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The Coexistence of Malnutrition and Anemia and its Effect on Early Childhood Development among Children Aged 36-59 Months in Cambodia

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ABSTRACT

Introduction

Early-life undernutrition has been linked to poor long-term physical and cognitive development in children. A significant number of children under 5 years of age in Cambodia also suffer from anemia. However, studies examining the concomitant effects of undernutrition and anemia on children's early development in the country are scarce. The current study aims to assess the association between malnutrition and anemia and early childhood development.

Methods

Using a subset of data from the 2014 Cambodia Demographic and Health Survey pertaining to children aged 36-59 months (n = 1733), we computed the prevalence of stunting, wasting, and anemia. We performed logistic regression to examine the relationship between being developmentally on track, based on their early childhood development index (ECDI) score, and malnutrition/anemia status, adjusting for confounders (child's age, sex, low birth weight status, activities that promote child's learning, mother's education, mother's age, residence location and wealth index).

Results

The prevalence of stunting, wasting and anemia was 36.5% (n = 633), 8.7% (n = 152), and 43.2% (n = 749), respectively. In logistic regression, after adjusting for confounders, children with both malnutrition and anemia were less likely to be developmentally on track than children who were neither malnourished nor anemic, adjusted OR = 0.62 (95% CI: 0.40, 0.96).

Conclusion

The current study confirms that early childhood undernutrition could have detrimental effects on children's physical and cognitive development and that adding anemia could significantly worsen their early development.

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Introduction

According to the 2021 Global Nutrition Report, 149.2 million and 45.4 million children under the age of 5 are stunted and wasted, respectively [1]. Anemia is another highly prevalent public health problem affecting approximately 25% of the world's population, especially preschool-aged children [2]. With a prevalence of 47% among children aged 0-5 years [3], the World Health Organization (WHO) recognized anemia as a "severe" public health problem [2]. With an estimation of approximately 40% (or 59 million children) and 53% (or 27 million children) of stunted and wasted children, respectively, some parts of Asia, especially South Asia, harbor a very high burden of children's undernutrition and the highest burden of anemia [4].

In the era of the Millennium Development Goals (MDGs), nutrition had been ''one of the great missed opportunities'' [5], and recently, multiple reviews also suggested that various types of undernutrition, such as stunting and wasting, should be examined together instead of viewing them as a separate issue, as often times, they occur in the same population and share common risk factors [6]. Likewise, the coexistence of conditions such as anemia (which can be in part nutritionally related and is highly prevalent among children under 5) and undernutrition should also be jointly investigated.

The latest Cambodia Demographic and Health Survey (CDHS), which was conducted in 2014, reported several nutritional indicators for children under age 5. This population's prevalence of stunting and wasting was 32% and 10%, respectively [7]. Anemia is also common in the Cambodian population and was found in 45% of women aged 15-49 years and 56% of children aged 6-59 months [7]. Despite being both prevalent, the extent to which the coexistence of malnutrition and anemia, whether or not nutritionally related, affects children's development has not been extensively explored in previous research.

Cognitive ability in early life affects how people think, reason, understand and remember information, solve problems, and learn as they grow up and predicts later cognitive competence [8]. Understanding how various forms of undernutrition (not only stunting) could affect a child's cognitive development is of extreme importance. This is such a clear knowledge gap that the United Nations International Children's Emergency Fund (UNICEF) Regional Office for South Asia even assigned analyses of the association between anthropometric failure and child development in 2017 [4], as much of the evidence about brain development is from research conducted in high-income countries (HICs) [9].

The assessment of the coexistence of malnutrition and anemia in childhood development is evidently needed among Cambodian children to help identify children who might be at increased risk of suboptimal development and encourage discussion and preparation from policy makers as well as other stakeholders in an attempt to halt this obstacle to future human capacity building in Cambodia.

Methods

A. Data source and study population

The current study used a subset of data from the 2014 CDHS, in which the unit of analysis was children aged 36-59 months (weighted n = 1733), from the CDHS-KR file. Detailed information on the DHS survey methodology and questionnaire can be found in the CDHS report [7] and on the DHS website (www.dhsprogram.com/data/Using-Datasets-for-Analysis.cfm).

B. Definitions and classifications

1. Public Health Measures

Malnutrition in the current study refers to stunting, wasting or both. Children were then classified into each of these categories based on the WHO's standards [10]. Children considered stunted and wasted when their height-for-age-z score (HAZ) and weight-for-height-z score (WHZ) were <-2 SD, respectively, compared with the WHO reference population. Anemia was defined based on hemoglobin levels (Hb). A child is considered anemic if he/she has Hb <11 g/l [11].

The exposure under study has three categories (levels): children with neither malnutrition nor anemia, children with either malnutrition or anemia and children with both malnutrition and anemia. The first group represents an unexposed group (reference), whereas the last two groups were both exposed (high risk), but those with both malnutrition and anemia were considered the highest-risk category.

2. Early Childhood Development (ECD)

The early childhood development index (ECDI) is a new module that was incorporated into the 2014

CDHS questionnaire. The development of the questionnaire to assess early child development was tasked with the UNICEF when early childhood development became a part of the SDGs in 2015 to track the progress of this SDG indicator [12]. The details of the questionnaire on ECDI 2030 are available on the UNICEF website at https://data.unicef.org/resources/early-childhood-development-index-2030-ecdi2030.

Although the new ECDI (namely, ECDI 2030) consisted of 20 questions on the behaviors, skills and knowledge of children between the ages of 36-59 months, the ECDI in the 2014 CDHS questionnaire was a shorter version of the questionnaire and contained only 10 questions, which evaluates a child's early development in four domains (which are the same as the new ECDI 2030): literacy-numeracy, physical, learning and social-emotional [13, 14]. Each of the ECDI domains is composed of a series of yes/no questions for parents/caregivers, and based on the answer given, each domain is scored either 0 – "not developmentally on track" or 1 – "developmentally on track" for that specific domain. The overall early childhood development is then determined from the combination of all four domains. The UNICEF classified children as developmentally "on track" if they are on track in at least three out of the four domains, and children who do not fit this definition are considered "at risk" [14]. The details on the questions used to evaluate ECDI can be found in the 2014 CDHS report [7]:

1) Literacy-numeracy: Children are evaluated based on whether they can identify/name at least 10 letters of the alphabet; whether they can read at least four simple, popular words; and whether they know the names and recognize the symbols of all numbers from 1 to 10. If at least two of these capabilities are observed, the child is considered developmentally on track.

2) Physical: If the child can pick up a small object such as a stick or a rock from the ground with two fingers and/or the mother does not indicate that the child is sometimes too sick to play, then the child is regarded as being developmentally on track in the physical domain.

3) Social-emotional: A child is considered to be developmentally on track if two of the following are true: the child gets along well with other children; the child does not kick, bite, or hit other children; and the child does not become distracted easily.

4) Learning: If the child follows simple directions on how to do something correctly and/or when given something to do and is able to do it independently, then the child is considered to be developmentally on track in this domain

3. Sociodemographic and other risk factors

Maternal information, including education, age, socioeconomic status (wealth index), BMI (calculated from heights and weights), smoking and anemia status, was also collected.

4. Power calculation

The present study has more than 90% power to detect the difference in the proportion of children who were considered developmentally on track in at least three out of four ECDI domains among exposed children (those with both malnutrition and anemia) and unexposed children (those with neither malnutrition nor anemia). However, the study was underpowered to examine the difference in the proportion of children who were considered developmentally on track in at least three out of four ECDI domains among those with either malnutrition or anemia and those who were unexposed. Power calculation was performed using the online calculator available from https://www.openepi.com/Power/PowerCross.htm.

5. Statistical analysis

We calculated the means and percentages of continuous and categorical variables, respectively, by malnutrition and anemia status (exposure status under study). We examined the effect of malnutrition and anemia on children's early childhood development by performing a logistic regression, adjusting for potential confounding variables, such as the child's age, sex, low birth weight status, activities that promote the child's learning, mother's education, age, residence location (rural vs. urban) and wealth index. Using the logistic procedure, goodness-of-fit tests were used to assess the global fitness of the specified model. All test results (except the Deviance test) suggested that the model fits adequately, and the Hosmer and Lemeshow Goodness-of-Fit Test for logistic regression showed that the specified model was adequate ($P = 0.6049$).

All analyses were conducted using SAS Studio (SAS University Edition by ©SAS Institute Inc., USA), which had been replaced by SAS® OnDemand starting from August 2021. Appropriate

sampling weights were applied (accounting for complex survey design effects) in all calculations.

6. *Ethical considerations*

The survey data were deidentified, with no individual names or household addresses in the data files. Each enumeration area (primary sampling unit or PSU) has a PSU number in the data file, but the PSU numbers do not have any labels that allow the geographic locations or names to be identified. The current study was also approved by the National Ethics Committee for Human Research in Cambodia (NECHR #298).

Results

A. Socio-demographics

Table 1 describes selected sociodemographic characteristics of children and their mothers by malnutrition and anemia status of the first. The age and sex distribution of children under study were more or less comparable across the three groups. Boys accounted for 52.4% (n = 304) in the normal children group (no malnutrition or anemia), 48.3% (n = 347) in children who were either malnourished or anemic and approximately 51.3% (n = 178) among those who had both malnutrition and anemia. The mean age of the children was approximately 47.6 months (SD = 0.3) for the first two groups and slightly older, 46.5 months (SD = 0.4), for the third group.

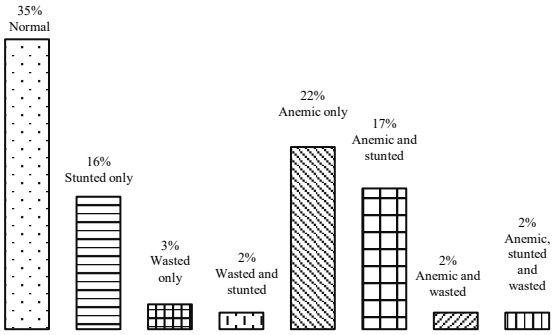
Table 1: Sociodemographic characteristics of mothers and children aged 36-59 months, Demographic and Health Survey (n^a = 1733), Cambodia, 2014

	Neither anemia nor malnutrition (n^a = 580)		**Either anemia or malnutrition (n^a = 719)**		**Anemia and malnutrition (n^a = 346)**	
	n^a	%[a]	n^a	%[a]	n^a	%[a]
Socio-demographics						
Gender						
Boy	304	52.4	347	48.3	178	51.3
Girl	276	47.6	372	51.7	169	48.7
Child's age in months (mean, SD)	(47.6, 0.3)		(47.6, 0.3)		(46.5, 0.4)	
36-47 months	284	49.0	367	51.1	192	55.3
49-59 months	296	51.0	352	48.9	155	44.7
Maternal age (mean, SD)	(30.1, 0.3)		(30.1, 0.3)		(30.4, 0.4)	
15-24 years	115	19.8	118	16.5	65	18.8
25-34 years	343	**59.2**	464	**64.5**	199	**57.5**
35-44 years	113	19.5	125	17.4	74	21.4
45-49 years	11	1.5	10	1.6	8	2.2
Mother's education						
None	76	13.0	111	15.5	59	17.1
Primary	315	54.4	388	54.0	225	65.0
Secondary or higher	189	32.6	220	30.5	62	17.9
Mother's occupation						
Agri-self-employed	201	34.7	300	41.7	150	43.4
Sale	117	20.1	114	15.8	40	11.6
Unemployed	113	19.5	131	18.2	75	21.7
Skilled manual	92	15.9	120	16.7	63	18.4
Professional, technical, managerial	25	4.3	23	3.2	6	1.9
Services	19	3.3	23	3.1	7	1.9
Unskilled manual	8	1.4	8	1.1	3	0.8
Clerical work	4	0.8	1	0.2	1	0.3
Wealth index						
Poorest	117	20.2	209	29.0	115	33.3
Poorer	100	17.3	165	22.9	82	23.7
Middle	117	20.1	113	15.7	69	20.0
Richer	99	17.1	122	17.0	54	15.5
Richest	147	25.3	111	15.4	26	7.4
Residence location						
Urban	101	17.5	78	10.8	28	8.2
Rural	478	**82.5**	642	**89.2**	318	**91.8**

SD, standard deviation.
Anemia was defined as having Hb levels <11 g/dl.
Malnutrition, either stunted or wasted or both.
[a] Weighted *n* and %, might exceed totals due to rounding.

B. Prevalence of anemia, malnutrition and their coexistence

Overall, the prevalence of anemia among Cambodian children aged 36-59 months was found to be 43% (n = 721), stunting was approximately 37% (n = 633) and wasting was 9% (n = 152). We also present the distribution of children's malnutrition status and anemia separately in **Figure 1**.



Source: Demographic and Health Survey (n = 1733), Cambodia, 2014

Figure 1: Distribution of stunting, wasting and anemia and their coexistence among children aged 36-59 months

C. Maternal and child risk factors

The majority of mothers were non-smokers (> 90%) and were not underweight (<10%) across the three groups of children **(Table 2)**, with the exception of those whose children were in the group with both malnutrition and anemia, where smoking prevalence was approximately 10.6% (n = 37) and underweight mothers accounted for 16.7% (n = 58). Low birth weight was approximately 5.4% (n = 30) and 7.9% (n

= 51) among all children who were neither malnourished nor anemic and those with either malnutrition or anemia, respectively.

Table 2: Selected risk factors for mothers and children aged 36-59 months, Demographic and Health Survey (n^a = 1733), Cambodia, 2014

	Neither anemia nor malnutrition (n^a = 580)		**Either anemia or malnutrition (n^a = 719)**		**Anemia and malnutrition (n^a = 346)**	
	n^a	%[a]	n^a	%[a]	n^a	%[a]
Maternal risk factors						
Smoking status						
Yes	18	3.2	41	5.7	37	10.6
No	561	96.8	678	94.3	310	89.4
Body Mass Index (BMI)						
Normal	389	67.3	505	70.5	244	70.6
Underweight	40	7.0	70	9.7	58	16.7
Overweight and obese	149	**25.7**	141	**19.8**	44	**12.7**
Anemia status						
No anemia	355	**40.2**	370	**25.4**	158	**29.3**
Mild anemia	30	41.9	58	49.2	30	45.8
Moderate and Severe anemia	186	17.9	291	25.4	158	24.9
Child's risk factors						
Low birth weight						
Yes	30	**5.4**	51	**7.9**	32	**11.2**
No	516	94.6	591	92.1	252	88.8
Activities that promote learning[b]	201	34.7	300	41.7	150	43.4
<4 activities	218	37.7	277	38.7	143	41.9
≥4 activities	360	62.3	439	61.3	199	58.1

Anemia was defined as having Hb levels <11 g/dl.
Malnutrition, either stunted or wasted or both.
[a] Weighted n and %, might exceed totals due to rounding.
[b] Activities that promote learning assessed during the last three days and include reading books or looking at picture books; telling stories; singing songs; taking children outside the home, compound, or yard; playing with children; and spending time with children naming, counting, or drawing things.

Only mothers who were underweight had the highest percentage of wasting, stunting and anemic children, and both overweight and normal weight mothers had a lower percentage of malnourished and anemic children **(Figure 2)**.

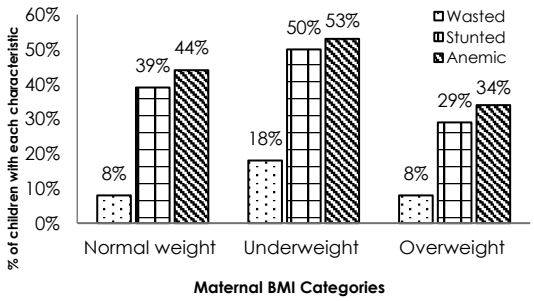
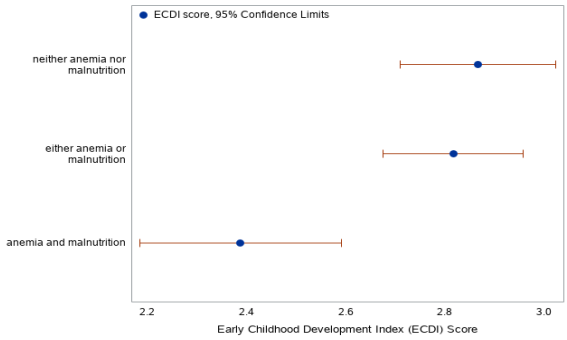


Figure 2: Percentage (%) of children wasted, stunted and anemic by maternal body mass index (BMI)

Source: Demographic and Health Survey (n = 1733), Cambodia, 2014

D. Association between ECD and malnutrition and anemia status

The mean ECDI score was the lowest among children with both malnutrition and anemia compared with the other two groups (**Figure 3**).



Source: Demographic and Health Survey (n = 1733), Cambodia, 2014

Figure 3: Mean ECDI score by children's malnutrition and anemia status

The crude and adjusted odds ratios for the association between ECD and malnutrition and anemia status are reported in **Table 3.** Without adjustment, children with both malnutrition (stunted, wasted or both) and anemia were found to be negatively associated with being developmentally on track in at least three ECDI domains, OR = 0.52 (95% CI: 0.36, 0.76) compared with those without any of these conditions. This was also the case for children with either condition (compared with healthy children), although the association was lower in magnitude, OR = 0.78 (95% CI: 0.58, 1.06). However, once we adjusted for potential confounding variables, the associations only changed slightly for children with both malnutrition and anemia, aOR = 0.62 (95% CI: 0.40, 0.96). For children with either condition (compared with children with neither condition), the odds ratio remained relatively stable, aOR = 0.78 (95%: 0.56, 1.09).

Table 3: Association between malnutrition and anemia and early childhood development (ECD) among children aged 36-59 months, Demographic and Health Survey (n^a = 1733), Cambodia

	≥ 3 ECDI domains considered on track		
	Crude OR (95% CI)	Adjusted OR[a] (95% CI)	P value
Anemia and malnutrition	0.52 (0.36, 0.76)	0.62 (0.40, 0.96)	**.03**
(ref. neither anemia nor malnutrition)			
Either anemia or malnutrition	0.78 (0.58, 1.06)	0.78 (0.56, 1.09)	.15
(ref. neither anemia nor malnutrition)			
Girl (ref. boy)	1.08 (0.83, 1.41)	1.16 (0.86, 1.57)	.32
Low birth weight	1.13 (0.66, 1.92)	1.36 (0.78, 2.37)	.27
(ref. normal birth weight)			
<4 activities that promote learning[b]	0.49 (0.38, 0.64)	0.50 (0.38, 0.67)	**<.001**
(ref. ≥4 activities)			
Maternal age	1.00 (0.98, 1.03)	1.01 (0.98, 1.04)	.44
Reside in rural area	0.50 (0.36, 0.69)	0.84 (0.54, 1.32)	.45
(ref. urban area)			
Maternal education			
(ref. secondary or higher)			
None	0.48 (0.32, 0.71)	0.75 (0.45, 1.26)	.28
Primary	0.54 (0.39, 0.73)	0.64 (0.44, 0.93)	**.02**
Wealth index			
(ref. richest)			
Poorer	0.42 (0.27, 0.67)	0.78 (0.43, 1.43)	.42
Poorest	0.38 (0.24, 0.58)	0.83 (0.45, 1.54)	.56
Middle	0.39 (0.25, 0.61)	0.66 (0.37, 1.17)	.16
Richer	0.45 (0.29, 0.69)	0.66 (0.38, 1.14)	.13

CI, Confidence Interval.
ECDI, Early Childhood Development Index.
[a]*Adjusted for child's sex, birth weight, activities that promote early learning, residence location, maternal education, occupation and wealth index.*
[b]*Activities that promote learning assessed during the last three days and include reading books or looking at picture books; telling stories; singing songs; taking children outside the home, compound, or yard; playing with children; and spending time with children naming, counting, or drawing things.*

Discussion

Our study found a negative association between malnutrition and anemia and overall on-track development based on the ECDI score. Multiple cross-sectional studies have also reported a negative association between stunting and cognitive and motor development among children [15].

A cross-sectional study examining the association between anthropometric growth indicators and the development of Tanzanian children aged 18-36 months reported that mild and severe chronic malnutrition, i.e., stunting, were both associated with increased developmental deficits [15]. Although similar in terms of design and findings, another study was conducted among a younger group of children (18-36 months), and the developmental assessment was based on a different scale (Bayley Scales of Infant Development III (BSID-III) [15].

An ecological study data collected from 15 LMICs found that severe stunting was negatively associated with overall development (measured by the ECDI score), aOR = 0.75 (95% CI: 0.67, 0.83) [14]. Unfortunately, these figures reported were from the population level and only examined the stunting effect.

Significant delays in the motor, language and social domains have also been reported in hospitalized Malawian children aged 6 months to 8 years with severe wasting [16]. However, the child development used a tool specifically adapted for their population – The Malawi Development Assessment Tool (MDAT) [16].

When assessing anemia and its effects on childhood development, Hurtado et al. reported in their study that a decrease in hemoglobin concentrations was associated with an increased risk of mild or moderate mental retardation, an association that persisted even after we controlled for all other variables [17]. Although it is generally agreed upon that anemia poses substantial risks to early child development, iron deficiency is often suspected to be the underlying cause [18]. This makes it difficult to directly compare our findings with others because we examined anemia without regard to iron status.

We also acknowledge several limitations of our study. First, we understand that our study is, by design, limited in assessing causal relationships in general. However, we already discussed similar reporting in other studies, suggesting that the investigated associations might be somewhat close to the underlying relationships between malnutrition and anemia and child development.

Second, the ECDI assessment was based on reports from parents or caregivers. While recalls might have been inevitable, the ECDI assessment tool was a set of simple yes/no questions on children's overall everyday behaviors and activities, not specific to any timeframe, and was meant to simply provide an overall picture of the development of Cambodian children.

Last, our interest was the biological effect of low hemoglobin levels (anemia) (regardless of iron status), which makes comparison with other studies (which usually focus on iron deficiency anemia) challenging. However, we have learned earlier that iron deficiency anemia among Cambodian children older than 2 years is not very common.

Implications for policy and practice

Assessing childhood development and nutritional status ensures early detection of anomalies so that appropriate measures can be taken. Various stakeholders need to work together for the common good of the children's future wellbeing (top-down involvement, i.e., national programs and support partners to the primary care providers and the community involved). From recommending a systematic assessment and ensuring sufficient resources to fulfill the tasks to making sure that the implementers at the grassroots level (care providers and the community) understand the importance of this assessment and feel welcoming toward their participation. Of course, further investigations are also needed to understand the extent to which policy-level stakeholders and the community could work together and positively influence children's development in the long run.

Conclusions

The current study confirms that early childhood undernutrition had detrimental effects on childhood development, but concurrent anemia could significantly worsen their development. Systematically measuring hemoglobin levels for malnourished children might be useful to understand the extent to which anemia is present. Further studies to advance the knowledge, develop and assess proper interventions should be considered.

Declaration of Conflicting of Interest

The authors declare that there are no conflicts of interest.

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