusted life years.[6 8] Ethiopia, a country with the highest burden of malnutrition, 44% and 27% of children below 5 years and under 6 months of age, respectively, are affected.[10 11] Nearly half of the under-5 mortality in Ethiopia is also imputed by malnutrition.[5 9] Moreover, 16.5% of the country's gross domestic product and about US$157.8–US$230.2 million are lost annually owing to the long-term and short-term effects of malnutrition, respectively.[12–15]

Malnutrition has both short-term and long-term shattering effects that impacted not only the lives of children but also extend to affect the subsequent generations.[3 7 16 17] Undernutrition, in particular, in early life results in impairment of cognitive development, irreversible physical and physiological destruction, and puts children at higher risk of morbidity and mortality.[18 19] It also contributes to incur non-communicable diseases like type 2 diabetes due to the rushed weight gain in the later life.[5 6 9 19–22]

Childhood malnutrition, particularly among newborns, is usually attributed to poor nutrition in utero and repeated bouts of infection that start from conception.[23 24] Multifaceted reproductive and maternal nutritional and medical disorders are likewise the contributing factors of malnutrition among newborns.[25] The likelihood of developing malnutrition is associated with short maternal stature, poor maternal nutritional status, illness during pregnancy (diabetes mellitus, hypertension, anaemia, and toxoplasmosis rubella, cancroid and herpes simplex virus (TORCH) infection), having no antenatal care (ANC) visit, short pregnancy interval, maternal age (advanced and younger) and not supplemented with iron folate during pregnancy.[25–31]

To curve the observed, Ethiopia has been working to end malnutrition through designing various programmes, including the National Nutrition Program and the Seqota Declaration to achieve the World Health Assembly's target of reducing stunting to 26.8% by 2025. Nonetheless, the annual average reduction rate (AARR) of stunting is only 2.8%, which is far off the expected decline rate of 6%.[32] Similarly, the annual average reduction rate of wasting is 0.1% that is still remarkably lower than the expected AARR, which is 5%.[13]

Despite the findings that show the burden and contributing factors of malnutrition among newborns can be used as preliminary evidence for further intervention, the existing pieces of evidence are concentrated only on children aged 6–59 months. The burden of malnutrition among newborns is supposed to be high in Ethiopia associated with high maternal malnutrition in the country though there is no study that reveals the prevalence and contributing factors. The aim of this study was, therefore, to estimate the prevalence of wasting, stunting, concurrent WaSt, LBW, overweight/obesity and DBM, as well as to identify the contributing factors. Understanding the problem at an earlier stage will provide a spotlight for local decision-makers, project planners and policymakers for designing programmes to mitigate the burden through strengthening care during pregnancy, tackle the ill effects at the right time and halt the combined negative effect of various types of malnutrition.

METHODS AND MATERIALS
Patient and public involvement
Mothers and their newborns were included in this study by providing their valuable information including measurements. However, they have never participated in conducting the study, designing the protocol and data collection tools, reporting the results and disseminating the study findings.

Study design and period
A hospital-based cross-sectional study was conducted from 10 March to May 2020. The study was prepared using the Strengthening the Reporting of Observational studies in Epidemiology.

Study period and area
The study was carried out at the University of Gondar Comprehensive Specialized Referral Hospital situated in the Amhara region, northwest of Ethiopia. The region has been affected by the high prevalence of malnutrition, lesser economic development and poor infrastructure.[33 34] The hospital is a teaching hospital that tailors health services for about 5 million clients from the central Gondar Zone and other neighbouring zones.

Study participants
Alive newborns right after birth to 72 hours of age were included. Nevertheless, newborns whose mothers were suffering from critical illnesses like postpartum haemorrhage were excluded. Similarly, newborns suffering from an illness and who were very and extremely preterm were excluded to ascertain LBW and stunting at birth. In addition, newborns whose length was less than 45 cm were excluded to determine wasting, overweight/obesity, concurrent WaSt and DBM.[35]

Sample size determination
The required sample size for investigating the prevalence of malnutrition was determined using Epi Info considering the single population proportion formula by taking the following statistical assumptions: proportion (p): 50%; CIs: 95%; margin of error: 5% and non-response: 10%.

n= $(Z\alpha/2)2$ p $(1-p)/d^2=(1.96)2$ (0.5) (0.5)/$(0.05)2$=which was increased to 384 after adding 10% of non-response. Thus, 422 mother–newborn pairs were invited and approached.

Sampling procedure and technique

An estimated 10 599 newborns were delivered at the University of Gondar Comprehensive Specialized Referral Hospital delivery ward per annum. For the purpose of the current study, we randomly selected 4 months (1 month from each of the four seasons). This season-based stratification was important because the number of birth varies throughout the four seasons; accordingly, an average of 884 live births was assumed to occur per month.[36] Systematic random sampling technique was employed and for sampling purposes, the value of 'K' (to be used as the length of the interval in systematic random sampling) was estimated using the formula N/n=884/422 and found to be 2.

Variables of the study

Outcome variables: stunting, wasting, concurrent WaSt, LBW, overweight/obesity and DBM.

Independent variables

Sociodemographic variables: age, marital status, residence, religion, maternal occupation, maternal education status and paternal education status.

Maternal-related factors: ANC visit, interbirth interval, maternal height, illness during pregnancy, mid-upper arm circumference (MUAC), gravidity, parity, gestational age, pregnancy intention and history of iron supplementation.

Newborn-related factors: sex, maturity status and birth status (singleton vs multiple).

Environmental factors: indoor fire smoke and season of conception.

Definition of variables
Outcome variables
Stunting: newborns whose length-for-gestational age measurement was <10 centile.[37]

LBW: newborns whose weight-for-gestational age was <10 centile.[37]

Wasting: newborns whose WHZ (weight-for-height) measurement was <(−2 SD).[16]

Concurrent WaSt: newborns who were concomitantly wasted and stunted.[4]

Overweight/obesity: newborns whose WHZ (weight-for-length) measurement was >(+2 SD).[16]

DBM: newborns who had overweight/obesity and stunting simultaneously.[16]

Independent variables
Maternal nutrition characteristics
Short maternal stature: mothers whose height measurement was <145 cm.[25]

Maternal undernutrition: mothers whose MUAC value was <22 cm.[38]

Anaemic woman: a woman whose haemoglobin measure was below 11 g/dL.[39]

Reproductive/obstetrics and maternal morbidity characteristics
Short interbirth interval: if the interval between the index birth and the older child is <24 months.[40]

Primigravida: a women who conceived for the first time.[41]

Multigravida: a woman who got pregnant more than once.[41]

Primiparous: a women who give birth one time.[41]

Multipara: a woman who gave birth more than once.[41]

Unintended pregnancy: if mothers reported the current pregnancy was unwanted or mistimed.[42]

Illness during pregnancy: mothers who had at least one of the following illnesses during pregnancy: diabetes mellitus, hypertension, anaemia, and infections like hepatitis B, HIV and TORCH.[27]

Wealth status: classified as richest, rich, middle, poorer and poorest, for participants who fall in the first, second, third, fourth and fifth ranks, respectively, using an index generated by the principal component analysis (PCA).[43]

Newborn characteristics
Term: newborns delivered between 37 and 42 weeks.[44]

Preterm: newborns delivered before completing 37 weeks.[44]

Data collection tool and procedures

A face-to-face structured and interviewer-administered questionnaire developed after reviewing different pieces of literature was used. Maternal illness during pregnancy and some newborn characteristics were collected through chart review. Various anthropometric measurements have been measured and collected. The newborns were placed in recumbent supine position and length was measured by two BSc nurses, one who assisted and supported to keep the head stable and the other who took the measurement from the top of the head to the heel of the foot. The procedure was repeated three times using infanto-metre (ITEM CODE: WS025 and SIZE18'X7'); the average length of the measurements was recorded to the nearest of 0·5 cm to ensure its accuracy. Likewise, the weight of the newborns was measured using a unit scale made by the UNICEF. The measurement was recorded at the nearest 10 g. All anthropometric measurements were taken within 72 hours of birth and analysed using the INTERGROWTH-21st project and the WHO software.[37]

Stunting and wasting

To measure stunting, the length of newborns with the corresponding gestational age was gathered, and a composite variable (length-for-gestational age) was generated using the INTEGROWTH-21st software. Similarly, wasting was ascertained through collecting the length and weight of a newborn to create a composite variable (length-for-weight) by using the WHO Anthro software.

Concurrent WaSt

The two outcome variables (stunting and wasting) were summed up to generate a variable, 'concurrent WaSt', after ascertaining the two outcome variables separately using the appropriate and corresponding composite variables.

Overweight/obesity

This was collected by measuring the length and weight of the newborns to produce a composite variable (length-for-weight) using WHO Anthro.

Double burden of malnutrition

DBM was generated by combining stunting and overweight/obesity.

Maternal height

The height of mothers was measured using a wall stadiometer in a standing position. The measurement was recorded to the nearest 0.5 cm.

Maternal MUAC

Maternal MUAC was measured by using fibre tape from the left upper arm at the midpoint between the tip of the shoulder (the acromion) and the tip of the elbow (the olecranon process). To ensure accuracy, repeated measurements with an increment of 0.1 cm were taken.

Wealth status

A questionnaire adapted from the Ethiopian Demographic and Health Survey, 2016 and other literature was used to collect all necessary data that can help to determine the wealth status of the study participants. The tool was comprised of the number and kinds of livestock that participants had, availability of agricultural land, the amount of cereal products they gathered (in tone), the amount of money deposited in the bank and availability of materials in their house. After recoding each of the variable to have a value of '0' or '1', the PCA was applied to construct wealth index.[43] Data were collected by two BSc midwives supervised by one MSc nurse who earned a degree in paediatric nursing.

Data quality control

We did a pretest at the University of Gondar Comprehensive Specialized Referral Hospital 2 weeks ahead of the actual data collection period by recruiting 21 eligible newborn–mother pairs. The quality of the data was assured through careful planning and using a properly translated questionnaire. The content of the questionnaire and extraction formats were reviewed by a senior paediatrician and paediatric nurse specialist to maintain the validity of the tool. Questions were checked for clarity, completeness, consistency and ambiguity; corrections were made accordingly.

One-day training was delivered to the data collectors and supervisor aiming at briefing the objective of the study, the anthropometric measurements and so forth. Anthropometric measurements were calibrated each day before starting data collection. Repeated anthropometric measurements have been taken and the average was considered. Furthermore, the principal investigator, together with the supervisor, has checked the collected data for its completeness and takes corrective measures on a daily basis.

Data processing and analysis

The collected data were entered into Epi Info 7 V.7.2.1.0 and exported to SPSS V.20 for coding, cleaning and analyses. Continuous independent variables were categorised. The household wealth status was determined using PCA. In doing this, all categorical and continuous variables were categorised so that the value for every variable gets either '0' or '1'. During extracting the underlying factors, factors with communality value of ≥0.5 and Eigenvalues of 1 were retained. Next, all eligible factor scores were computed using the regression-based method to generate one variable that stands for wealth status. The final scores were categorised into five quantiles namely: first, second, third, fourth and fifth, and they were, respectively, interpreted as richest, richer, middle, poorer and poorest, respectively.

The INTERGROWTH-21st software was used to analyse LBW and stunting. The newborn's length in centimetre and the corresponding gestational age were entered to produce 'stunting'; whereas weight in kilogram and the respective gestational age were entered so as to generate 'LBW'. Similarly, using the WHO Anthro software, the newborn's wasting status and overweight/obesity were analysed. The newborn's length, identification number, age (0 months), weight in kilogram and sex were entered to determine wasting and overweight/obesity. After generating the variables, the flags (Height-for-Age (HAZ) <(−5SD) and >(+5 SD)) were removed. The outcome variables were dichotomised and coded as '1' and '0', representing those who have the outcome variables (stunting, wasting, concurrent WaSt, LBW, overweight/obesity and DBM) and who did not, respectively. For continuous variables, age, for instance, the distributional assumption of normality was examined by the Shapiro-Wilk test to choose the appropriate measure of central tendency. Frequency, percentage, mean, and SD were used to describe demographic and other variables.

A X^2 test was employed and the binary logistic regression analysis was applied for variables that satisfy the X^2 test assumption. All variables, irrespective of their statistical significance in the bivariable analysis, were entered into the multivariable logistic regression model to control the possible effects of confounder/s.[45] Prior to identifying the significant factors, the presence of multicollinearity was examined using the Pearson correlation coefficient. The Hosmer and Lemeshow test was used to diagnose the model adequacy. Finally, in the multivariable regression analysis, variables having a p value of at most 5% were reported as having independent associations with the outcome variables, adjusted OR (AOR) with its corresponding 95% CI used as a measure of the strength and the direction of the association.

RESULTS

Sociodemographic characteristics

A total of 419 study participants were included to estimate stunting and LBW, making the response of 99.3%. After

Table 1 Sociodemographic characteristics of mothers who had delivered at the University of Gondar Comprehensive Specialized Referral Hospital, northwest Ethiopia, 2020

Characteristic		Number	Per cent
Age of mother	10–19	30	7.6
	20–35	309	78.4
	>35	55	14
Religion	Orthodox	339	86.0
	Muslim	55	14.0
Educational status of the mother	No schooling	108	27.4
	Primary school	75	19.0
	Secondary school	101	25.6
	Higher education	110	27.9
Educational status of the father	No schooling	92	23.4
	Primary school	87	22.1
	Secondary school	98	24.9
	Higher education	117	29.7
Occupation of mother	Government employee	95	24.1
	Housewife	255	64.7
	Merchant	44	11.2
Birth status	Single	385	97.3
	Multiple	9	2.7
Wealth index	Richest	75	19.0
	Richer	80	20.3
	Middle	78	19.8
	Poorer	80	20.3
	Poorest	81	20.6

Table 2 Maternal characteristics and anthropometric measurement of newborn–mother pairs recruited at the University of Gondar Comprehensive Specialized Referral Hospital, northwest Ethiopia, 2020

Characteristics		Number	Per cent
Iron intake during pregnancy	Yes	345	87.6
	No	49	12.4
Gravidity	Primigravida	118	29.9
	Multigravida	276	70.1
Parity	Primiparous	136	34.5
	Multiparous	258	65.5
Height of the mother	Tall	354	89.8
	Short	40	10.2
MUAC	Normal	256	65
	Chronic malnutrition	138	35
Birth status	Single	385	97.7
	Multiple	9	2.3
Illness during pregnancy	GDM	7	1.8
	PIH	35	8.9
	Anaemia	21	5.3

GDM, gestational diabetes mellitus; MUAC, mid-upper arm circumference; PIH, pregnancy-induced hypertension.

excluding extremely preterm newborns and those whose length was less than 45 cm, 394 newborns were considered to estimate wasting and overweight/obesity.[35] The sociodemographic and other relevant findings of stunting are available in the previously published article.[46] The mean age of the mothers was 27.51 (SD=5.46) years and 20.3% of mothers were from the poorer wealth group. Almost all (97.6%) participants were Amhara by ethnicity and 72.8% were urban dwellers.

Slightly lower than a quarter (24.1%) of the mothers were government employees and more than one-fourth (27.4%) of them had no schooling at all. The majority (97.3%) of the newborns were single birth and a bit higher than half (54.6%) of the newborns were male (table 1).

Maternal and anthropometric measurements
The majority of the mothers (94.4%) had at least one ANC visit and 87.6% of them had taken iron supplementation during pregnancy. More than two-thirds of the mothers (70.1%) were multigravidas, 34.5% were primiparous, 9.9% had a short interbirth interval and 8.9% had pregnancy-induced hypertension.

The mean birth weight of the newborns was 3080.20 (SD 457.97 g) while the median newborn's length was 48.0 cm at the second percentile. More than three-fourths (80.7%) of newborns had an appropriate birth weight for age. The mean maternal MUAC was 24.55 (SD 2.58 cm) and the median gestational age was 39 weeks at the second percentile. The mean height of the mother was 154.73 (SD 7.33 cm). Well over one-third (38.2%) of mothers were malnourished while 10.7% of them had short stature (table 2).

Environmental characteristics
A bit more than two-thirds (66.2%) of the newborns were conceived in Belg (spring) season and 15.5% of the mothers had been exposed to indoor fire smoke during the current pregnancy.

Prevalence of malnutrition
A bit higher than a quarter (26.6%) of newborns is stunted, while the tiny proportion (2.5%) of newborns is both wasted and stunted (figure 1).

Factors associated with malnutrition among newborns
As presented in the table below, variables denoted by 'N/A' are those that did not fulfil the X^2 assumption. Since all variables for concurrent WaSt as well as the DBM fail the X^2 assumption, only descriptive findings are reported.

The odds of LBW were more than twofold (AOR=2.8; 95% CI: 1.19 to 6.65) higher for newborns whose fathers
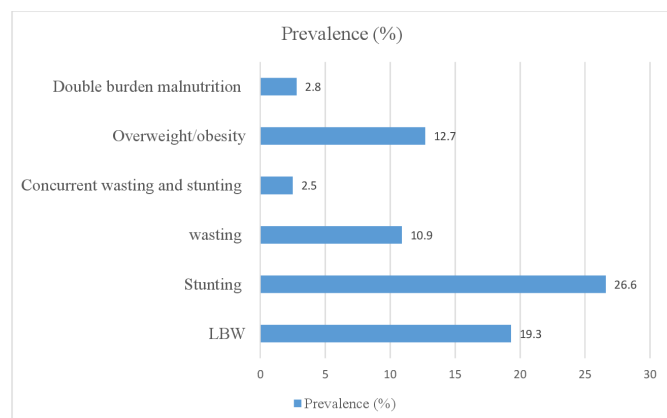
Figure 1 A figure depicting the burden of malnutrition among newborns delivered at the University of Gondar Comprehensive Specialized Referral Hospital, northwest Ethiopia, 2020. LBW, low birth weight.

had attained a primary level of education than newborns whose fathers attained a higher level of education. Likewise, the odds of having LBW were higher among stunted newborns (AOR=3.1; 95% CI: 1.6 to 6.0) as compared with non-stunted newborns. The risk of overweight/ obesity was reduced by 65% (AOR=0.35; 95% CI: 0.12 to 0.99) among newborns whose mothers were from rural as compared with urban dwellers. None of the investigated variables were statistically associated with wasting at birth (table 3).

DISCUSSION

The deleterious effect of undernutrition on children is well-established evidence and it is more severe among children having the concurrent form of the nutritional disorder. Malnutrition at birth has a permanent life-threatening impact on the physical health and cognitive performance of children.[47] A newborn's malnutrition is the main testimony for improper prenatal nutrition and a powerful predictor of infant survival.[48 49] The risk of mortality among newborns with multiple anthropometric deficits is higher than those having a single nutritional problem.[50] Studies aiming to estimate the prevalence of multiple forms of malnutrition and factors have a paramount impact on battling malnutrition at birth.[51] Thus, this study aimed at estimating both undernutrition and overnutrition among newborns.

The study highlights that just over 1 in every 10 (12%) and 26.6% of newborns were overweight/obese and stunted, respectively. Besides, about 28 newborns from 1000 have DBM. This suggests that DBM is becoming an emerging challenge in impoverished areas of the world, including Ethiopia.[52] In stunted newborns, there are impaired fat oxidation and low-resting energy expenditure, thus the result of these adaptations could facilitate fat storage and being overweight that drove children to DBM.[22 53] The implication is that the intrauterine period is a window of opportunity to tackle the concomitant occurrence of stunting and overweight/obesity.

The study has also evidenced that 26.6% and 10% of newborns experienced stunting and wasting, respectively. Similarly, 2.5% of newborns have concurrent (WaSt) forms of malnutrition. The burden was highly prevalent among newborns born to chronically malnourished mothers and newborns who were small for gestational age, which was also the case in previous findings.[22 48] The growth and development of the fetus is the interaction between the intrinsic growth pattern itself and environmental factors, including maternal and paternal genetics, maternal size and the capacity of the placenta to supply essential nutrients that enable the fetus to mature.[25] Although malnutrition among newborns is the interwoven effect of the aforementioned important factors, the nutritional status of mothers, both low pre-pregnancy Body Mass Index (BMI) and insufficient gestational weight gain, take the biggest share of the problem.[54] Parental genetics and having a healthy and capable placenta to supply nutrients are not the guaranty to attain the nutritional requirement of the fetus unless the mother has all the essential nutrients to be provided.[27] Likewise, wasting and stunting are often present in a similar population and they share many causal factors.[8 9] Hence, the promotion of maternal nutrition should be considered to reduce the problem of 'multiple anthropometric deficits' of newborns that risks them to serious morbidity as well as mortality.[9] Investing in methods that make the intrauterine growth as healthy as possible through maintaining gestational weight gain as per the pre-pregnancy BMI could be one strategy that professionals in the field should consider. This might be the way forward to end childhood malnutrition.

The proportion of newborns in the current study having LBW is relatively higher than the pooled prevalence reported in 30 studies in Ethiopia.[55] Various factors might be considered to explain the observed difference. The former finding was an aggregate of various studies from different settings with better economic status while the current study was conducted in the poorest region of the country.[55] The method used across these studies is also distinct; the current study ascertained LBW by adjusting for the length of the newborns for the corresponding gestational age, unlike the previous studies that used simply the weight of the baby without considering the effect of the maturity level (gestational age) on birth weight. In light of the observed arguments, it is recommended for future scholars to consider the gestational age while determining LBW and stunting to bring credible evidence and avoid misleading data.[37]

In agreement with the previous study, this study underscores that a low level of paternal education is significantly associated with increased odds of LBW.[56] Better social support is one of the factors that positively contributes to pregnancy care and a healthy pregnancy period. In this respect, fathers are the most intimate and responsible people to provide the required social support for their pregnant wives to have a healthy pregnancy and healthier newborn.[57]

Table 3 Summary findings from multivariable logistic regression where outcomes are wasting, low birth weight and overweight/obesity of newborns delivered at the University of Gondar Comprehensive Specialized Referral Hospital, northwest Ethiopia

Variables	Low birth weight		Wasting only		Overweight/obesity	
	AOR	95% CI	AOR	95% CI	AOR	95% CI
Age						
<19	0.46	0.15 to 1.39	N/A	N/A	N/A	N/A
20–35	1	1	N/A	N/A	N/A	N/A
>35	0.87	0.39 to 1.90	N/A	N/A	N/A	N/A
Residence						
Rural	1.37	0.62 to 3.03	1.12	0.49 to 2.54	0.35*	0.12 to 0.99
Urban	1	1	1	1	1	1
Religion						
Muslim	1.12	0.49 to 2.52	2.07	0.66 to 6.48	1.24	0.39 to 4.01
Orthodox			1	1	1	1
Educational status of the father						
No schooling	1.48	0.42 to 5.14	1.02	0.23 to 0.46	0.48	0.12 to 2.19
Primary	2.82*	1.19 to 6.65	0.72	0.19 to 2.62	0.59	0.17 to 2.00
Secondary	1.95	0.71 to 5.36	1.64	0.61 to 4.38	0.68	0.25 to 1.85
Higher education	1	1	1	1	1	1
Educational status of the mother						
No schooling	1.36	0.35 to 5.32	2.54	0.45 to 14.41	1.41	0.25 to 8.09
Primary	0.52	0.15 to 1.78	1.65	0.34 to 8.18	1.63	0.35 to 7.59
Secondary	1.22	0.45 to 3.30	2.56	0.72 to 9.12	0.85	0.24 to 2.98
Higher education	1	1	1	1	1	1
Occupation of the mother						
Government employee	1	1	1	1	1	1
Merchant	1.17	0.43 to 3.19	0.52	0.21 to 1.98	0.33	0.09 to 1.18
Housewife	0.71	0.21 to 2.44	0.79	0.09 to 7.05	0.92	0.24 to 3.45
Wealth index						
Richest	1	1	1	1	1	1
Richer	0.9	0.40 to 2.06	0.69	0.25 to 1.98	2.02	0.69 to 5.89
Middle	1.07	0.48 to 2.44	0.62	0.21 to 1.83	1.20	0.41 to 3.58
Poorer	1.44	0.63 to 3.27	0.75	0.26 to 2.19	1.35	0.45 to 4.03
Poorest	0.45	0.17 to 1.18	1.12	0.40 to 3.04	1.53	0.50 to 4.69
Sex of the newborn						
Male	0.97	0.57 to 1.66	0.90	0.46 to 1.75	1.01	0.56 to 1.99
Female	1	1	1	1	1	1
Iron intake during pregnancy						
Yes	1	1	1	1	1	1
No	0.86	0.32 to 2.34	0.60	0.19 to 1.89	0.75	0.26 to 2.16
Parity						
Multipara	0.58	0.32 to 1.6	0.32	0.04 to 2.63	1.37	0.27 to 6.90
Primiparous	1	1	1	1	1	1
ANC						
Yes	1	1	N/A	N/A	N/A	N/A
No	1.45	0.36 to 5.79	N/A	N/A	N/A	N/A

Continued

Table 3 Continued

Variables	Low birth weight		Wasting only		Overweight/obesity	
	AOR	95% CI	AOR	95% CI	AOR	95% CI
Intention of pregnancy						
Not intentional	0.99	0.37 to 2.65	N/A	N/A	N/A	N/A
Intentional	1	1	N/A	N/A	N/A	N/A
Height of the mother						
Short	0.61	0.26 to 1.47	N/A	N/A	N/A	N/A
Tall	1	1	N/A	N/A	N/A	N/A
MUAC						
Malnutrition	0.72	0.37 to 1.39	1.5	0.60 to 2.63	0.97	0.48 to 1.95
Normal	1	1	1	1	1	1
Length for age						
Short for age	3.17	1.6 to 6.0†	N/A	N/A	N/A	N/A
Normal	1	1	N/A	N/A	N/A	N/A
Season of conception						
Kiremt/winter	0.83	0.46 to 1.48	0.88	0.45 to 1.77	0.92	0.48 to 1.78
Bega/summer	1	1	1	1	1	1
Exposed to indoor fire smoke						
Yes	0.59	0.27 to 1.28	1.92	0.63 to 5.84	1.01	0.39 to 2.56
No	1	1	1	1	1	1

N/A=variables that do not fulfil the X^2 assumption.
*P≤0.05=strong association.
†P≤0.0001=very strong association.
ANC, antenatal care; AOR, adjusted OR; MUAC, mid-upper arm circumference; N/A, not applicable.

Higher level educational attainment of fathers has a significant positive influence on their health service utilisation and healthy practices are better.[58] In Ethiopia, where there is a low literacy level, the problem is likely affecting thousands of newborns if special emphasis is not in place. Likewise, stunted newborns in the current study tripled the risk of LBW, which was not indicated in previously conducted studies. Different nutritional deficits share similar risk factors; the same is true for LBW and stunting where the pre-pregnancy weight and gestational weight gain highly determine their occurrence.[16] Given the higher risk of comorbid illnesses and mortality in newborns with the combined nutritional problems, urgent public health measures should be considered.[20]

In the current study, there were significantly higher odds of overweight/obesity among mothers of newborns residing in an urban area as compared with rural areas, which is in line with the previous report. The rapid increase in overweight/obesity is indicated in urban areas of Ethiopia, asserting it is a major public health concern.[59] The difference in dietary intake and physical activity could be among the key drivers for the observed urban and rural variation.[60] Mothers in rural areas of Ethiopia stay engaged in different laborious household and agricultural activities until they give birth that will make them unable to gain optimal gestational weight.[60] In urban areas, however, mothers usually spend their pregnancy period resting, watching television for a long time, and consuming fortified and manufactured meal products, which collectively put them at risk of attaining high pregnancy weight and ultimately give birth to obese/overweight newborns.[61] Healthcare providers should, therefore, provide nutrition education for pregnant women along with ANC that mainly focuses on dietary behaviour and dietary preference.

The study has some strengths and admissible limitations. One of the strengths of the current study is providing comprehensive evidence of different anthropometric deficits and their combined occurrence among newborns in a setting where there was no such evidence previously. However, owing to the inaccessibility of data, we did not assess the pre-pregnancy weight and weight gain during pregnancy of mothers, which is presumed to be one of the best indicators of the nutritional status of newborns. Though various strategies were used to control different sources of biases including recall bias, the findings are not completely free from various biases that might have impacted the findings.

CONCLUSION

The study remarks that malnutrition among newborns in Ethiopia is a public health problem. Fathers' educational status (low level) and being stunted are associated with a high burden of LBW. Mothers' residency (being urban) elevated the risk of overweight/obesity among newborns. Thus, improving the literacy of fathers and preventing stunting through maintaining intrauterine nutrition are recommended to mitigate LBW while paying special attention to newborns born from urban resident mothers is necessary to reduce the burden of overweight/obesity. Future scholars in the field are recommended to conduct longitudinal studies to look at the effect of malnutrition at birth on the later nutritional status as well as the growth and development of the victims. Further, it is recommended to ascertain the nutritional status of the newborns (LBW and stunting) using the INTERGROWTH-21st software to account for the gestational age of the newborns.

ORCID iDs
Almaz Tefera Gonete http://orcid.org/0000-0001-8854-1394
Eskedar Getie Mekonnen http://orcid.org/0000-0002-8558-1718
Wubet Worku Takele http://orcid.org/0000-0003-3121-5808

REFERENCES

1. Ijarotimi OS. Determinants of childhood malnutrition and consequences in developing countries. *Curr Nutr Rep* 2013;2:129–33.
2. Nandy S, Irving M, Gordon D, *et al*. Poverty, child undernutrition and morbidity: new evidence from India. *Bull World Health Organ* 2005;83:210–6.
3. Ferreira HdaS, da Silva Ferreira H. Anthropometric assessment of children's nutritional status: a new approach based on an adaptation of Waterlow's classification. *BMC Pediatr* 2020;20:65.
4. Mwangome M, Ngari M, Bwahere P, *et al*. Anthropometry at birth and at age of routine vaccination to predict mortality in the first year of life: a birth cohort study in BukinaFaso. *PLoS One* 2019;14:e0213523.
5. United Nations Children's Fund (UNICEF) WHO, International Bank for Reconstruction and Development/The World Bank. *Levels and trends in child malnutrition: key findings of the 2020 edition of the joint child malnutrition estimates*. Geneva: World Health Organization, 20202020. https://www.who.int/publications/i/item/jme-2020-edition
6. Abarca-Gómez L, Abdeen ZA, Hamid ZA, *et al*. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet* 2017;390:2627–42.
7. Novotny R, Li F, Leon Guerrero R, Guerrero RL, *et al*. Dual burden of malnutrition in US affiliated Pacific jurisdictions in the children's healthy living program. *BMC Public Health* 2017;17:483.
8. Khara T, Mwangome M, Ngari M, *et al*. Children concurrently wasted and stunted: A meta-analysis of prevalence data of children 6-59 months from 84 countries. *Matern Child Nutr* 2018;14:e12516.
9. Myatt M, Khara T, Schoenbuchner S, *et al*. Children who are both wasted and stunted are also underweight and have a high risk of death: a descriptive epidemiology of multiple anthropometric deficits using data from 51 countries. *Arch Public Health* 2018;76:28.
10. Bank UWW. *Ethiopia's stunting prevalence compared with selected regions of the world*, 2018.
11. ICF EPHIEEa. *Ethiopia mini demographic and health survey 2019: key indicators*. Rockville, Maryland, USA: EPHI and ICF, 2019.
12. AU C. *The cost of hunger in Ethiopia: the social and economic impact of child undernutrition in Ethiopia summary report*, 2013.
13. Laillou A, Baye K, Meseret Z, *et al*. Wasted children and wasted time: a challenge to meeting the nutrition sustainable development goals with a high economic impact to Ethiopia. *Nutrients* 2020;12:3698.
14. UNICEF. Monitoring the situation of children and women. malnutrition, 2018. Available: http://data.unicef.org/nutrition/malnutrition.html
15. Olofin I, Flaxman SR, Mascarenhas MN. Associations of suboptimal growth with all-cause and cause-specific mortality in children under five years: a pooled analysis of ten prospective studies. *Prevalence* 2012;1:10Z.
16. Okubo T, Janmohamed A, Topothai C, *et al*. Risk factors modifying the double burden of malnutrition of young children in Thailand. *Matern Child Nutr* 2020;16 Suppl 2:e12910.
17. Mutunga M, Frison S, Rava M, *et al*. The forgotten agenda of wasting in Southeast Asia: burden, determinants and overlap with stunting: a review of nationally representative cross-sectional demographic and health surveys in six countries. *Nutrients* 2020;12:559.
18. Berkman DS, Lescano AG, Gilman RH, *et al*. Effects of stunting, diarrhoeal disease, and parasitic infection during infancy on cognition in late childhood: a follow-up study. *Lancet* 2002;359:564–71.
19. Ozanne SE, Hales CN. The long-term consequences of intra-uterine protein malnutrition for glucose metabolism. *Proc Nutr Soc* 1999;58:615–9.
20. United Nations Children's Fund (UNICEF) WHO, International Bank for Reconstruction and Development/The World Bank. *Malnutrition*, 2020.
21. Masood JS. *The effect of infant malnutrition on future learning outcomes of children in developing countries*. Georgetown University, 2019.
22. Black RE, Victora CG, Walker SP, *et al*. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013;382:427–51.
23. Victora CG, de Onis M, Hallal PC, *et al*. Worldwide timing of growth faltering: revisiting implications for interventions. *Pediatrics* 2010;125:e473–80.
24. United Nations Children's Fund (UNICEF) WHO, International Bank for Reconstruction and Development/The World Bank. *Levels and*

trends in child malnutrition: key findings of the 2020 edition of the joint child malnutrition estimates. Licence: CC BY-NC-SA 3.0 IGO 2020. Geneva: World Health Organization, 2020. https://www.who.int/publications-detail-redirect/jme-2020-edition

25 Sumarmi S. *Maternal short stature and neonatal stunting: an inter-generational cycle of malnutrition*, 2016.

26 Leroy JL, Olney DK, Ruel MT. PROCOMIDA, a Food-Assisted maternal and child health and nutrition program, contributes to postpartum weight retention in Guatemala: a cluster-randomized controlled intervention trial. *J Nutr* 2019;149:2219–27.

27 CDC. Pregnancy complications, 2018. Available: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/pregnancy-complications.html

28 Kuhnt J, Vollmer S. Antenatal care services and its implications for vital and health outcomes of children: evidence from 193 surveys in 69 low-income and middle-income countries. *BMJ Open* 2017;7:e017122.

29 Workicho A, Belachew T, Argaw A, *et al*. Adolescent pregnancy and linear growth of infants: a birth cohort study in rural Ethiopia. *Nutr J* 2019;18:22.

30 Solomons NW, Vossenaar M, Chomat A-M, *et al*. Stunting at birth: recognition of early-life linear growth failure in the Western highlands of Guatemala. *Public Health Nutr* 2015;18:1737–45.

31 Rashad AS, Sharaf MF. Does maternal employment affect child nutrition status? new evidence from Egypt. *Oxford Development Studies* 2019;47:48–62.

32 WHO. Global target tracking tool, 2015. Available: http://www.who.int/nutrition/trackingtool

33 NP.Commission. *Ethiopia's Progress towards Eradicating Poverty: an Interim Report on 2015/16 Poverty Analysis Study*, 2017.

34 Jazeera AA. *Amhara region not only the poorest in Ethiopia but also in the world*, 2014.

35 WHO. *Any mention of the software in published reports should include the following citation of the source: WHO Anthro for personal computers, version 3.2.2, 2011: Software for assessing growth and development of the world's children*. Geneva, 2010. https://www.who.int/childgrowth/software/anthro_pc_manual_v322.pdf

36 Hospital UoGCSR. *Annual delivery report of Gondar university Comprhensive and Referal hospitals*, 2019.

37 Villar J, Cheikh Ismail L, Victora CG, *et al*. International standards for newborn weight, length, and head circumference by gestational age and sex: the newborn cross-sectional study of the INTERGROWTH-21st project. *Lancet* 2014;384:857–68.

38 Kruger HS. Maternal anthropometry and pregnancy outcomes: a proposal for the monitoring of pregnancy weight gain in outpatient clinics in South Africa. *Curationis* 2005;28:40–9.

39 World Health Organization,. *Immunization, vaccines, and biologicals: implementation research in immunization*, 2017.

40 WHO. *Report of a who technical consultation on birth spacing Geneva, Switzerland*, 2005.

41 Opara EI, Zaidi J. The interpretation and clinical application of the word 'parity': a survey. *BJOG* 2007;114:1295–7.

42 Fite RO, Mohammedamin A, Abebe TW. Unintended pregnancy and associated factors among pregnant women in Arsi Negele Woreda, West Arsi zone, Ethiopia. *BMC Res Notes* 2018;11:671.

43 CSA I. *Central Statistical Agency (CSA) [Ethiopia] and ICF,Ethiopia demographic and health survey*. Addis Ababa, Ethiopia and Calverton, Maryland, USA, 2016.

44 Federal HIV/AIDS Prevention and Control Office Federal Ministry of Health July. Guidelines for HIV counselling and testing in Ethiopia, 2007. Available: https://www.who.int/hiv/topics/vct/ETH_HCT_guidelinesJune26_clean.pdf

45 Sun GW, Shook TL, Kay GL. Inappropriate use of bivariable analysis to screen risk factors for use in multivariable analysis. *J Clin Epidemiol* 1996;49:907–16.

46 Gonete AT, Kassahun B, Mekonnen EG, *et al*. Stunting at birth and associated factors among newborns delivered at the University of Gondar comprehensive specialized referral hospital. *PLoS One* 2021;16:e0245528.

47 Khalatbari-Soltani S, Marques-Vidal P. The economic cost of hospital malnutrition in Europe; a narrative review. *Clin Nutr ESPEN* 2015;10:e89–94.

48 Bosquet Enlow M, Sideridis G, Bollati V, *et al*. Maternal cortisol output in pregnancy and newborn telomere length: evidence for sex-specific effects. *Psychoneuroendocrinology* 2019;102:225–35.

49 Boah M, Azupogo F, Amporfro DA, *et al*. The epidemiology of undernutrition and its determinants in children under five years in Ghana. *PLoS One* 2019;14:e0219665.

50 Wells JC, Sawaya AL, Wibaek R, *et al*. The double burden of malnutrition: aetiological pathways and consequences for health. *Lancet* 2020;395:75–88.

51 Santos MP, Turner B, Chaparro MP. The double burden of malnutrition in Peru: an update with a focus on social inequities. *Am J Clin Nutr* 2021;113:865–73.

52 Gubert MB, Spaniol AM, Segall-Corrêa AM, *et al*. Understanding the double burden of malnutrition in food insecure households in Brazil. *Matern Child Nutr* 2017;13:e12347.

53 Jayalakshmi R, Kannan S. The double burden of malnutrition: an assessment of 'stunted child and overweight/obese mother (SCOWT) pairs' in Kerala households. *J Public Health Policy* 2019;40:342–50.

54 Sumarmi S. *Editor maternal short stature and neonatal stunting: an inter-generational cycle of malnutrition. Dalam proceeding of international Conference on health and well being*, 2016.

55 Endalamaw A, Engeda EH, Ekubagewargies DT, *et al*. Low birth weight and its associated factors in Ethiopia: a systematic review and meta-analysis. *Ital J Pediatr* 2018;44:1–12.

56 Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. *Bull World Health Organ* 1987;65:663.

57 Wado YD, Afework MF, Hindin MJ. Effects of maternal pregnancy intention, depressive symptoms and social support on risk of low birth weight: a prospective study from southwestern Ethiopia. *PLoS One* 2014;9:e96304.

58 Agushybana F. Influence of husband support on complication during pregnancy and childbirth in Indonesia. *Journal of Health Research* 2016;30:249–55.

59 Tebekaw Y, Teller C, Colón-Ramos U. The burden of underweight and overweight among women in Addis Ababa, Ethiopia. *BMC Public Health* 2014;14:1–11.

60 Abrha S, Shiferaw S, Ahmed KY. Overweight and obesity and its socio-demographic correlates among urban Ethiopian women: evidence from the 2011 EDHS. *BMC Public Health* 2016;16:1–7.

61 Desalew A, Mandesh A, Semahegn A. Childhood overweight, obesity and associated factors among primary school children in dire dawa, eastern Ethiopia; a cross-sectional study. *BMC Obes* 2017;4:1–10.