**Research Analysis Plan**

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**Title:**

Factors associated with the coexistence of stunting, wasting and anemia among 6-59 months children in Nepal: Secondary analysis of Nepal Demographic and Health Survey 2011-2022

**Background:**

Stunting, wasting and anemia are the major public health problems among under 5 children globally, especially in developing countries like Nepal 1–3. Stunting indicates chronic malnutrition reflecting long-term nutrient deficiencies. Wasting indicated acute malnutrition associated with recent severe food shortages or illnesses leading to weight loss. Anemia indicates the deficiency of iron and the consequences of poor nutrition. The existence of all three conditions indicates the presence of critical situation of the child that may result in morbidity and mortality.

In 2022, the prevalence of stunting was 22.3% globally and 31.8% in South Asia whereas the prevalence of wasting was 6.8% globally and 14.8% in South Asia among under 5 children 4. In 2019, global anemia prevalence was 39.8% in children aged 6-59 months, equivalent to 269 million children with anemia 5. In Nepal, the prevalence of stunting, and wasting among under 5 children was 25% and 8% respectively and the prevalence of anemia was 43% among 6-59 months children 6.

Undernutrition and anemia are linked with the morbidity and mortality of children and pregnant women7–9. Nearly half of deaths among children under 5 years of age are linked to undernutrition. These mostly occur in low- and middle-income countries. The developmental, economic, social and medical impacts of the global burden of undernutrition and anemia among children are serious and lasting, for individuals and their families, communities and countries 10.

Anemia and undernutrition are both concentrated in socioeconomically disadvantaged groups, and they share numerous multifaceted causes involving complex interactions between diet, transmissible illnesses, and other factors, such as inadequate care and unhealthy household environments 11–13. For instance, lower maternal education levels and socioeconomic status are linked with higher rates of malnutrition among children11

The co-existence of stunting, wasting and anemia indicates a serious multifaceted public health issue related to malnutrition that adversely affects the cognitive development and physical well-being of children and may lead to increased mortality11. Though the concern on nutrition has advanced beyond the existence of single form of malnutrition to co-existence of multiple malnutrition 11, most of the studies focused on stunting, wasting and anemia separately. There are very limited studies that explored the co-existence of stunting, wasting and anemia among under 5 children. In addition, there are limited studies on factors associated with the co-existence of anemia, stunting and wasting among under 5 children in Nepal. This study will help to identify factors associated with the coexistence of stunting, wasting, and anemia among under 5 children which is crucial to identify, develop and implement targeted interventions and policies aimed at reducing malnutrition in this vulnerable population. This will ultimately improve child health outcomes and reduce the burden of malnutrition in Nepal.

**Study Aim:**

* To determine the prevalence of co-existence of all combinations of stunting, wasting and anemia among 6-59 months children in Nepal.
* To compare the prevalence of co-existence of all combinations of stunting, wasting and anemia among 6-59 months children in Nepal between 2011, 2016 and 2022
* To determine the association of co-existence of stunting, wasting and anemia with food insecurity, mother’s nutritional status, and minimum dietary diversity among 6-59 months children in Nepal.

**Methods:**

*Data source:*

In this study, we analyzed data from three consecutive Nepal Health Demographic Survey (NDHS) conducted in 2011, 2016 and 202214. NDHS is the nationally representative survey implemented by New ERA under the aegis of the Ministry of Health and Population (MoHP) with the technical support of ICF International and funding from the US Agency for International Development (USAID) 6.

*Ethical approval:*

We received permission from official website of “the DHS program” (<https://www.dhsprogram.com>) to download and use the NDHS 2011, NDHS 2016, and NDHS 2022 datasets 14. NHDS obtained ethical approval from the institutional review board of ICF International, United States of America and the ethical review board of Nepal Health Research Council 6.

*Study setting:*

This study used nationally representative data of Nepal. Nepal is a landlocked country located in Southeast Asia with an area of 147, 516 km2 15. Nepal has seven administrative provinces, within which lies 753 municipalities (metropolitan cities: 6, sub-metropolitan cities: 11, urban municipalities: 276, rural municipalities: 460) 15. Nepal has three ecological belts- Mountain, Hill and Terai. Based on Census 2021, the total population of Nepal was 29164578 of which 14911027 (51.1 %) were females and 14253551 (48.9 %) were males 15. The human development index (HDI) of rural and urban parts of Nepal were 0.647 and 0.561 respectively with an overall HDI of Nepal to be 0.587 16.

*Sample and sampling:* The Nepal Demographic and Health survey used a two-stage stratified cluster sampling of households and stratification was achieved based on rural and urban settings. In the first stage of sampling, PSUs were nominated by probability proportional to size followed by a systematic selection of households from individual PSUs during the second stage of sampling. In this study, we will analyze the data of 2027 children aged 6-59 months (651 from NDHS 2011, 681 from NDHS 2016 and 695 from NDHS 2022).

*Measures*

Outcome variables

“Coexistence of stunting, wasting and anemia” is the outcome variable. Three variables used to compute outcome variables- Stunting, wasting and anemia, will be assessed through height-for-age z score, weight-for-height z score and altitude-adjusted hemoglobin level respectively. Children whose height-for-age z score is below minus two standard deviations (–2 SD) from the median of the reference population were stunted. Children whose weight-for-height z score is below minus two standard deviations (–2 SD) from the median of the reference population were wasted. The children are considered to have anemia if the altitude-adjusted hemoglobin level is <11.0 gm/deciliter. They will be coded into ‘0’ for ‘normal’ and ‘1’ for presence of the condition. They will be added to generate our outcome variable with scores ranging from 0 to 3 where 0 implies ‘Normal’, indicating the absence of all three conditions; 1 implies ‘Single burden’, indicating child suffers from one of the three conditions; 2 indicating child suffers from ‘Double burdens’ out of the three; and 3 implies ‘Coexistence of all three conditions’, indicating child suffers from all three conditions.

*Exposure variables:*

*The list of exposure variables that will be used in this study is as follows:*

*Table 1: List of exposure variables with their definition*

|  |  |
| --- | --- |
| **Variables** | **Definition** |
| *Household factors* |  |
| Food insecurity | Food insecurity is measured using the Food Insecurity Experience Scale (FIES) developed by the Food and Agriculture Organization of the United Nations17. It is classified as no food insecurity, mild, moderate and severe. |
| *Maternal Factors* |  |
| Mother’s nutritional status | Mother’s nutrition status will be classified as Thin, Normal, Overweight and Obese based on the body mass index of the mother. The mother will be considered thin if BMI is less than 18.5 kg/m2, normal if BMI is between 18.5 to 24.9 kg/m2, overweight if BMI is between 25-29.9 kg/m2 and obese if BMI is greater than 30.0 kg/m2 |
| *Child Factors* |  |
| Minimum Dietary Diversity | The children aged 6–59 months who were fed a minimum of five out of eight defined food groups during the previous day were considered to have a minimum dietary diversity. The eight food groups are as follows: breast milk; grains, roots, and tubers; legumes and nuts; dairy products (milk, yogurt, and cheese); flesh foods (meat, fish, poultry, and organ meat); eggs; vitamin A-rich fruits and vegetables; and other fruits and vegetables. |

*Potential confounding variables*

* Sociodemographic variables: It includes place of residence (rural/urban), ecological belt (mountain / hill / terai), age of child (in months), sex of child (male/female), and ethnicity (Brahmin or Chhetri /Dalit/Janajati/Madhesi/Muslim/Other), and wealth quintile (poorest, poorer, middle, richer, richest).
* Child-related variable: It includes the birth weight of the child (in kg).
* Mother-related variables: These include mother’s participation in decision-making (yes/no), and the mother’s education. Mother’s education is classified into “no education”, “basic”, “secondary” and “high education”. Basic education includes education from grade 1 to 8. Secondary education includes education from grade 9 to 12. Higher education includes more than secondary (grade 13 and above). No education refers to having no formal education.
* Survey year: The survey year (2011, 2016 and 2022) will also be adjusted in the final model

*Statistical analysis*

We will conduct pre-analytical processing and statistical analysis using the SAS 9.4 (SAS Institute, Inc, Cary, NC). We will carry out descriptive and inferential analysis.

We will present parametric numerical variables as mean (standard deviation) and non-parametric numerical variables as median (interquartile range) with their 95% confidence interval. We will present categorical variables as frequency, per cent and their 95% confidence interval. We will compute the prevalence and 95% confidence interval (CI) of the co-existence of multiple combinations of stunting, wasting and anemia, and present them using Venn diagram. We will compare prevalence between 2011, 2016 and 2022 using the Z-test of two proportions and compute the difference in proportion and its 95% CI. We will use chi-square test to determine association between categorical variables. We will conduct univariable and multivariable ordinal logistic regression, if the proportional odds assumption is met otherwise univariable and multivariable multinomial logistic regression, to determine the association between the co-existence of stunting, wasting and anemia (Normal/Single burden/ Double burden/Co-existence) and predictor variables. All controlling variables will be checked for effect modifiers by checking the p-value of the interaction term and for confounding by using the 10% rule. We will fit a final model by adjusting for the identified effect modifier and confounding variables. We will calculate and present crude and adjusted odds ratios or odds like ratio and 95% confidence interval based on the regression analyses.

**Potential challenges and strategies to handle them:**

The potential challenges linked with this study are as follows:

* Complex survey design and presence of non-response rates:
  + We will carry out a weighted analysis to account for complex survey design and non-response rates
* Complexity of the datasets (variables are present in different datasets)
  + We will follow procedures provided by “The DHS program” to merge multiple datasets.
* Insufficient number in the cells within frequency table (co-existence of all three conditions can be rare leaving poor cell count)
  + We will merge stunting and wasting together to make a composite variable -undernutrition and determine association of coexistence of undernutrition and anemia.
  + We will try to apply extensions of logistic regression like exact logistic regression or other depending on need.

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