PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	Risk factors associated with the co-existence of stunting, underweight, and wasting in children under five from 31 sub-Saharan African countries
AUTHORS	Amadu, Iddrisu; Seidu, Abdul-Aziz; Duku, Eric; Boadu Frimpong, James; Hagan Jnr., John; Aboagye, Richard; Ampah, Belinda; Adu, Collins; Ahinkorah, Bright

VERSION 1 – REVIEW

REVIEWER	Richard, Stephanie Henry M Jackson Foundation for the Advancement of Military Medicine Inc, IDCRP
REVIEW RETURNED	02-May-2021

GENERAL COMMENTS	This is a paper looking at multiple anthropometric deficiencies and their association with sociodemographic and environmental characteristics. The text of the paper could use some simplification and pruning, and the tables are numerous and could also be simplified and or moved to supplemental materials. In addition, the authors do not recognize other researchers who have done work in this area, and I've suggested some references (but the authors are suggested to look at those references and cite additional sources as well). Specific suggestions and comments are included in the attached pdf.

REVIEWER	Pham, Bang PNG Institute of Medical Research, Population Health and Demography Unit
REVIEW RETURNED	23-Jul-2021

GENERAL COMMENTS	Reviewer Report Manuscript: 'Socio-demographic and environmental risk factors accounting for the co-existence of wasting, stunting and underweight in children under five: analysis of cross=sectional surveys from 31 sub-Sahara African countries' Thank you for giving me an opportunity to review this manuscript. In this study the authors examined the malnutrition statuses among children under five years of age and their associated risk factors, using the anthropometry data extracted from DHS conducted in 31 countries in sub-Sahara region of Africa over the period 2010-2019. The study had some strength that it would be worldwide to consider for publication. Malnutrition is among priorities in global public health agenda. It is a particular concern among children under five, who in low and middle income countries. DHS is an international standard data collection tool, which can be used in

	many countries to provide national representative and compatible data for comparison across socioeconomic development settings. The authors used anthropometrical and socioeconomic demographic environmental data from 31 countries, providing a large sample size for analysis of associated risk factors. Multinomial logistic regression models are appropriate analytic tool to provide estimates of relative risk ratios of malnutrition. However, there are major issues the authors should address in the study: 1. What are the rationales for combining three dimensions of malnutrition: wasting, stunting and underweight? These three indicators are used to measure three different aspects of child growth and development. It is hard to imagine a child having all these three nutritional statuses at the same time. Wasting, stunting and underweight are the measure outcomes of child nutrition, but these conditions progress with different mechanisms and processes. The combination of all three conditions in one outcome measure has diluted the result of analyses. 2. Previous studies on socioeconomic determinants of malnutrition have shown that wasting, stunting and underweight have distinguished associated risk factors. For example, wasting condition is more likely associated with acute morbidities such as diarrheal diseases while stunting are often associated with chronic morbidities, and underweight are often linked with hunger and food shortage for a long period. 3. Many socio-demographic and environmental variables included in the MLR model are confounding factors. For example, maternal age can be confounding factor of birth order (children of older mothers are likely at higher birth order), access to media (younger mother are likely to have access to media than older mother), while birth weight can be confounding with underweight, household wealth can be confounded by mother educational attainment, employment status, use of antenatal services, place of birth delivery, access to media (again confounded) electricity, safe water, and improved toilet. It is obvious that urban-rural residence is confounding factor of access to media and use of electricity. It seems that all factors have been included in MLR models without considering their levels of significance. 4. DHS do not collect data on household wealth status. These indices have to calculate using potential variables such as household asset, housing characteristics, and access to water, sanitation and hygiene, maternal / household head's education occupation, employment (Principle Component Analysis can be used). How household wealth statuses (poor, middle, rich) were defined and calculated is not presented in the method. It suggests that the authors calculate the house wealth indices for each child participant. This variable can be used as proxy indicator and included in MLR model, replacing the variables mentioned above. Minor issue includes: 1. Maternal age was grouped into 15-19 and 20-49 years obviously introduces biases as the former represented 7% of the total sample size compared to 93% for the later. 2. What are the justifications for inclusion of variables on household head and sex of household in the MLR models? 3. Caption of Table 2 is incorrect. This table is not about the association, it is about the prevalence (%) of co-existence of wasting, stunting and underweight. As shown in this table, the prevalence of co-existence of the three conditions was very low, most of the times below 5% of the total children across socio-demographic and environmental characteristics.

	4. What are rationale for grouping co-existence into ‘normal’, one-two conditions, and 3 conditions? This grouping has mixed up different issues, resulting in a long list of associated risk factors, in which many are confounding factors as explained above. The findings are therefore not helpful to countries in responses to the child malnutrition. Most of the study countries have a list of similar risk factors, which could have been predicted previously. In short, this study would not be published until the above methodological issues have been fixed. It suggests that participating countries are grouped into 4-5 categories with similar socioeconomic, politic and development setting. The authors should present the prevalence of wasting and stunting among these countries for comparison, then run MLR analyses to identify key factors associated with wasting and stunting across these categories, and make specific recommendations on which factors should be addressed in each category to reduce the prevalence.

VERSION 1 – AUTHOR RESPONSE

REVIEWER: 1

Comments to the Author:
This is a paper looking at multiple anthropometric deficiencies and their association with sociodemographic and environmental characteristics. The text of the paper could use some simplification and pruning, and the tables are numerous and could also be simplified and or moved to supplemental materials. In addition, the authors do not recognize other researchers who have done work in this area, and I've suggested some references (but the authors are suggested to look at those references and cite additional sources as well). Specific suggestions and comments are included in the attached pdf.

Comment: I would change the order of the metrics in these sentences so that they are aligned (eg, stunting first, followed by underweight and wasting) It doesn't have to be that order, but please pick an order and stick with it - it facilitates understanding.

Response: Thank very much for the suggestion. We have changed the order to stunting, underweight and wasting.

Comment: It seems like you are missing a whole piece of the puzzle - you aren't the first to look at coexistence of these metrics... Might want to cite others who have done similar work, and also build the argument that coexistence is important to consider... https://doi.org/10.1111/mcn.12516 and Angood C, Khara T, Dolan C, Berkley JA, WaSt Technical Interest Group (2016) Research riorities on the Relationship between Wasting and Stunting. PLoS ONE 11(

Response: Thank you for the useful material. We have cited the papers you suggested and two other useful papers for our study

Boah M, Azupogo F, Amporfro DA, Abada LA. The epidemiology of undernutrition and its determinants in children under five years in Ghana. Plos one. 2019 Jul 31;14(7):e0219665.
Khan RE, Raza MA. Determinants of malnutrition in Indian children: new evidence from IDHS through CIAF. Quality & Quantity. 2016 Jan 1;50(1):299-316.

Comment: You mentioned this in the first paragraph of the intro, but with a different reference. No need to repeat yourself. (and I'm not sure ref 19 is right for this statement anyway?)

Response: We appreciate your comment. The sentence has been taken out.

Comment: Did you define double burden? Different definitions exist, e.g., the coexistence of stunting and overweight

Response: Thank you for the comment. This aspect of the introduction has been taken out as part of the revision as we have revised our argument to be around the co-existence of stunting, underweight, and wasting.

Comment: The dataset included...

Response: Thank you for the suggestion. We have modified the sentence accordingly.

Comment: This whole paragraph could be greatly simplified. This is not new information - it is a standard way of classifying children - your definitions could be put into one paragraph <-2=stunted/wasted/underweight. Not sure why so many words are needed?

Response: We appreciate this insightful comment. The paragraph has been simplified.

Comment: Please change all of these means to medians

Response: Given that we have cited the widely known DHS categorization following the WHO standards. We have simplified the paragraph. These are accessible details we admit should not make the paper heavy for minor reasons.

Comment: Groups? categories? A word seems to be missing here.

Response: The word “factors” have been added to clarify the sentence. See page 6.

Comment: No 3?

Response: Thank you. 3 is included as presented in the table.

Comment: You don't need to specify this

Response: We appreciate this suggestion considering that these coding was done following precious studies and more of normative knowledge.

Comment: This paragraph might be simplified if you combine all binary variables together and just say that the following variables were binary (0/1):

Response: We appreciate this suggestion. Given that the variables are clear in the table, we have removed the details that are contained in the table.

Comment: Also, the variables are pretty clear in the table, so all of this detail is unnecessary.

Response: We have removed the details of coding as the table presents the categories clearly.

Comment: superscript needed here

Response: We have rectified this

Comment: Also, no need to write 'see'

Response: This has been corrected

Comment: Why do Ns have non-whole numbers? Isn't this number of people? Can you round these? (I understand that the survey piece might be responsible for this, but these are meant to represent people...) Actually, are the numbers even necessary? The percents are the more interesting piece, in my opinion.

Response: We appreciate the suggestion. The table has been re-formatted to address the issues raised

Comment: And the tables here are excessive. What if you remove the Ns from this table, remove the countries (add to supplemental)?

Response: This suggestion is much welcome. The n has been removed and countries moved to supplementary files

Comment: Should maternal age be bolded?

Response: The table has been re-formatted.

Comment: Why so many digits???

Response: The n whose values were not rounded up has been removed.

Comment: What is this number just hanging out? Is it associated with an unnamed country?

Response: No. It was the “n” for South Africa but the table formatted shifted it. The new formatting addresses these

Comment: Geographic region should be bolded

Response: The new table formatted has addressed this.

Comment: How is the highest prevalence in the region 41% when the highest prevalence in a single country is 12%? 41% is not likely to be correct for the three metrics. Not sure what statistics you are doing but you state that the prevalence is 41% in Western Africa - perhaps you mean that 41% of those with all three metrics (stunting, wasting, and underweight) were found in Western Africa? I would lose the circles, and just color the regions by % of those who had the three metrics.

Response: Thanks for the insightful comment. The mistake in the reported figures has been corrected. These changes have been incorporated into the new maps presented.

Comment: It might be more helpful for understanding if you highlight the things that were not significantly associated, since most things were...

Response:
Comment: This paragraph is better, but simplify please (remove numbers, highlight specific findings, not everything)

Response: This has been done as suggested.

Comment: Suggest moving this to supplementary material

Response: We appreciate your this suggestion. However, this table contains main results and moving it to supplementary files would lead to significant obstruction.

Comment: Can you simplify this table (ie, remove the SE, p-values (indicate SS with *, +, etc.) and include RRR (LCI, UCI) instead of all of these columns. Or, as suggested in the text, make this a figure!

Response: Thank you. The table has been re-formatted as suggested.

Comment: Definitely move countries to supplemental

Response: Country-level estimates have been moved to appendix

Comment: Again, reword this. And perhaps don't repeat the results in the discussion.

Response: We have revised the discussion section. See page 15-17.

REVIEWER: 2

Thank you for giving me an opportunity to review this manuscript.
In this study the authors examined the malnutrition statuses among children under five years of age and their associated risk factors, using the anthropometry data extracted from DHS conducted in 31 countries in sub-Sahara region of Africa over the period 2010-2019.
The study had some strength that it would be worldwide to consider for publication. Malnutrition is among priorities in global public health agenda. It is a particular concern among children under five, who in low and middle income countries. DHS is an international standard data collection tool, which can be used in many countries to provide national representative and compatible data for comparison across socioeconomic development settings. The authors used anthropometrical and socioeconomic demographic environmental data from 31 countries, providing a large sample size for analysis of associated risk factors. Multinomial logistic regression models are appropriate analytic tool to provide estimates of relative risk ratios of malnutrition. However, there are major issues the authors should address in the study:

Comment: What are the rationales for combining three dimensions of malnutrition: wasting, stunting and underweight? These three indicators are used to measure three different aspects of child growth and development. It is hard to imagine a child having all these three nutritional statuses at the same time. Wasting, stunting and underweight are the measure outcomes of child nutrition, but these conditions progress with different mechanisms and processes. The combination of all three conditions in one outcome measure has diluted the result of analyses.

Response: Thank you. Child growth and development largely hinges on their nutritional status. The three indicators are recognized by the World Health Organization for tracking the nutritional status of children. In other studies, anemia status is considered in addition. Co-existence of these indicators: (i) two conditions in a child (double burden) (ii) two conditions in a child and another expressed by mother (Triple burden) are a reality in developing countries especially in sub-Saharan Africa where child malnutrition is pervasive. This presents a solid case for examining the risk factors associated with co-existence of stunting, underweight, and underweight. Following the methodological approaches of previous studies that have examined the co-existence of two of these indicators (https://doi.org/10.1111/mcn.12516; https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0153221) and others that have examined the co-existence of all three indicators (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0219665; https://link.springer.com/content/pdf/10.1007/s11135-014-0149-x.pdf), we think our study is very useful and has very important public health implications. For instance, Angood et al. (2016) mentioned in their study that wasting and stunting are global public health problems that frequently co-exist. However, they are usually separated in terms of policy, guidance, programming and financing. In our study, not only did we present the factors associated with the three indicators of undernutrition but we looked factors associated with any one of the indicators, the co-existence of two of the indicators and all three indicators. This makes this study very novel and very important for public health.

Angood C, Khara T, Dolan C, Berkley JA, WaSt Technical Interest Group. Research priorities on the relationship between wasting and stunting. PloS one. 2016 May 9;11(5):e0153221.

Comment: Previous studies on socioeconomic determinants of malnutrition have shown that wasting, stunting and underweight have distinguished associated risk factors. For example, wasting condition is more likely associated with acute morbidities such as diarrheal diseases while stunting are often associated with chronic morbidities, and underweight are often linked with hunger and food shortage for a long period.

Response: Thank you. We are cognizant of evidence on the risk factors associated with each (independent) indicator/condition. However, there are other studies that have also found risk factors for the co-existence of wasting, stunting and underweight (https://doi.org/10.1111/mcn.12516; https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0219665; https://link.springer.com/content/pdf/10.1007/s11135-014-0149-x.pdf). However, studies on the risk factors for the co-existence of wasting, stunting and underweight are scanty and that is why this study is very important. This clearly as mentioned in the background serves as critical bases for our study.

Comment: Many socio-demographic and environmental variables included in the MLR model are confounding factors. For example, maternal age can be confounding factor of birth order (children of older mothers are likely at higher birth order), access to media (younger mother are likely to have access to media than older mother), while birth weight can be confounding with underweight, household wealth can be confounded by mother educational attainment, employment status, use of antenatal services, place of birth delivery, access to media (again confounded) electricity, safe water, and improved toilet. It is obvious that urban-rural residence is confounding factor of access to media and use of electricity. It seems that all factors have been included in MLR models without considering their levels of significance.

Response: We appreciate your comment. With the potential confounding relationships among the independent variable in mind, we first run a multicollinearity diagnoses. It is therefore impossible for two independent variables (eg maternal age and birth order) as cited to share variance in the outcome variable. This is justified by the fitness of the model to the data without non-estimation of one of such

variables. With regards to consideration of level of significant, we considered statistical significance based on the results of the chi-square test at $p<0.05$. However, two variables (maternal age an age of household head) which were not significant were still included because we considered them as very important for our estimations. The model also fitted the data when these two variables were included. We therefore concluded that statistical significance at this stage of association testing should not limit our understanding of their contribution to the risk of co-existence of the three indicators.

Comment: DHS do not collect data on household wealth status. These indices have to calculate using potential variables such as household asset, housing characteristics, and access to water, sanitation and hygiene, maternal / household head's education occupation, employment (Principle Component Analysis can be used). How household wealth statuses (poor, middle, rich) were defined and calculated is not presented in the method. It suggests that the authors calculate the house wealth indices for each child participant. This variable can be used as proxy indicator and included in MLR model, replacing the variables mentioned above.

Response: Thank you very much. We did not calculate the wealth index. This is done by the DHS already. The DHS presents it in the following categories: poorer, poor, middle, rich, and richer. Based on literature we recategorized it into "poor" "middle" and "rich". As to description of how the DHS created the variable in the methods, we believe this is well-known in the literature (https://www.sciencedirect.com/science/article/pii/S2405844018349132; https://ir.ucc.edu.gh/xmlui/bitstream/handle/123456789/5397/Eshun.%20I.%2C%20%26%20Bordoh%2C%20A.%282014%29.%20Sense%20of%20efficacy%20in%20implementing%20the%20basic%20school%20social%20studies%20curriculum%20in%20Ghana.pdf?sequence=1&isAllowed=y. It would have been very critical to do so if we had calculated it.

Minor issue includes:

Comment: Maternal age was grouped into 15-19 and 20-49 years obviously introduces biases as the former represented 7% of the total sample size compared to 93% for the later.

Response: We agree with you on this. However, we did this based on evidence that children born to adolescent mothers are more likely to suffer from undernutrition compared to those born to adult mothers (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6288872/; https://academic.oup.com/cdn/article/4/Supplement_2/1463/5845785). Hence, we re-categorised age to test this hypothesis.

Comment: What are the justifications for inclusion of variables on household head and sex of household in the MLR models?

Response: We appreciate you comment. Variables on household head and sex of household are very important in our study because some of the decisions on nutrition for the child are done at the household level in most African countries (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0226041; https://onlinelibrary.wiley.com/doi/full/10.1111/cch.12670; https://ghrp.biomedcentral.com/articles/10.1186/s41256-019-0129-8) and these decisions have effects on the nutritional status of children. Hence, household level variables were considered important in our study.

Comment: Caption of Table 2 is incorrect. This table is not about the association, it is about the prevalence (%) of co-existence of wasting, stunting and underweight. As shown in this table, the

prevalence of co-existence of the three conditions was very low, most of the times below 5% of the total children across socio-demographic and environmental characteristics.

Response: Thank you. We agree that some of the content of Table 2 is on prevalence (%) of co-existence of wasting, stunting and underweight. However, part of the table is also on associations. Hence, we have revised the title as “Prevalence (%) of co-existence of wasting, stunting and underweight and its associated socio-demographic and environmental factors”

Comment: What are rationale for grouping co-existence into ‘normal’, one-two conditions, and 3 conditions? This grouping has mixed up different issues, resulting in a long list of associated risk factors, in which many are confounding factors as explained above. The findings are therefore not helpful to countries in responses to the child malnutrition. Most of the study countries have a list of similar risk factors, which could have been predicted previously.

Response: We clearly articulated in the background of the study that the focus of the study is to assess the risk factors associated with the co-existence of the three conditions (wasting, stunting and underweight). This is the major novelty the study presents as previous studies investigated either a single condition; co-existence of two conditions in a child; or two conditions in a child and one condition in mother. Studies focusing on a single condition for instance groups the responses into “Normal” and “Condition name”; studies on the double-burden of malnutrition that is co-existence of two-conditions group the responses into “Normal”, “One-condition” and “Two-conditions/double-burden). This has been the most plausible and parsimonious approach used by studies on the nutritional status of children drawing from DHS data. Previous studies have also followed the same methods (https://doi.org/10.1111/mcn.12516;
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0219665;
https://link.springer.com/content/pdf/10.1007/s11135-014-0149-x.pdf)

In short, this study would not be published until the above methodological issues have been fixed. It suggests that participating countries are grouped into 4-5 categories with similar socioeconomic, politic and development setting. The authors should present the prevalence of wasting and stunting among these countries for comparison, then run MLR analyses to identify key factors associated with wasting and stunting across these categories, and make specific recommendations on which factors should be addressed in each category to reduce the prevalence.

Response: Thank you for the suggestion. However, we consider this study as publishable based on our clearly articulated responses to your comments. Again, with respect of grouping participating countries into 4-5 categories with similar socioeconomic, politic and development setting, we clearly did this by creating a sub-regional variable (West Africa, East Africa, Central Africa, and Southern Africa). This is commonly used way of creating categories in for countries in sub-Saharan Africa. We have also presented the prevalence of co-existence of stunting, wasting, and undernutrition for each of these sub-regions in Figure 2. Not only that, we included these sub-regions in our MLR to show which sub-regions have lower and higher risks for the stunting, wasting, and undernutrition. Our objective was not to look at factors associated with undernutrition in each sub-region but in sub-Saharan Africa as a whole since the phenomenon is across the entire sub-Saharan Africa.

VERSION 2 – REVIEW

REVIEWER	Pham, Bang PNG Institute of Medical Research, Population Health and Demography Unit
REVIEW RETURNED	03-Sep-2021

GENERAL COMMENTS	Reviewer Report Reviewer: Dr. Bang Nguyen Pham Manuscript: 'Socio-demographic and environmental risk factors accounting for the co-existence of wasting, stunting and underweight in children under five: analysis of cross-sectional surveys from 31 sub-Sahara African countries' Thank you for giving me an opportunity to review again the manuscript. The paper has been substantially revised based on the reviewers' comments on the last version. However, there are still major issues which have not been properly addressed in the current version of the paper: 1. Implications for policy and programme interventions to address the associated risk factors, identified in the study were not discussed properly. Conclusions of the study should be based on the research findings, which were about the prevalence of co-existence of stunting, underweight and wasting among children under 5 years of age and associated risk factors in studied countries in sub-Saharan Africa. Recommendations on interventions targeting breast feeding, complimentary feeding, dietary supplementation and diversity are not directly linked to the findings of this study hence it should be revised. As many socio-demographic environmental factors were identified having significant associations with co-existence of stunting, underweight and wasting, the current recommendation to address all of these factors at the same time appears unfeasible. Policy recommendations should be classified into short, medium and long terms, targeting specifically different sub-regions (western, eastern, and central) and countries (if possible). 2. Rationale for measuring prevalence and predictor of co-existence of stunting, underweight and wasting is not justified. It was based on the argument that there not much work on the subject and hence children who are suffered from these nutritional conditions are less likely to be reached by nutrition programme in SSA, but no evidence/ reference support this. 3. It is unclear how the outcome variable 'co-existence under-nutrition' was measured. As defined in the paper, this outcome variable included three categories: (i) 0 = normal; (ii) 1 = one or two condition (it can be stunting or underweight or wasting, or stunting + underweight, or stunting + wasting, or underweight + wasting); and (iii) 3 = all three conditions (stunting + wasting + underweight). One can guess that the number of observations in category (iii)

	would be every small as show in the prevalence presented in Table 1. 4. The explanation for classification of independent variables into sociodemographic factors and environmental factors are confusing and the purpose for this grouping is unclear. In fact, these two groups of factors are not helpful at all in the analyses. All variables were included in the MLR models (Table 3). Many references and citations were included in this section, but they were not much valuable and relevant. 5. Data analysis: 2 layers of sampling should be included in the STATA declaration as DHS sampling framework was designed with two stratifications 6. Collinearity tests were conducted, but the purpose of this analysis was not explained. In fact, the results of these test (Appendix 2) were not used at all in the paper. 7. The statement 'sample weight was used to adjust for potential over and under sampling' is not correct. Sample weight in DHS is used to provide weighted samples (flat the sample size). 8. Ethical approval section needs to be corrected. The ethics approval of DHS was irrelevant in this study. 9. Positions for inserting Table 1, Figure 1-2 were not correct. They should be in the result section, not in the method section. 10. Table 1 caption should be corrected as 'distribution of study population by sociodemographic and environment characteristics. Overall description or key findings / observations in Table 1 should be highlighted in the result section. No description of Table 1 was provide at all in the current version. Numbers of samples (unweighted and weighted numbers of observations) should be included in the table. Note under Table 1 about Appendix 1 should be removed. 11. Table 2 caption should be corrected again. It should be like 'prevalence of co-existence of stunting, underweight and wasting (%) among children under five years of age in SSA countries (by maternal sociodemographic and environmental characteristics. Nothing about associated risk factors in this table. Calculations of proportion (%) do not tell anything about association. The Chi-squared p-values presented in the table show whether the differences between proportions (%) of categories in each variable are significant. 12. Table 3 reported two separate sets of RRR for: 1-2 condition; and for co-existence of three conditions. How these RRR were estimated for the two conditions? One can guess associated risk factors were similar between the two outcomes measures. Many factors, which were identified as non-significant in the previous multi-collinearity analysis (Appendix 2) i.e. birth order, maternal education, working

	status… were still included in the MLR analysis. Note under Table 3 about Appendix 2 should be removed. In summary, the paper has some improvements after the first review, but there are still major issues regarding the justification, data analysis, presentation and interpretation. Implications and recommendations from study findings are limited and unpractical. The paper is required for major revision.

VERSION 2 – AUTHOR RESPONSE

1. Implications for policy and programme interventions to address the associated risk factors, identified in the study were not discussed properly. Conclusions of the study should be based on the research findings, which were about the prevalence of co-existence of stunting, underweight and wasting among children under 5 years of age and associated risk factors in studied countries in sub-Saharan Africa. Recommendations on interventions targeting breast feeding, complimentary feeding, dietary supplementation and diversity are not directly linked to the findings of this study hence it should be revised. As many socio-demographic environmental factors were identified having significant associations with co-existence of stunting, underweight and wasting, the current recommendation to address all of these factors at the same time appears unfeasible. Policy recommendations should be classified into short, medium and long terms, targeting specifically different sub-regions (western, eastern, and central) and countries (if possible).

Response: Thank you. The discussion of the implications of the potential implications of the findings for policy and practices have been extended. Short-term and long-term efforts have been suggested. Given that analyses of risk factors were not disaggregated by geographic region, we believe it will be farfetched to make specific recommendations for each geographic region. Risk factors under the current analyses represent SSA as a whole. Nevertheless, we have provided recommendations for the disparate prevalence of the condition observed across them. “These findings demonstrate the urgent need for consideration of the co-existence of stunting, wasting and underweight among under-five children in policy design and programming of interventions to eradicate child malnutrition in SSA. In the short-term, national-level policies and interventions needs to be well-tailored considering the compositional characteristics including child’s age, sex, birth size; maternal education, working status, place of delivery, antenatal visit; and household’s wealth status, access to media and improved toilet facility are required. For instance, such programs could be geared towards improving female’s access to education, reducing unemployment, expanding access to the media and using it to promote education on the need for antenatal care. In the long-term, regional policies and coordinated interventions among governments of SSA countries need to be designed to address the disparate prevalence of the co-existence of stunting, wasting and underweight in under-five children across the four geographic regions. The implementation of these at the local-level should consider rural-urban differences in the prevalence of the condition and the risk factors elicited”. See lines 411-424

2. Rationale for measuring prevalence and predictor of co-existence of stunting, underweight and wasting is not justified. It was based on the argument that there not much work on the subject and

hence children who are suffered from these nutritional conditions are less likely to be reached by nutrition programme in SSA, but no evidence/ reference support this.

Response: We appreciate your comment. We argued that to the best of our knowledge, there are no empirical studies presenting analyses on the co-existence of the indicators of malnutrition in SSA in the literature (see lines 132-136). This is based on a careful and extensive search of the existing literature. It is therefore not out of place to insinuate that such data/knowledge paucity could make it impossible for interventionist to reach them.

3. It is unclear how the outcome variable 'co-existence under-nutrition' was measured. As defined in the paper, this outcome variable included three categories: (i) 0 = normal; (ii) 1 = one or two condition (it can be stunting or underweight or wasting, or stunting + underweight, or stunting + wasting, or underweight + wasting); and (iii) 3 = all three conditions (stunting + wasting + underweight). One can guess that the number of observations in category (iii) would be every small as show in the prevalence presented in Table 1.

Response: We appreciate your comment. We agree that the prevalence of co-existence of the three indicators is low. However, it is very important to note the presence of the condition in the sub-region. This is an important observation that would be of interest to many researchers, policymakers and practitioners given that focus on child nutrition in recent years has been on the double burden and triple burden of malnutrition. More evidence on the co-existence of child malnutrition indicators could spark the conversation and redirect efforts towards holistic solutions/interventions.

4. The explanation for classification of independent variables into sociodemographic factors and environmental factors are confusing and the purpose for this grouping is unclear. In fact, these two groups of factors are not helpful at all in the analyses. All variables were included in the MLR models (Table 3). Many references and citations were included in this section, but they were not much valuable and relevant.

Response: The references provided are evidence backing the coding (categorization) of the variables and not necessarily their grouping. The grouping was done to guide the analyses and discussion of the findings as well as their implications. We considered removing the grouping as it may be inconsequential. Thank you.

5. Data analysis: 2 layers of sampling should be included in the STATA declaration as DHS sampling framework was designed with two Stratifications.

Response: Thank you. We have indicated in the data analyses section (line 195-197) the "Svyset" command was used to declare the data survey. In executing the command, the strata and the sample weight variables were added to the command options to cater for the complex sampling techniques used by the DHS Program.

6. Collinearity tests were conducted, but the purpose of this analysis was not explained. In fact, the results of these test (Appendix 2) were not used at all in the paper.

Response: We are grateful to you for your comment. We have provided, in brief, the reason for the multicollinearity test. Multicollinearity diagnoses test were not conducted to achieve a specific objective but to only demonstrate that variables included in the model were not correlated. Hence, there is little usefulness in reporting.

7. The statement ‘sample weight was used to adjust for potential over and under sampling’ is not correct. Sample weight in DHS is used to provide weighted samples (flat the sample size).

Response: We have added the statement as Sample weight in DHS were used to provide weighted samples (see lines 202-203)

8. Ethical approval section needs to be corrected. The ethics approval of DHS was irrelevant in this study.

Response: We have revised the ethical statement. We believe that declaration of ethical consideration is extremely essential in all research involving living subject. Hence the need to mention the DHS program’s ethics statement.

9. Positions for inserting Table 1, Figure 1-2 were not correct. They should be in the result section, not in the method section.

Response: Thank you. We have moved them to the results section.

10. Table 1 caption should be corrected as ‘distribution of study population by sociodemographic and environment characteristics. Overall description or key findings / observations in Table 1 should be highlighted in the result section. No description of Table 1 was provide at all in the current version. Numbers of samples (unweighted and weighted numbers of observations) should be included in the table. Note under Table 1 about Appendix 1 should be removed.

Response: Thank you. We have provided (Lines 226-237) a brief description of the distribution of the characteristics of the sample as presented in Table 1.

11. Table 2 caption should be corrected again. It should be like ‘prevalence of co-existence of stunting, underweight and wasting (%) among children under five years of age in SSA countries (by maternal sociodemographic and environmental characteristics. Nothing about associated risk factors in this table. Calculations of proportion (%) do not tell anything about association. The Chi-squared p-values presented in the table show whether the differences between proportions (%) of categories in each variable are significant.

Response: The caption for Table 2 has been revised as suggested. Thank you.

12. Table 3 reported two separate sets of RRR for: 1-2 condition; and for co-existence of three conditions. How these RRR were estimated for the two conditions? One can guess associated risk factors were similar between the two outcomes measures. Many factors, which were identified as non-significant in the previous multi-collinearity analysis (Appendix2) i.e. birth order, maternal education, working status… were still included in the MLR analysis. Note under Table 3 about Appendix 2 should be removed.

Response: As indicated, a multinomial regression model was fitted to the data. The choice of the analytical procedure was because our outcome variable had three categories, (Normal, 1-2 conditions, and co-existence of three conditions). Hence, one of the three response categories (Normal) were chosen as the reference/base category and the effect sizes (RRR) are estimated for the other two (“1-2 condition” and “co-existence of three conditions”). The results of multicollinearity test show that the independent variables were not correlated among themselves and can be included in a regression model to predict an outcome. We have removed the note under Table 3 about appendix 2.

PREVIOUS COMMENTS ALREADY ADDRESSED

We have realised that the following comments numbered 14 to 17 were addressed in our previous round of revision.

14. What are the rationales for combining three dimensions of malnutrition: wasting, stunting and underweight? These three indicators are used to measure three different aspects of child growth and development. It is hard to imagine a child having all these three nutritional statuses at the same time. Wasting, stunting and underweight are the measure outcomes of child nutrition, but these conditions progress with different mechanisms and processes. The combination of all three conditions in one outcome measure has diluted the result of analyses.

15. Previous studies on socioeconomic determinants of malnutrition have shown that wasting, stunting and underweight have distinguished associated risk factors. For example, wasting condition is more likely associated with acute morbidities such as diarrheal diseases while stunting are often associated with chronic morbidities, and underweight are often linked with hunger and food shortage for a long period.

16. Many socio-demographic and environmental variables included in the MLR model are confounding factors. For example, maternal age can be confounding factor of birth order (children of older mothers are likely at higher birth order), access to media (younger mother are likely to have access to media than older mother), while birth weight can be confounding with underweight, household wealth can be confounded by mother educational attainment, employment status, use of antenatal services, place of birth delivery, access to media (again confounded) electricity, safe water, and improved toilet. It is obvious that urban-rural residence is confounding factor of access to media and use of electricity. It seems that all factors have been included in MLR models without considering their levels of significance.

17. DHS do not collect data on household wealth status. These indices have to calculate using potential variables such as household asset, housing characteristics, and access to water, sanitation and hygiene, maternal / household head's education occupation, employment (Principle Component Analysis can be used). How household wealth statuses (poor, middle, rich) were defined and calculated is not presented in the method. It suggests that the authors calculate the house wealth indices for each child participant. This variable can be used as proxy indicator and included in MLR model, replacing the variables mentioned above.