**Supplementary Appendix No. 1**

This appendix formed part of the original submission

Supplement to Manuscript: Associations Between Food Insecurity, and Key Metabolic Risk Factors for Diet-Sensitive Non-communicable Diseases in Sub-Saharan Africa: A Systematic Review and Meta-Analysis

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1. **Changes to the original protocol**

Please note attached application (See Supplementary Appendix No. 2) for Ethics Approval on the here noted request for amendments:

**TITLE OF STUDY**:

**Original protocol states:**

The Evidence on the Association Between Food Insecurity and Diet-sensitive Chronic Diseases in Sub-Saharan Africa: A Systematic Review and Meta-analysis

**Amendments Requested:**

Association Between Food Insecurity and Key Metabolic Risk Factors for Diet-Sensitive Non-communicable Diseases in Sub-Saharan Africa: A Systematic Review and Meta-Analysis

1. **Outcome of Interest**

The primary outcome of interest in this review, was to critically evaluate the accumulative evidence on the association between food insecurity and key metabolic risk factors, i.e., obesity, hypertension, underweight, dyslipidaemia, and overweight on the causal pathway to diet-sensitive NCDs, independent of socio-demographic characteristics.

The pooled prevalence estimates (%) of key metabolic risk factors, i.e., obesity, hypertension, underweight, dyslipidaemia, and overweight among the populace confronted with food insecurity, including variability in incidence by age, gender, or region was the secondary outcome of interest for the meta-analyses.

1. **Definition and method of ascertainment for variables (independent and dependent)**

Studies reporting any one of the food insecurity method of ascertainment/measure of food insecurity exposure listed in Table 1 as an independent variable, were included in this review.

**Table 1:** Definition of recoded food insecurity method of ascertainment

|  |  |  |
| --- | --- | --- |
| Criteria | Exposure definition | Theoretical minimum risk exposure level |
| Minimum Diet Diversity [[1]](#footnote-1) | The consumption of four or more food groups from the seven food groups. | The proportion of eating from less than four food groups, due to inconsistent access to food |
| Minimum Adequate Diet 1 | Average daily consumption of more than five servings of fruits and vegetables which is equivalent to at least 290–430 g per day | Consumption of fewer than five servings of fruits and vegetables, due to not enough money for food |
| Minimum Meal Frequency 1 | The proportion of the population who eat the recommended minimum number of meals in a day. Stratified by age | Two times for breastfed infants aged 6 to 8 months; three times for breastfed children aged 9 to 23 months; four times for non-breastfed children aged ≥ 23 months |
| Food Insecurity Access Scale 2 | The Household Food Insecurity Access Scale (HFIAS) Indicator Guide V.3 and categorized into four levels | Food secure, mildly food insecure, moderately food insecure, or severely food insecure. |

Studies reporting at least one of the major metabolic risk factors (see Table 2) as a dependent variable, diagnosed according to either one of the international diagnostic criteria were considered for inclusion: NCEP-ATPIII (2001) 1, International Diabetes Foundation (IDF 2005) 2, AHA/NHLBI criteria (2004) 3, and any other measures in line with the World Health Organization criteria (1998) 4 extensively used to diagnose metabolic risk factors.

**Risk Factors** - This refers to any attribute, characteristic, or exposure of an individual, which increases the likelihood of developing a disease or other unwanted condition/event. Metabolic risk factors increase the risk of diet-sensitive NCDs

**Table 2:** Definition of diagnostic criterions of the review outcomes

|  |  |  |
| --- | --- | --- |
| Risk factors | Definition | The criteria for diagnosis[[2]](#footnote-2) |
| Obesity | The abnormal or excessive fat accumulation | Body mass index 30 kg/m2 and/or waist: hip ratio (men > 0.9, women > 0.85) |
| Dyslipidaemia | Elevation of plasma cholesterol, triglycerides (TGs), or both, or a low HDL cholesterol level that contributes to the development of atherosclerosis | Lipoprotein-Cholesterol – HDL-cholesterol (male < 1.03 mmol/L (40 mg/dL), women < 1.29 mmol/L (50 mg/dL))  Hypertriglyceridemia – Raised triglyceride (≥ 1.7 mmol/L (150 mg/dL) |
| Hypertension | Defined as ≥140/90/90 mm Hg, systolic and diastolic pressure | Optimal blood pressure – <120/80 mm Hg, systolic and diastolic blood pressure  Prehypertension – 120–139/80–89 mm Hg, systolic and diastolic blood pressure  Stage 1 hypertension – 140–159/90–99 mm Hg, systolic and diastolic blood pressure  Stage 2 hypertension – > 160/100 mm Hg, systolic and diastolic blood pressure |
| Underweight and Overweight | Overweight can be defined as excessive and abnormal fat depositions in our bodies. | If body mass index = Underweight (<18.5); normal ([18.5–25[); overweight ([25–30[); obese (≥30) |

1. **Search Strategy with MeSH terms**

The PEO framework informed the development of the search strategy: **Search # 1** – Population (Human participants of all-age groups, residing in sub-Saharan Africa, both genders, and regardless of their ethnic background), **Search # 2** – Exposure (Food Insecurity) **Search # 3** – Outcomes (Diagnosed with any of the following diet-sensitive NCDs metabolic risk factors). All searches were conducted between 20 till 28 June 2019.

**Table 4:** Search strategy employed in the review

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Search | Search terms | PubMed | EBSCOhost\* | Web of Science | Ovid\*\* Platform | Google Scholar |
| # 1 | African filter ((((Angola OR Benin OR Botswana OR “Burkina Faso” OR Burundi OR Cameroon OR “Cape Verde” OR “Central African Republic” OR Chad OR Comoros OR Congo OR “Democratic Republic of Congo” OR Djibouti OR “Equatorial Guinea” OR Eritrea OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR “Guinea Bissau” OR “Ivory Coast” OR “Cote d’Ivoire” OR Kenya OR Lesotho OR Liberia OR Madagascar OR Malawi OR Mali OR Mauritania OR Mauritius OR Mozambique OR Namibia OR Niger OR Nigeria OR Principe OR Reunion OR Rwanda OR “Sao Tome” OR Senegal OR Seychelles OR “Sierra Leone” OR Somalia OR “South Africa” OR Sudan OR Swaziland OR Tanzania OR Togo OR Uganda OR “Western Sahara” OR Zambia OR Zimbabwe OR “Central Africa” OR “Central African” OR “West Africa” OR “West African” OR “Western Africa” OR “Western African” OR “East Africa” OR “East African” OR “Eastern Africa” OR “Eastern African” OR “South African” OR “Southern Africa” OR “Southern African” OR “sub Saharan Africa” OR “sub Saharan African” OR “sub Saharan Africa” OR “sub Saharan African” NOT “guinea pig” NOT “guinea pigs” NOT “aspergillus niger” )))) | 88 799 | 823 050 | 505 656 | N/A | N/A |
| # 2 | Unhealthy diet OR Food Insecurity OR Food security status OR Food Shortage OR Food insufficiency OR Hunger OR Malnutrition OR nutritional transition OR FI OR Undernutrition OR Food scarcity OR Food OR lack of food OR Fasting OR deprivation of food OR famine OR Poor Nutrition OR Minimum Diet Diversity OR Minimum Adequate Diet OR Minimum Meal Frequency | 152 447 | 345 051 | 99 089 | N/A | N/A |
| # 3 | Hypertension OR chronic diseases OR Diet-Related OR diet-sensitive chronic diseases OR Diet-Related non-communicable disease OR Diet-Related Chronic Diseases OR non-communicable disease OR Obesity OR Diet-sensitive NCDs OR NCDs OR Underweight OR Overweight OR Dyslipidaemia OR metabolic syndrome OR Metabolic Risk Factors | 137 322 | 72 021 | 32 686 | N/A | N/A |
| # 4 | # 1 AND # 2 AND # 3  Limits   * Publication Date = 01/01/2015 to 30/08/2019 * Language = No Restrictions * Study Participants = Humans’ studies only | 433 | 1 834 | 20 | 5 756 | 3760 |
| **Total**  **=** **885 exported to EndNote Virtual Library, after title screening** | | 149 | 347 | 14 | 215 | 160 |
| Note: N/A the Platform doesn’t allow multiple search to be ran separately and combine the hits on a new run.  \* EBSCOhost (Academic Search Complete, CINAHL with full text, Health Source – Consumer/Nursing/Academic Editions, MedLine with full text, and MedLine),  \*\*Ovid (Journals@Ovid Full Text, and Your Journals@Ovid) | | | | | | |

1. **Results of quality assessment of the included studies**

**Table 5:** Risk of bias in individual studies using the Mixed Methods Appraisal Tool (MMAT) – Version 2018 5

| **First author, Year, Reference** | **Country** | **Screening questions**  **(for all types)** | | **4. Quantitative descriptive** | | | | | **Score\* (%)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S1** | **S2** | **4.1** | **4.2** | **4.3** | **4.4** | **4.5** |
| Abebe, 2017 6 | Ethiopia | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 100 |
| Agaba, 2017 7 | Nigeria | Yes | Yes | Yes | No | Yes | Yes | Yes | 86 |
| Anteneh, 2015 8 | Ethiopia | Yes | Yes | Yes | No | Yes | Yes | Yes | 86 |
| Colecraft, 2018 9 | Ghana | Yes | Yes | Yes | No | Yes | No | Yes | 71 |
| Cox, 2016 10 | Malawi | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 100 |
| Desalew, 2017 11 | Ethiopia | Yes | Yes | Yes | No | Yes | No | Yes | 71 |
| Di Gioia, 2016 12 | Madagascar | Yes | Yes | Yes | No | Yes | Can't tell | Yes | 71 |
| Gebremichael, 2019 13 | Ethiopia | Yes | Yes | Yes | No | Yes | Yes | Yes | 86 |
| Soubeiga, 2017 14 | Burkina Faso | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 100 |
| Katalambula, 2018 15 | Tanzania | Yes | Yes | Yes | No | Yes | Yes | Yes | 86 |
| Kejo, 2018 16 | Tanzania | Yes | Yes | Yes | No | Yes | Can't tell | Yes | 71 |
| Lapauw, 2016 17 | Ghana | Yes | Yes | Yes | No | Yes | Can't tell | Yes | 71 |
| Maimela, 2016 18 | South Africa | Yes | Yes | Yes | No | Yes | No | Yes | 71 |
| Mbaissouroum, 2017 19 | South Africa | Yes | Yes | Yes | No | Yes | No | Yes | 71 |
| Mohammed, 2016 20 | Ghana | Yes | Yes | Yes | No | Yes | No | Yes | 71 |
| Musaiger, 2016 21 | Sudan | Yes | Yes | No | No | Yes | Can't tell | Yes | 57 |
| Musaiger, 2016 22 | Sudan | Yes | Yes | Yes | No | Yes | No | Yes | 71 |
| Mutisya, 2015 23 | Kenya | Yes | Yes | Yes | No | Yes | No | Yes | 71 |
| Solomons, 2018 24 | South Africa | Yes | Yes | Yes | No | Yes | No | Yes | 71 |
| Omech, 2016 25 | Botswana | Yes | Yes | Yes | No | Yes | Can't tell | Yes | 71 |
| Nansseu, 2019 26 | Cameroon | Yes | Yes | Yes | No | Yes | Yes | Yes | 86 |
| Tateyama, 2018 27 | Zambia | Yes | Yes | Yes | No | Yes | Yes | Yes | 86 |

\* meets % of the MMAT criteria

1. **Full-articles screening results, calculated degree of agreement following full article screening**

After the full-article screening, we measured the degree of the agreement between screeners

**Table 6: Full-article screening results**

|  |  |  |
| --- | --- | --- |
| **Author and Date** | **Screener One (PI)** | **Co-Screener** |
| Abebe, 2017 | 1 | 1 |
| Abubakari, 2015 | 1 | 0 |
| Abusalma, 2015 | 1 | 1 |
| Ackatia-Armah, 2015 | 1 | 0 |
| Adejumo, 2016 | 1 | 0 |
| Agaba, 2017 | 1 | 1 |
| Ahmed, 2018 | 1 | 1 |
| Alicke, 2017 | 1 | 1 |
| Altare, 2016 | 1 | 1 |
| Amare, 2015 | 1 | 1 |
| Anteneh, 2015 | 1 | 1 |
| Audain, 2017 | 0 | 1 |
| Aworh, 2018 | 0 | 1 |
| Barich, 2018 | 1 | 1 |
| Benzekri, 2015 | 0 | 1 |
| Boateng, 2019 | 1 | 1 |
| Cabral, 2019 | 0 | 0 |
| Carruth, 2019 | 1 | 1 |
| Cockx, 2018 | 0 | 0 |
| Cox, 2017 | 1 | 1 |
| Craveiro, 2016 | 1 | 1 |
| Daivadanam, 2019 | 0 | 1 |
| Danquah, 2018 | 1 | 1 |
| De Vita, 2019 | 1 | 1 |
| Demaio, 2018 | 0 | 0 |
| Desalew, 2017 | 1 | 1 |
| Di Gioia, 2016 | 1 | 1 |
| Doumit, 2015 | 0 | 0 |
| Ebbeling, 2018 | 0 | 0 |
| El Kabbaoui, 2018 | 1 | 1 |
| Faber, 2016 | 0 | 0 |
| Fekadu, 2015 | 1 | 1 |
| Gebremariam, 2018 | 0 | 0 |
| Gebremichael, 2019 | 1 | 1 |
| Gebreselassie, 2015 | 1 | 1 |
| Gebrihet, 2017 | 1 | 1 |
| Grellety, 2017 | 1 | 1 |
| Guwatudde, 2015 | 1 | 1 |
| Gyamea, 2018 | 1 | 1 |
| Holmes, 2018 | 1 | 1 |
| Humphries, 2015 | 1 | 1 |
| Hunter-Adams, 2019 | 0 | 0 |
| Jannasch, 2017 | 1 | 1 |
| Jones, 2016 | 1 | 1 |
| Kakota, 2015 | 0 | 0 |
| Katalambula, 2018 | 1 | 1 |
| Kejo, 2018 | 1 | 1 |
| Koma, 2017 | 1 | 1 |
| Korkalo, 2015 | 0 | 0 |
| Krasevec, 2017 | 1 | 1 |
| Lapauw, 2016 | 1 | 1 |
| Lelijveld, 2016 | 1 | 1 |
| M'Kaibi, 2017 | 1 | 1 |
| Mahgoub, 2017 | 0 | 0 |
| Maimela, 2016 | 1 | 1 |
| Maiyoh, 2019 | 1 | 1 |
| Maketa, 2015 | 0 | 0 |
| Mbaissouroum, 2017 | 1 | 1 |
| Melaku, 2016 | 1 | 1 |
| Melaku, 2018 | 1 | 1 |
| Melaku, 2018 | 1 | 1 |
| Mohammed, 2016 | 1 | 1 |
| Molyneux, 2018 | 0 | 0 |
| Moore, 2016 | 1 | 1 |
| Motbai0r, 2015 | 1 | 1 |
| Musaiger, 2016 | 1 | 1 |
| Musaiger, 2016 | 1 | 1 |
| Mutisya, 2015 | 1 | 1 |
| Mwenda, 2018 | 0 | 0 |
| Neupane, 2015 | 1 | 1 |
| Obirikorang, 2015 | 1 | 1 |
| Olaitan, 2018 | 1 | 1 |
| Padrão, 2015 | 1 | 1 |
| Peer, 2015 | 1 | 1 |
| Peer, 2016 | 1 | 1 |
| Raji, 2015 | 1 | 1 |
| Solomons, 2018 | 1 | 1 |
| Steenkamp, 2016 | 1 | 1 |
| Stobaugh, 2018 | 1 | 1 |
| Tadesse, 2017 | 1 | 1 |
| Trehan, 2015 | 0 | 0 |
| Van Der Kam, 2016 | 0 | 0 |
| Van Der Linden, 2019 | 1 | 1 |
| Wekesah, 2018 | 1 | 1 |
| Wesonga, 2016 | 1 | 1 |
| Whyte, 2016 | 0 | 0 |
| Willie, 2018 | 0 | 0 |
| Wilson, 2018 | 0 | 0 |
| Wu, 2015 | 1 | 1 |
| Yaya, 2018 | 1 | 1 |
| Yaya, 2018 | 1 | 1 |
| Ze, 2018 | 1 | 1 |
| Zlotnick, 2015 | 0 | 0 |

**Note:** Yes =1 No =0

**Stata output**

Expected

Agreement Agreement Kappa Std. Err. Z Prob>Z

-----------------------------------------------------------------

92.47% 62.23% 0.8007 0.1037 7.73 0.0000

. mcc ScreenerOnePI CoScreener

| Controls |

Cases | Exposed Unexposed | Total

-----------------+------------------------+------------

Exposed | 66 3 | 69

Unexposed | 4 20 | 24

-----------------+------------------------+------------

Total | 70 23 | 93

McNemar's chi2(1) = 0.14 Prob > chi2 = 0.7055

Exact McNemar significance probability = 1.0000

Proportion with factor

Cases .7419355

Controls .7526882 [95% Conf. Interval]

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difference -.0107527 -.0772214 .0557161

ratio .9857143 .9148426 1.062076

rel. diff. -.0434783 -.2737873 .1868308

odds ratio .75 .1098635 4.43326 (exact)

**Interpretation of the above results (you need this in your results section)**

We calculated degree of agreement following full article screening. The results showed that there was 92.47% agreement versus 62.23% expected by chance which constitutes a considerably high agreement between screeners (Kappa statistic = - 0. 80 and p-value <0.05). In addition, the McNemar's chi-square statistic suggests that there is no statistically significant difference in the proportions of yes/no answers by reviewers with p-value >0.05.

**Table 7:** Meta-weighted pooled prevalence results of metabolic risk factors with included studies

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Region | Country | Author, Year | Total Participants | | MetS Cases | | Prevalence (95% CI) |
| Male | Female | Male | Female |
| Central Africa | Cameroon | Nansseu, 2019 26 | 501 | 430 | 134 | 173 | 0.33 (0.30, 0.36) |
| Western Africa | Ghana | Mohammed, 2016 20 | 90 | 90 | 52 | 72 | 0.69 (0.62, 0.75) |
| Ghana | Lapauw, 2016 17 | 0 | 250 | 0 | 186 | 0.65 (0.59, 0.71) |
| Burkina Faso | Soubeiga, 2017 14 | 2230 | 2399 | 1114 | 1181 | 0.50 (0.48, 0.51) |
| Ghana | Colecraft, 2018 9 | 513 | 652 | 28 | 35 | 0.05 (0.04, 0.07) |
| Nigeria | Agaba, 2017 7 | 521 | 362 | 254 | 199 | 0.51(0.48, 0.55) |
| Southern Africa | Botswana | Omech, 2016 25 | 75 | 216 | 58 | 227 | 0.56 (0.50, 0.62) |
| South Africa | Solomons, 2018 24 | 113 | 341 | 60 | 172 | 0.51 (0.46, 0.56) |
| South Africa | Mbaissouroum, 2017 19 | 879 | 1266 | 225 | 569 | 0.37 (0.35, 0.39) |
| South Africa | Maimela, 2016 18 | 525 | 878 | 337 | 865 | 0.84 (0.82, 0.85) |
| Eastern Africa | Zambia | Tateyama, 2018 27 | 335 | 354 | 169 | 183 | 0.51 (0.47, 0.55) |
| Kenya | Mutisya, 2015 23 | 3462 | 3396 | 1858 | 1491 | 0.49 (0.48, 0.50) |
| Sudan | Musaiger, 2016 21 | 507 | 438 | 46 | 54 | 0.11 (0.09, 0.13) |
| Sudan | Musaiger, 2016 22 | 183 | 217 | 58 | 88 | 0.37 (0.32, 0.41) |
| Tanzania | Kejo, 2018 16 | 242 | 194 | 155 | 258 | 0.78 (0.74, 0.82) |
| Tanzania | Katalambula, 2018 15 | 684 | 766 | 239 | 276 | 0.36 (0.33, 0.38) |
| Ethiopia | Gebremichael, 2019 13 | 156 | 164 | 92 | 76 | 0.53 (0.47, 0.58) |
| Madagascar | Di Gioia, 2016 12 | 147 | 166 | 63 | 61 | 0.40 (0.34, 0.45) |
| Ethiopia | Desalew, 2017 11 | 187 | 261 | 61 | 85 | 0.33 (0.28, 0.37) |
| Malawi | Cox, 2016 10 | 517 | 311 | 45 | 24 | 0.08 (0.07, 0.10) |
| Ethiopia | Anteneh, 2015 8 | 177 | 254 | 22 | 50 | 0.17 (0.13, 0.20) |
| Ethiopia | Abebe, 2017 6 | 409 | 751 | 137 | 261 | 0.34 (0.32, 0.37) |

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