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Title: Meat, fruit and vegetable consumption in sub-Saharan Africa: a systematic review and meta-regression analysis.

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ABSTRACT

Context: The dietary choices people make affect personal health and have consequences for the environment, both of which have serious implications for the 2030 Sustainable Development Agenda. In global reviews, the literature on meat, fruit, and vegetable consumption in sub-Saharan Africa (SSA) is limited.

Objective: This systematic review set out to quantify meat, fruit, and vegetable consumption in sub-Saharan African populations and to answer the question: How much meat, fruit and/or vegetables are being consumed daily by which individuals in SSA over the years?

Data Sources: Following the PRISMA guidelines, the authors systematically searched MEDLINE, EMBASE, ASSIA CINAHL, Web of Science, POPLINE and Google Scholar to identify 47 (out of 5922 search results) studies reporting meat, fruit and/or vegetable consumption in sub-Saharan African populations.

Data Extraction: Three independent investigators extracted data on year of data collection, study country, study population and geographical context, and population intake of meat, fruit and/or vegetables.

Data Analysis: Using STATA SE version 15, random effects meta-regression analyses were used to test the effect of year of data collection and method of data collection on population meat, fruit, and vegetable consumption. The analyses also tested any association between age, sex, urban/rural residence or a country's economic development, and population intake of meat, fruits and/or vegetables. The review was started in 2017 and completed in 2019.

Results: Richer SSA countries were likely to consume more meat (ß =36.76, p=0.04) and vegetables (ß =43.49, p=0.00) than poorer countries. Vegetable intake has increased dramatically over the last three decades from ≈10g to ≈110g (ß=4.43, p=0.00). Vegetable (ß=-25.48, p=0.00) consumption was higher in rural than urban residents. Although the trend of meat consumption has gone up (≈25g to ≈75g), the trend is non-significant (ß=0.63, N.S.). Daily average per capita meat consumption was 98g, above 70g recommendation, while fruit and vegetable intake (268g) remain below WHO's recommendation (400g).

Conclusions: Given the low intake of plant-based foods it is likely that SSA populations may be deficient in high quality protein and micronutrients as suggested by the EAT-lancet commission.

There is the need for promoting both the adequate supply and demand of plant-based protein and micronutrients including fruit, vegetables, nuts, seeds and legumes in SSA countries. While dietary changes in SSA may offer large absolute benefits, consideration of the magnitude of dietary change, particularly increasing or reducing meat consumption, will need to occur in a way that ensures that policy and interventions support the reduction of under-nutrition and micronutrient deficiencies without worsening NCD prevalence and environmental impacts. There is also the need for preventive action that ensures that SSA populations do not increase their meat consumption as disposable incomes increase and countries' economic development rise as seen in most countries undergoing economic transformation.

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INTRODUCTION

The dietary choices people make affect personal health and have consequences for the environment. The food system, for example, accounts for 70% of freshwater[*] drawn for human consumption. [1] It also takes up over one-third of the Earth's productive land [2] and is responsible for nearly a fourth of global greenhouse gas (GHG) emissions [3] with livestock production alone accounting for 80% in each instance .[2,3] According to the 2017 Global Burden of Diseases, Injuries and Risk Factors Study, poor diets including overconsumption of meat and low intake of fruit and vegetables, is a risk factor in one of five deaths worldwide and the second highest risk factor (after smoking) for premature deaths. [4] This situation is projected to worsen in the absence of planned and directed dietary shifts or modifications as a growing, increasingly urban and wealthy global population adopt diets that are obesogenic.[5] These in turn may contribute to increasing the burden of non-communicable diseases (NCDs), [6–9] emit more GHGs, [5] and potentially limit the Earth's future capacity to supply safe and affordable food for all.[10,11] This is particularly important for Africa where the largest population growth [12] and most drastic future urbanisation, as well as the largest growth in NCD deaths [13] are expected to happen in the next few decades amid severe food insecurity issues.

There is a strong consensus in recent evidence that reducing meat intake in favour of fruit and vegetables and other plant-based diets could offer multiple benefits, including improved public

[*]**Freshwater** refers to all naturally occurring water except seawater and brackish water. Freshwater drawn for human consumption includes those that could be used for drinking, hygiene, agriculture and industry.

health [14,15] and potentially reduced environmental impact. [15,16] Meat is an important source of protein, readily absorbable zinc and other essential minerals (iron, potassium and selenium), amino acids and vitamins (vitamins B3, niacin, B6, riboflavin, and B12).[17–19] This makes meat admittedly important for combating micronutrient-deficiency including iron deficiency (leading to anaemia) in sub-Saharan Africa (SSA), where prevalence is highest. [20] However, excessive consumption of meat leads to excess intake of energy, saturated fats and cholesterol which are important risk factors for ischaemic heart disease. [21] This may partly explain meat's association with all-cause mortality in recent research. [22] Meat (particularly red and processed meat) has also been positively linked to some cancers, particularly, colorectal, pancreatic, stomach and prostate and other NCDs. [23] Recent evidence corroborating this has suggested that every 50g meat consumed per day increases the likelihood of developing colorectal cancer by about 18%.[23,24]

Epidemiological studies imply a convincing involvement of carcinogenic compounds such as polycylic aromatic hydrocarbons (PAHs) and N-nitro formed in meat during high temperature cooking in the development of some NCDs. [25–28] In contrast, high fruit and vegetable intake is proven to increase carotenoids and vitamin C, both of which possess antioxidant characteristics that may prevent the initial phase development of some NCDs. [29–32] The protective effect of dietary fiber contained in fruit and vegetables (with some starchy vegetables containing higher amounts) for some NCDs such as colorectal cancer is well documented. [33–39] Low fruit and vegetables consumption is thus an important risk factor for NCDs, accounting for nearly 5.2 million deaths annually. [40] Populations in SSA may be at a higher risk given that one in four people lack adequate food. [41] Moreover, along with a complexity of other determinants of food choice, high meat diets are desirable status symbols in most parts of the African sub-region. [42] Along with meat, other foods like starchy staples, are deeply entrenched in the local religious beliefs, customs and traditions. [43] Empirical evidence on meat, fruit and vegetable (MFV) consumption in SSA is a precondition for effective interventions targeted at reducing NCD deaths as targeted in the WHO Global Action Plan for the Prevention and Control of NCDs. [45] The WHO suggests nine key targets including a 25% relative reduction in risks of death from NCDs and a 0% increase in obesity and diabetes by 2025. [45]

The environmental sustainability of meat-rich diets has become a global concern on the grounds that meat production overexploits and degrades land and water resources and is the single largest contributor to global warming within agriculture. [45] Meat and dairy alone account for 14.5% of global GHG emissions. [46] According to recent analysis, emissions for every gram of protein from meat is 250 times the GHG emissions from plant-based food[5]. Emerging literature indicates that meat uses 36 times more land than vegetarian protein, [45] requires 11 and 6 times more water and fertilizer, respectively, than other crops.[47] Additionally, one-third of global food crops are fed to livestock with only 12% returning as meat and other dairy products.[48]

A dietary shift from meat and dairy to fruit and vegetables, could deliver major reductions in environmental impacts, e.g. 70 to 80% of GHG emissions, 50% land use and 50% of water use, compared to 1995 levels.[16] It may also contribute to the current target of the International Climate Change treaty of keeping global temperature increases below 2^0C.[3] Increasing fruit and vegetables consumption to WHO recommended levels could also prevent 6 to 10% deaths globally. [8] The EAT-Lancet Commission has recently introduced a flexitarian dietary regime that requires dietary shifts in every part of the world which makes it possible to feed 10 billion people a healthy diet within planetary boundaries by 2050.[49] The Commission suggests a drastic increase of plant protein in the diet which can optimally contain modest amounts of fish and dairy foods, while drastically cutting back on meat consumption. Recent evidence has also highlighted that dietary shifts in Africa and other developing countries would offer the largest absolute health and environmental benefits.[8] Clearly, these have serious implications for the 2030 Sustainable Development Agenda.[50] They have direct implications for the achievement of seven of the Sustainable Development Goals (SDGs) from poverty alleviation through sustainable production and consumption to food security, ensuring healthy lives, climate change, and protecting planetary resources, including water, land, biodiversity, etc. At the same time, one of the key health and well-being co-benefits of sustainable development include sustainable food production and distribution.[51,52] Moreover, while health and well-being is an end in itself in the principle of sustainable development, it is also an essential prerequisite for achieving all other SDGs as they are intrinsically connected and interdependent.[52,53] There is thus a strong consensus on the need for intersectoral actions among nutrition, health and non-health sectors in achieving health, well-being and sustainable development.[51,54–56]

Though only a small proportion of the global population meets the WHO/FAO (2003)[58] recommended daily minimum of 400g or five servings of fruit and vegetables,[59] little is known about how much is consumed by populations in SSA. The World Cancer Research Fund International's recommendation of less than 500g (18oz) [or 71.43g per day] of meat per person per week [61] is also exceeded in many populations.[62] While consumption trends seem to have stagnated or declined in high income countries (HICs) in the last five decades, consumption trends across sub-Saharan Africa are not clear. [62] As SSA is on the path of an unprecedented wave of urbanisation,[12] understanding meat, fruit and vegetable (MFV) consumption trends in SSA is an important first step in understanding the dynamics of how urban/rural food environments impact diets in SSA. Robust results could be used to develop new and improved agricultural, trade, food security and nutrition policies. Moreover, given the importance of the quantity of MFV in constituting a healthy diet, and in achieving the UNFCC climate change, [63] WHO NCD targets [64] and the SDGs, it is essential to quantify MFV consumption in SSA populations and any accompanying secular trend.

Systematic reviews that synthesize evidence on meat, fruit and vegetables consumption have focused on developed countries and low-and-middle-income countries (LMICs) in Asia.[65–67] This review aims to bridge this gap by systematically gathering and synthesizing evidence on the quantity of MFV consumed in SSA using the PRISMA guidelines to inform the development of tailored policy interventions. The main review question is: How much meat, fruit and/or vegetables are being consumed daily, by which individuals in SSA over the years?

REVIEW QUESTIONS

This systematic review aimed to answer three questions defined following the PICOS model (table 1):

1. How much meat, fruit and/or vegetables are being consumed daily by individuals in SSA?
2. Who is consuming the most (rural/urban; male/female, etc.)?
3. How has consumption changed over time?

METHODS

Study protocol

A protocol for this systematic review was registered with PROSPERO on 15th March 2018 CRD42018090497 (available from: http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018090497).

Search Strategy

The search strategy designed in consultation with a specialist librarian included the following steps:

1. An initial limited search of MEDLINE database was conducted with the following search terms; (Fruit or vegetable or meat) combined with (consumption or portion size) AND (sub-Saharan Africa) to identify additional relevant keywords from the titles, abstracts and subject descriptors.
2. Key words identified from the initial scoping search were then included as search terms for extensive searches of MEDLINE, EMBASE, ASSIA CINAHL, Web of Science, POPLINE and Google Scholar electronic databases. The search terms are summarized in Table 2. Searches were conducted between July and September 2018 with no time limits. Results were limited to French and English Languages.
3. Reference lists of papers that met the inclusion criteria after formal screening were also searched for additional relevant papers.

Inclusion Criteria

Types of studies

The review considered quantitative studies that explored the consumption of meat, fruit and/or vegetable consumption in sub-Saharan Africa. Study types considered for inclusion were observational studies such as cross-sectional studies, and longitudinal studies like cohort studies and panel surveys with reports published in peer-reviewed academic journals. Studies that did not report the outcome of interest were excluded. Experimental studies that reported baseline consumption data were also considered for inclusion.

Types of participants

Studies that included children, adolescents or adults were considered for inclusion. Studies that included patient population samples were excluded.

The research participants should have been in a sub-Saharan African country. The World Bank's definition of sub-Saharan Africa as of July 2018 was adopted (see Appendix 1 or here: https://data.worldbank.org/region/sub-saharan-africa). Multi-country studies that did not report country-specific data for included sub-Saharan African countries were excluded.

Phenomena of interest

Studies that estimated the portions/quantities/servings of meat, fruit and/or vegetables consumed were included.

Definition of Meat

Meat was essentially defined as animal tissue, including any accompanying skeletal muscle and fat consumed as food. This comprised both red and white meat. Red meat, according to the WHO[61] are usually listed to include beef and veal from cattle, mutton from sheep, chevon from goat, venison from deer, ham, bacon and pork from pigs. White meat includes fish and poultry from chicken, ducks and turkeys. These were considered in this review, not excluding their processed forms such as sausages, corned beef, hot dogs, khebabs, canned meat, canned fish/sardines, etc.[68] Studies that looked at bush meat and dog flesh consumption were also included. Studies that included eggs within their definition of meat were also eligible for inclusion.

Definition of Fruit and Vegetable

The significant between-country variations in the definition of what constitutes fruit and vegetable are well-known concerns among food and nutrition researchers. [69,70] The main area of controversy has been the inclusion or exclusion of starchy tubers such as potatoes in classifying fruits and vegetables.[71] For instance, the USA, Australia, and Canada classify potatoes as vegetable, whiles the UK does not.[71] The review followed the definitions of study authors, but where possible, starchy crops such as potatoes, plantain, yam, taro, cassava, and breadfruits were excluded from the definition of vegetable. The global estimates of the burden of disease attributable to inadequate intake of fruit and vegetable [72,73] and other studies that assess fruit and vegetable consumption, including WHO studies (WHO and FAO, 2003)[58] and other research [74,75] have exempted starchy crops. Although, starchy vegetables provide a variety of valuable nutrients that can make a healthy addition to diets, starchy vegetables contain 3 to 6 times more carbohydrates and calories than non-starchy vegetables. [76] A sensitivity analysis was also conducted excluding studies that included starchy vegetables in their estimation of vegetable consumption to assess the robustness of the results.

To ensure transparency, the search procedure and results, including the number of studies in/excluded at each stage have been summarized in a Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) flow chart presented in the results section (Figure 1).[77,78]

Study selection

There was an initial decision for possible inclusion based on titles and abstracts conducted by two independent researchers (DOM, TB). At this stage, studies were only eliminated if eligibility criteria were clearly not met. Where there was uncertainty about a study meeting the inclusion criteria, full texts were obtained for extensive assessment against the criteria. Full texts of potentially relevant papers selected based on titles and abstracts were retrieved and assessed against the eligibility criteria by two independent reviewers (DOM, OO). Any differences in opinions were resolved by consensus.

Data Extraction and Quality Assessment

Data Extraction

Three independent investigators completed data extraction in duplicate (DOM, ARN, OO). Data were organized in excel spreadsheets using the following data types as headings:

1. Authors
2. Type of study
3. Year of publication
4. Year of data collection
5. Study population (e.g. size, age cohort, etc.)
6. Country of research
7. Geographical context (this included rural or urban). Peri-urban/semi-urban
8. Variable(s) measured (meat, fruit or vegetables)
9. Measurement method used
10. Meat, fruit or vegetables intake (g/day/portion/serving size). Data were extracted for age cohorts, male and female, and urban and rural settings. Where required, portion or serving size is converted into grams using the conversion 1 Portion/Serving=80g. Consumption data were reported differently in different studies. For example, some studies presented mean (standard deviation or standard error or confidence intervals) and others presented median (inter-quartile ranges IQR) in various measurement units. Measurement units reported in the selected papers include grams, number of servings, litres, ounce, and kg (per year, month and day). Consumption data were therefore standardized into gram/day (SD). Conversions used have been outlined in Appendix 2.
11. Standard deviation of mean meat, fruit or vegetables intake
12. Standard error of mean meat, fruit or vegetables intake

Any disagreements and discrepancies were resolved by referring to original papers and further discussion.

Quality Assessment

It was anticipated that the robustness of methods of the papers included in the review would differ, and that lower quality papers could disguise essential findings. This was more importantly so, given that a number of confounding factors and design limitations often exist in observational studies.[79,80] The quality of included studies was therefore carefully and rigorously assessed.

There is no universally accepted quality assessment tool for observational studies [79–81] at the time of writing this report. The methodological quality of included studies was assessed using a tool adapted from Louw and colleagues (2007)[82] and subsequently used in systematic reviews by Wong et al., 2008; [83] Davids and Roman 2014; [84] Davids et al., 2016; [85] Roman and Frantz 2013, [86] among others. The areas outlined in Table 3 were examined to assess methodological quality.

At the quality appraisal stage, studies with methodological weakness were not excluded. All studies were initially included in the analysis. Sensitivity analysis was conducted at a later stage to gauge or evaluate the impact of low quality papers on the overall review outcome.

Statistical Analysis

A descriptive summary of findings from the included studies was organized as presented in Table 6. Table 6 presents important information regarding characteristics of study population, type of research, and measurement technique, among others enlisted above under data extraction section.

Extracted data were pooled into a meta-regression using a random effects model in Stata SE version 15. [87] Random effects model was used because the studies included in this review were conducted by different people in different locations at different times using different sample sizes. It is assumed that the studies included in the analysis are a random sample of all possible studies that meet the inclusion criteria for the review. Though the studies looked at the same or similar phenomena (MFV consumption in this case) it holds that the true mean will differ from study to study and therefore a random effects analysis fits best. This was intended to test heterogeneity among included studies as a result of gender, age cohort, rural/urban residence, year of data collection, method used to measure dietary intake, and the economic development of the setting/countries where included studies were conducted. The economic development of the study setting was based on the World Bank definition (low income, lower-middle income, upper-middle income) at the time of writing this report. [88] In conducting these analyses, 'farm' men and women, peri-urban, semi-urban, and pastoralist populations were classified as rural, whiles unplanned settlements were considered urban. Country-specific data for each particular country in multi-country studies were treated as separate/standalone entries. The age cohort classifications used by authors of included studies were followed (see Table 6).

Food intake measurement methods were grouped into Single 24-hour recalls, Food Frequency/Propensity Questionnaires, Multiple-pass 24-hour recalls, Food Balance Sheets and Others. The latter "Others" group captured all methods that did not fall under the first 4, including papers that did not report method of collection.

Where studies did not report period of data collection, three years prior to date of publication was estimated. [89] A median estimate was used in cases where reported collection period spanned two years or more. [90] For longitudinal studies, each reported year was treated separately in the meta-analysis. The baseline year and baseline data were extracted in the case of experimental studies.

Median intakes were converted to means where both median and interquartile ranges (IQRs) were reported following the quantile rule (after Wan et al., 2014 and Higgins et al., 2008) [91,92] as indicated in Table 3 along with other conversion methods adopted. Studies reporting only median intakes without sufficient data (without IQRs, etc. which are required to estimate mean intakes and standard deviations) to approximate mean intakes were excluded from the meta-analysis. Where standard deviations were missing, they were calculated using Cochrane Handbook procedures [91] where ample data were reported or supplied by original authors when contacted.

Sensitivity analyses were also conducted to assess the robustness of review conclusions. This involved the exclusion of studies with the lowest overall methodological appraisal scores that fell within the "Bad/Low" class score as described in Table 3. The quality appraisal scores for the various studies are presented in Table 7. All consumption estimates for children and adolescents were excluded in the third model of the sensitivity analyses. In a fourth model, studies that included starchy vegetables in their estimation/definition of vegetable consumption were excluded.

RESULTS

Our searches of MEDLINE, EMBASE, ASSIA, CINHAL, POPLINE, Google Scholar, and Web of Science retrieved 5922 records. The search of Google scholar found 28508. The first 1000 papers, after sorting by relevance, were included for review, making a total of 6922 records. These records were screened, and the abstracts of 1197 papers retrieved after omitting irrelevant papers. After title and abstract screening, the full-texts of 215 papers were retrieved after 982 papers were excluded. Of the remaining, 44 papers were found relevant after reviewing full-texts against eligibility criteria. Five more papers were identified through reference searches, giving a total of 49 papers.[94–142] Two [103,112] studies were subsequently excluded due to insufficient reported data and authors not responding with additional information when contacted. The remaining 47 [94–104,113–124,133–140] were included in the narrative synthesis. Figure 1 is a PRISMA flow chart detailing the search results.

The included studies covered 24 SSA countries with the highest number of studies coming from South Africa (17) [31–47] followed by Kenya (4) [101–104] and Ghana (4) [97–100]. Fifty percent of these were conducted in low income countries, 29% within lower-middle income and 21% within the Upper-middle income category (based on World Bank, 2018 classification). These studies were published between 1985 and 2018. Dates of data collection span from 1977 to 2015, though a few papers did not report this. Of the 47 included studies, 31 reported on meat, fruit and vegetable consumption, [93–95,99,101,103–108,110–112,116,121–131,134–136,138] 8 reported on fruit and vegetables only, [97,98,102,113,115,118,120,139] 3 reported on meat and vegetables only, [109,132,133] 1 reported on vegetables only, [117] and 4 reported on meat only. [96,100,119,137] In terms of age-cohort, 28 of the included studies looked at adults only, 13 included children only and 6 studied both children and adults. Consumption of meat, fruit and vegetables in the various populations reported in the 47 studies are summarized in Table 6. Quality of these studies were assessed by two reviewers working independently (summarized in Table 7).

Meat Consumption

After extracting data separately for five domains; children and adults, for male and female, for rural and urban populations, for method, and period of data collection, as reported in included studies, there were 91 (adults=75, children=16) population estimates for meat consumption. The oldest and most recent data collection dates were 1977 and 2013, respectively. Forty-eight percent (45) of all 91 meat consumption estimates were above 70g per day, putting average per capita intake at 98g. Fifty-one percent of adult estimates were above 70g per day, compared to 44% of child population estimates.

The 3 lowest meat intakes (1 to 2g) were reported in rural Mali populations in the mid-1990s. Of the remaining intakes under 12g, one was recorded in rural Namibians in the 1980s, four from rural Malian adults and one found in rural children in Kenya all of which were studied in the late 1990s. The rest included 2 urban adult populations and one rural adult population, respectively found in Ethiopia and Burkina Faso and all were studied in the early 2000's.

The highest meat intakes of over 380g and 340 g per day were respectively recorded in urban adult populations in Equatorial Guinea and Ghana in 2003 and 2005. These, including a 320g per day intake in two other South African adult populations, were outliers and are likely to be unreliable. These estimates were mostly extracted from studies that derived consumption data (portions) from household expenditure on meat, [100] total protein intake from meat, fish, poultry, eggs, legumes and nuts reported together as 'meat group' [131] and 24-hour recalls of amount of meat purchased. [137]

In all 8 studies that reported meat intakes for both males and females separately, male intake estimates were always higher, except for Amare et al., 2012.[95] In 5 studies that reported estimates for both urban and rural populations, urban intakes were always higher than intakes in rural populations.

For the meta-regression, two studies, [138,140] were excluded due to non-reporting of IQRs of median meat intakes to allow mean intake conversions and attempts to contact authors were unsuccessful. Six outliers were also excluded. Regressing mean meat intake on 6 potential sources of heterogeneity separately, suggested that there was a correlation between method of data collection and meat intake; between economic development of included countries and meat intake; and between residence (rural or urban) and meat intake. Meat consumption has been on an upward trend over the last 3 decades, with higher intakes in more recent studies, however this trend was not statistically significant. (Table 4 and Figures 2 to 5).
Multivariate meta-regression showed statistically significant association between country economic development and meat intake, with populations from richer countries consuming more meat than those from lower income countries. This association remained robust in sensitivity analysis (Table 5).

Vegetable Consumption

By extracting data separately for the five domains, 87 population estimates were recorded between 1985 and 2015 for vegetable intake. Out of this, 39.1% (34) reported daily per capita vegetable intakes below 80g (1 portion) while 72.4% (63) reported intakes of less than 160g (2 portions). An overall average consumption of 132.26g compared to a 100.66g average in adults and 245.33g average daily intake in children.

The 3 lowest intakes (2 to 8g) were reported in rural Namibian and urban Ethiopian adults in 1985 and 2005 respectively. Five others under 30g were recorded in rural adults studied in Mali in the 1990's. Of the rest, one each was found in Kenya, Mozambique and Congo (D.R) among adults in the early 2000's.

The highest vegetables intake was found in rural Kenyan children at 502g per day in 2012. Other high vegetables intakes at more than 400g per day were recorded in 2 South African populations in 2011 and 1999. Intakes between 240 and 323g (3 and 4 portions) per day were also found in 13 populations in Zambia, Kenya, Ghana, South Africa, Nigeria, and Benin. Of the remaining, 7 study populations were reported to be consuming between 160 and 232g (2 to 2.5 portions) per day. In terms of rural-urban differences in vegetables intake, 60% of studies reporting estimates separately for both populations, pointed to higher intakes in urban than rural residents.

All 87 population estimates were included in the meta-regression. Examining the 6 potential sources of heterogeneity separately, suggested that there was an association between year of data collection and vegetable intake; between economic development of included countries and vegetable intake; and between age and vegetable intake. Vegetable consumption has increased dramatically over the 30-year period, with higher intakes in more recent studies, higher intakes in children than adults; higher intakes in higher income than poorer SSA economies/countries; and slightly higher intakes in rural than urban populations(Table 8 and Figures 6 to 8).

A meta-regression including all covariates confirmed statistically significant association between year of data collection and vegetable intake; between rural-urban residence and vegetable intake; between economic development and vegetable intake; and between age and vegetable intake (at

10% level). These associations remained robust in sensitivity analysis excluding low quality studies (Model 2, Table 9). In sensitivity analyses including only non-starchy vegetables, the associations remained robust between vegetable intake and year of data collection; vegetable intake and rural-urban residence; and economic development and vegetable intake (Model 4, Table 9a and Figure 8a). However, the rural-urban gradient became more visible after excluding starchy vegetables.

Fruit Consumption

There were 83 population estimates for fruit intake. These data were collected between 1991 and 2015. Of all 83 estimates, the proportion consuming less than 80g (1 portion) and 160g (2 portions) of fruits a day reached 36.1% (30) and 66.0% (55) respectively. Average daily fruit intake in adults was lower at 147.45g than the overall mean of 155.64g. These compared to an average of 187.45g in children.

The lowest intakes found in 6 study populations in Botswana, Ethiopia, and Mali between 2002 and 2005 were less than 10g per day. All these but one study in Botswana were urban adult populations. Of the remaining, 14 of the populations studied reported daily per person intakes of between 10 and 49g, studied mostly between 2000 and 2009. The rest included 9 populations in Ghana, South Africa and Kenya consuming between 60 and 80g. Whiles the lowest fruit intake (0.80g) was recorded in urban adults in Ethiopia, the lowest intake in children was at 10g, reported in rural Kenya in 2012.

Fruit intake was highest at over 805g per day in Senegalese adults studied in 2007. Other high daily fruit intakes between 450 and 687g (4.5 and 6.6 portions) were also recorded in 5 other adult populations in Nigeria, Uganda and South Africa. The rest included 11 estimates, representing 13%, consuming between 240 and 365g (3 to 4.5 portions) per day. The highest fruit intake in children was reported at 365g per day found in South Africa compared to over 805g in Senegalese adults.

All the 83 population estimates were included in the meta-regression. Exploring the 6 potential sources of heterogeneity separately, suggested that there was an association between year of data collection and fruit intake, with lower intakes in more recent studies; between age and fruit intake, with children consuming higher; and between residence (rural or urban) and fruit intake, where intakes were higher in rural than urban populations (Table 10 and Figures 9 to 11).

A meta-regression including all covariates pointed to statistically significant association between age and fruit intake. This relationship remained robust in sensitivity analysis (Table 11).

Fruit and Vegetables intake

Data werer extracted for 115 population estimates based on the five domains (children and adults, male and female, rural and urban populations, method dietary data collection, and period of data collection) for fruit and vegetables intake, reported between 1977 and 2015. These covered 22 SSA countries and included 90 estimates for adults and 25 estimates for children. Of all 115 estimates, 79.13% (91) reported intakes below WHO's recommended daily intake of 400g. Up to 15.65% (18) found per capita intakes below 80g per day and 28.70% (33) consuming less than 160g (2 portions). Over 32% (37) reported daily intakes of 161 to 240.70g (2 to 3 portions). Those reporting intakes of 400g or more reached 20.87% (24), with 15.65% (18) consuming between 502 and 923g per day.

The 4 lowest intakes (3 to 4g) were adult populations (1 male, 3 females) in 1977 and 2005 in South Africa and Ethiopia. Other low fruit and vegetables intakes (between 10 and 74g) were found in 12 adult and 2 populations of children in Namibia, Kenya, Ethiopia, Botswana, Burkina Faso, Mali, Mozambique and Zimbabwe mostly recorded between 2002 and 2005. The lowest intake in children was 10g per day reported in rural Namibia in 2002 compared to 3.22g in urban adults reported in 2005 in Ethiopia.

The highest fruit and vegetables intakes at 922.52g and 830.50g were respectively recorded in Senegalese and South African adults in 2007 and 1994. Other high intakes between 705 and 774g (8.8 and 9.7 portions) per day were found in 4 populations (2 adult, 2 children) in Nigeria and South Africa. The rest included 12 populations (5 adult, 7 children) in Cameroon, Kenya, Ghana, South Africa and Uganda consuming between 500 and 690g. In children, the highest intake reported was 738g per day in South Africa in the 2005.

In 6 of 8 papers that reported separately for both males and females reported higher intakes for females than males. Out of 9 papers reporting intakes separately for both urban and rural residents, 6 always reported higher intakes in urban. The highest intake in females (830.50g) and males (344g) were both reported in South Africa in 1994 and 1979 respectively.

All 115 population estimates were pooled in the meta-regression. Exploring the 6 potential sources of heterogeneity separately suggested that there was an association between method of data collection and fruit and veg. intake; and rural-urban residence and fruit and veg. intake. Although not statistically significant, fruit and veg. consumption has increased over the last 38 years, with higher estimates in more reliable methods; higher intake in rural than urban areas; and higher intake in males and females (Table 12 and Figures 12 to 14). No clear difference was observed between LICs and HICs. However, in a sensitivity analysis removing starchy vegetables, higher consumption was observed in HICs than LICs (Figures 15) and this was statistically significant (Table 13a).

DISCUSSION

This review systematically identified and reviewed 49 papers reporting meat, fruit and/or vegetables consumption focused on sub-Saharan Africa and with no date restrictions.

Summary of Key Findings

The average per capita daily consumption over the previous 30 years was found to be 98g for meat and 268g for fruit and vegetables. While nearly a half of mean population meat intake estimates were above 70g, about a third of mean population daily vegetable (32%) or fruit (36%) consumption estimates was less than one portion. Through random effects meta-regression, it was found that richer SSA countries consumed more meat (p=0.010) and more vegetables (p=0.000) per capita than poorer SSA countries, and these findings remained robust in both multivariate and sensitivity analyses. Vegetable consumption (p=0.000) in rural areas was also more likely to reach WHO recommended levels than in urban areas, after controlling for age, gender, year of data collection, method of data collection, and country economic development. This rural-urban gradient became more evident after removing estimates that included starchy vegetable consumption; suggesting that a greater proportion of the vegetables that urban SSA populations consume is starchy vegetables. Rural residents were more likely than their urban counterparts to meet WHO recommended daily intakes for fruits (p=0.000) in univariate regression analyses, but meat consumption (p=0.013) was higher in urban populations. The rural-urban difference in meat or fruit consumption was, however, not robust in multivariable analyses. No clear gender differences in meat, fruit or/and vegetables consumption were found.

Comparison & Interpretation

MFV consumption by Countries' Economic Development

The results of the meta-regression showed that higher income SSA countries consumed more meat (p=0.002) than poorer countries (Figure 4, Table 4), which appear to support the hypothesis that meat consumption increases as societies get richer. This income gradient was also observed for vegetable intake in the meta-regression (Figure 7). Poorer countries consumed fewer vegetables than higher income SSA countries (p=0.006) (Table 8, 9 and 9a). These results are in line with existing literature [142–144] which could be a confirmation of the robustness of the results in this review. As disposable incomes increase, usually resulting from economic development and urbanisation, people tend to consume more protein and high-calorie products, especially meat and other livestock products, potentially influenced by a desire to emulate "western" lifestyle. Economic growth and urbanisation are widely believed to alter lifestyle and dietary patterns partly as a result of changes they bring to the food environment, increased disposable incomes, more sedentary and time-consuming occupations. [145,146] According to Marques et al. (2018)[143] economic growth has greater impact on poorer countries' change in the consumption of such products. This impact reduces along the way towards the richer HIC state on the Economic development scale. At this point the consumption of meat plateaus and possibly even declines among individuals in high-income economies as is being witnessed in some HICs, according to the FAO.[147,148] Given that meat consumption in HICs (at already high levels) will level off, in the future, the greater adverse health and environmental impacts will likely result from low-income and emerging economies. It has been previously found that persons in lower income economies are less likely than those in high income economies to meet recommendations for vegetables consumption. [149] Miller and colleagues [149] also found that for persons in LICs, the cost of both fruits and vegetables in relation to household incomes were markedly higher compared to individuals in richer countries. In the same study, increase in the prices of fruits and vegetables was associated with reduced intakes. A systematic review and other studies have also found recommended healthy diets to be more expensive and less desirable in deprived and lower income societies. [150,151] Households on low incomes are more concerned about hunger and are more likely to choose food that is filling or with high satiety value (such as starchy staples, including starchy vegetables) over food such as fruit or vegetable with high nutrient value. [152] The current results provide added support for studies that have reported monetary cost as a key determinant and known barrier to vegetable and fruit consumption, especially for those in lower socioeconomic societies. [153–155] Culture as an influence on dietary behaviours is well-documented. [146,156,157] In most African cultures and other LICs, some food items are associated with social status and seen as desirable status symbols [158]—often referred to as 'luxury' foods, and usually include meat, other animal products, chocolates and other confectionery, biscuits, ice-cream, soft drinks, fried foods and ready meals. [159,160] Eating such foods on a regular basis is seen to confer a superior social status compared to fruit, vegetable and legumes which are less desirable and seen as survival food for the poor. [160,161]

MFV Consumption trends between 1977 and 2015

The results of the meta-regression also showed that consumption of two of the variables of interest (meat and vegetables) have been on an upward trend over the last three decades (Figures 2, 6, 9 & 13). Meat consumption (N.S) and especially, vegetable intake (p=0.002) are likely to have increased dramatically over the 30-year period, with meat intake in many adult populations (49% of population estimates) exceeding the upper limit of 70g recommended by the WCRF, and above this level in some populations of children. It is however possible a section of the population may be consuming way too small amounts of meat given that the results presented here are averages. This is because averages may conceal the differences in consumption among different sections of the population. This finding is consistent with global meat consumption trends which has seen a 20kg per capita increase per annum between 1961 and 2014 [62] and in LICs, [142] but in contrast, a slow decline in many HICs. [62] The results also support the EAT Lancet Commission's report regarding low intake of fruit and vegetables compared to higher meat intakes. [49] Though the increase in meat consumption in this study (Figure 2) was statistically non-significant, other studies have also found an upward trend in many LDCs. [162] In most SSA cultures and especially countries going through economic transition, eating meat is seen as a symbol of wealth and thus aspirational and desirable. [42,163] Such between-country disparities in meat consumption have been attributed partly to cultural differences. [164,165]

On the contrary, fruit or/and vegetable intake remain substantially below WHO recommended levels (Figures 6 and 9). Similar findings of less than 1 portion of fruit or vegetables have been reported in Ghana, [98] Uganda, [166] Tanzania [167] and other low-income countries (LICs) like Bangladesh, India, Jamaica, and Philippines. [168] The prevalence of low fruit intakes (less than 1 portion daily) was in a similar range as those reported by other studies conducted in some high-income countries. In 2015, for example, 37% of U.S adults in the Behavioral Risk Factor Surveillance System (BRFSS) survey consumed less than 1 serving of fruit. [169] A similar finding

has been reported in 29% of Austrian adults. [170] In Barbados 26.9% of adults are reported to consume less than 1 serving of fruit and vegetable. [168]
Compared to meat and other animal-source foods consumption which in most African cultures is seen to confer a superior social status, fruit, vegetables, legumes, and grains are less desirable and seen as survival food for the poor. [160,161] It is therefore likely that as suggested in the EAT-Lancet commission's report, the consumption of other plant-based foods like legumes, nuts or seeds is also low in SSA populations apart from fruit and vegetables, though the review did not cover legumes, nuts or seeds. Based on inference from the EAT-Lancet report on plant-based foods as sources of high quality protein and micronutrients, it may also follow that the SSA population may likely be deficient in micronutrients and high quality protein.

Rural/urban variations in MFV consumption

Through a between-study comparison in univariable meta-regression, it was found that urban populations in SSA may be consuming significantly more meat than rural populations (p=0.013) (Figure 5) but taking slightly fewer vegetables (p=0.000) and fruits (p=0.000) than rural residents (Figures 8 and 14). The observed vegetable consumption difference between rural and urban areas becomes more prominent after adjusting for starchy vegetables (Figures 8 and 8a). This suggests that urban populations may be consuming more starchy vegetables than non-starchy vegetables which are usually relatively cheaper in urban areas. Although rural-urban difference for meat consumption did not remain statistically significant (robust) in multivariable analysis, higher meat intakes in urban areas may be due to higher disposable incomes associated with urban living [99,171–173] and/or shifts towards high animal protein diets that characterize populations in transition to the "degenerative disease" period of Popkin's (1999) nutrition transition. [174] Yıldırım & Ceylan (2008) [175] have previously reported similar finding of high meat intakes in urban populations in Turkey, and there are similar findings report in urban Ghanaian adults [99] and in Italian adolescents. [176] Conversely, studies conducted in Australia and Romania have reported higher meat intakes in rural than urban adults. [177,178]

Regarding fruit and vegetable consumption, the rural-urban difference observed in this review is corroborated by findings in other African countries (Congo, Côte d'Ivoire, Kenya, Zambia and Tunisia) and in Bangladesh, Ecuador, Paraguay, Philippines, and Ukraine in a multi-country study based on WHO survey data. [74] Padrão et al. (2012)[179] have also reported lower intakes of both fruit and vegetables in urban than rural Mozambique's. In rural areas in SSA and other LICs, farming is largely for subsistence and provides increased access to fruits and vegetables in rural areas. It is therefore conceivable that rural populations would consume more fruits and vegetables. The influences of food environments on food choice may also explain low fruit and vegetable intake in urban areas of SSA where the food environment offers a wider variety of food products, especially ultra-processed foods. However, based on household expenditure data on 10 SSA countries, Ruel et al. (2005)[75] reported higher fruit and vegetable intake in urban than rural populations. While this may have changed after nearly two decades of their research, similar findings have been reported in 3 Baltic countries (Estonia, Lithuania and Latvia) and in Norway. [180–182] Similarly, rural residence has been associated with low fruit and vegetable intake also in countries of the former Soviet Union, [183] in the USA, [178] Morocco, [184] India, [185] and other countries from 8 geographical regions. [186]

MFV consumption by Age cohort & Dietary Assessment Method

Whiles there was no clear difference between adults and children for meat consumption, it was found that consumption decreased with age for fruits (Table 10) and for vegetables (Table 9). This finding is in line with findings from studies by Ndagire et al. (2019)[166] in Uganda, [166] for fruits in Tanzania [167] and in the UK based on National Diet and Nutrition Survey (NDNS). [187] Conversely, studies from Tanzania [167] have reported higher vegetable intakes in the old than in younger populations. Surprisingly, adults consumed more in terms of fruit plus vegetables, though this was not statistically significant (p=0.310) (Table 12), given that higher intakes in children for fruits only and vegetable only were both statistically significant (Tables 9 and 11). There were no clear and statistically significant differences in consumption of MFV between sexes.

In terms of method of data collection, studies that adopted more reliable dietary assessment methods (MDR, FFQ) reported lower consumption estimates than methods considered less accurate, such as a single dietary recall method (Figures 3, 10 & 13 and Tables 10, 12 & 13), except for combined fruit and vegetable intakes, though not statistically significant. A systematic review that assessed the validity of dietary assessment methods against doubly labelled water as a gold standard, found similar results. [188] Over-reporting was most often associated with 24-hour recalls than food frequency questionnaires. As most of the reviewed studies adopted single 24-hour dietary recalls, it is recommended that future research adopts more reliable assessment methods that give more accurate dietary intake estimates.

Strengths and Weaknesses of the study

This systematic review has a number of strengths and weaknesses. Most of the shortcomings of this review largely reflect the limitations of the included studies.

This review is the first of its kind that focuses on SSA and in terms of strengths, it involved an extensive and thorough search of literature. Despite adopting narrow inclusion criteria, a large set of 47 relevant studies that focused on SSA and provides diversity were identified. Previous systematic reviews like [189] included 7 studies from SSA. To minimize bias, ensure transparency and achieve objectivity, this review included articles published in peer-reviewed journals selected based on predetermined criteria. Papers written in languages other than English and French were excluded, which is a potential limitation, as other relevant data may have been identified in such papers. However, the diversity of included studies offers an interpretive context in which the generalizability of findings is enhanced, which is otherwise not available in any one study or a smaller number of studies. This is because the large set of reviewed studies captured a diversity of SSA participants, wide variety of MFVs, and different methods of measurement.

The large diversity regarding data available from the included studies may also be a limitation. While some consumption data were derived from national level data based on FAO balance sheet and Euromonitor passport, other studies collected and reported consumption estimates at the individual level. The data were however standardized using conversion parameters in appendix 2. Congruently, some of the reviewed reports were restricted regarding sample size and generalizability as they included small non-random samples of specific groups (including, for example, studies with less than 200 participants) which may not be nationally representative. The inclusion of studies with both large and small sample sizes means a low/no publication bias, which is more likely to capture a more complete picture of MFV consumption in SSA populations. However, the results may not be necessarily representative of dietary intakes of the different countries or other sub-population groups used in the analysis. The results must be interpreted cautiously. In relation to the above, non-reporting of response rate in some of the included studies could increase non-responder bias in the results. This was dealt with by conducting a sensitivity analysis in which studies with low quality were excluded. It is recommended that future SSA research reporting should highlight response rates and other relevant statistics including missing data which was also not reported in some of the reviewed reports.

The included studies defined "meat", "fruits" and "vegetables" differently. The significant between-country and between-study variations in the definition of what constitutes fruits or vegetables are well-known concerns among food and nutrition researchers. [69,70] The main area in classifying vegetables. [71] Eleven [107,108,112,118,121,122,124,127,129,130,134,190] of 43 studies reporting on vegetable intake captured starchy tubers in their vegetable consumption estimates, while others [110,121,138] did not. In 5 [99,120,133,139] of studies reporting fruit consumption, fruit juices were captured in fruit consumption estimates. Of the 38 studies that reported meat consumption estimates, 15 studies included fish but 23 excluded it from meat consumption estimates. These differences in definitions may affect the accuracy of consumption estimates.

Another potential limitation relates to the use of different dietary intake measurement methods that agree less with each other. Some methods also relied on respondents' memory and skills of the interviewer. This has been associated with recall bias and social desirability bias [191] and may have resulted in under-and/or over-reporting of consumption estimates. By entering this into the multivariable models, the investigators have taken some account of the nature of the measurements in the analyses.

It is also widely known that vegetable and fruit consumption display seasonal variability, which may limit the comparison of the current findings within and across countries. This is because the different time periods for data collection for the various countries included in this review may have influenced meat, fruit or vegetable intakes at the time of data collection.
For example, according to Amo-Adjei and Kumi-Kyereme (2014)[97] in Ghana and most SSA countries, [98,105,108,127,134] during peak season, fruit and vegetable are in abundant supply and prices are cheaper. This is especially so in and around production areas and areas that are better connected to production areas in terms of distribution systems. Where majority of included studies are based on dietary data gathered during off peak season, resulting consumption estimates would not be representative of consumption in a full year. Though some papers included in this review collected data during the dry season, [102,106,119,133] others captured data during the peak season or throughout the year. [97,98,101,123] This makes consumption estimates in this review reflective of consumption estimates throughout the year.

Policy Implications

The findings of this review have important implications for food and nutrition security, health and environmental sustainability policies in sub-Saharan Africa. This is because the subregion has the world's highest prevalence of hunger and undernourishment. Coexisting with this is a rapidly increasing prevalence of nutrition-related NCDs. These trends are likely to worsen in the business-as-usual scenario where meat consumption continues to increase as incomes rise in SSA countries as have been observed in this review. Meat production and supply would need to increase to meet increasing demand. This will mean the emission of more GHGs to increase climate change and catastrophic weather events which impairs agricultural production and contributes to food insecurity and undernutrition in LICs. GHG emissions from livestock production in SSA and other LICs has increased by 117% between 1961 and 2010 compared to a 9% global average increase and a 23% decrease in HICs. [192] In addition to the adverse environmental footprints of meat production including biodiversity loss, land and water degradation, and deforestation, about 36% of global crop calories (especially from grains) is fed to livestock and only 12% return as food for people. [48] The latter increases demand for grain and drives up grain prices making it difficult for the poor in especially SSA to feed. This traverses the 2030 Sustainable Development agenda and makes the achievement of the SDGs and targets problematic. Apart from the need for the adoption of more efficient livestock production methods in SSA, climate change, health and well-being need to be properly integrated in livestock production systems along with other agricultural practices in the sub-region. There is the need for the promotion of both the adequate supply and demand (including the production, access to and consumption) of plant-based protein and micronutrients including nuts, seeds and legumes in SSA countries. While dietary changes in SSA may offer large absolute health and environmental benefits, consideration of the magnitude of dietary change, particularly reducing or increasing the consumption of meat or other animal protein, will need to occur to ensure reduction of under-nutrition and micronutrient deficiencies without worsening NCD prevalence and environmental impacts. There is also the need for interventions like public health education to ensure that as disposable incomes increase and countries' economic development rise, SSA populations do not continue to increase their meat intake as seen in most countries undergoing economic transformation. The EAT-Lancet Commission's planetary health diet may be a good starting point. The Commission recommends a flexitarian diet that does not completely eliminate meat and dairy but recommends a larger proportion of plant-based protein portions. [49] In Africa, however, the guideline calls for reduction in the consumption of starchy vegetables like cassava and taro, which the sensitivity analyses (model 4) indicate make up a larger proportion of vegetable consumption in richer SSA countries and in urban populations. Given that starchy vegetables are important staple foods in most SSA countries, it might be recommendable retaining them as part of healthy diet of developing and urbanizing countries. While low starchy vegetable diets would fit the EAT-Lancet Commission's flexitarian dietary regime retaining a place in a healthy diet of developing and urbanizing countries may deserve more attention. The flexitarian diet promises to save 11 million lives each year and ensure availability of safe, nutritious and affordable food for all 10 billion global population expected by 2050, without causing damage to the environment. The adoption of such policy will require multi-sectoral and multi-disciplinary collaboration to be successful and sustainable given the complexity of the nutrition situation in the sub-region. The complexity and multi-faceted nature of the factors that influence food behaviour and choice are also well-known.

Countries like South Africa, Nigeria, Ghana, Tanzania and Uganda have been proactive in interventions and national food and nutrition policy frameworks. Apart from Uganda's National Nutrition Action plan, these policies acknowledge the need for multi-sectoral and multi-dimensional approaches at both national and community levels to achieving good nutrition that is safe and accessible to all. However, there appears to be a disconnect among relevant sectors in terms of sector-specific policy direction. For example, while health sector institutions (public/private) educate on health benefits of fruit and vegetable consumption and good nutrition, government institutions in charge of finance focus on providing financial assistance mainly to cash crop producers, while agricultural sector policies encourage farmers to "farm for cash" rather than producing more healthy food and meat products and in ways that protect the environment. Fertilizer use in SSA for instance has increased by 240% since 1961 compared to 8% in Europe. [193] Run off from fertilizer application has polluted many water bodies [194] and nitrogenous fertilizers are harmful to human health and threaten terrestrial ecosystems. [195,196] Agricultural policies in SSA need to be properly aligned with environmental sector policies due to the existing interdependencies. Likewise, trade ministries are more export-oriented and this is counterproductive to the health and nutritional needs of local populations, [97] and to health promotion efforts. Efforts need to move away from discrete sector-specific actions and objectives towards 'integrated and indivisible' actions for sustainable development.

Across the sub-region, the most popular policy interventions have been catchall health promotion interventions that have sought to educate on the health benefits of fruit and vegetables/good nutrition with little or no attention to environmental sustainability and climate change mitigation. [98,190,197] This may be partly attributable to the reluctance of political decision makers to implement more effective policies which they deem expensive, opposition by powerful commercial vested interests and inadequate pressure from the public and civil society to demand for change from policy makers. Though there has been some improvement over the years through health promotion interventions, [98,197] consumption of fruit and vegetable is still unpopular in the sub-region. This has been attributed to the one-size-fits-all nature of interventions though the determinants of food consumption behaviour are complex and vary across socio-cultural, economic, demographic and genetic factors. [156,198,199] Additionally, of the 28 low-middle income countries (LMICs) that have policies to promote fruit and vegetable consumption, only 5 include strategies to meet WHO's recommended daily intake for fruit and vegetable. [197] This underscores the need for innovative and informed policy interventions that are tailored to various socioeconomic and demographic sub-groups. Of concern is the fact that meat and other dairy as well as starchy staples (like cassava, taro, potato, etc.) have been longstanding and entrenched cultural identity, religious and status symbols in most societies of the sub-region. Suggestions to reduce or increase consumption of starchy staples and meat may challenge or reinforce most of these values. Interventions aimed at reducing or increasing consumption of these foods need to recognize these values as they may pose major barriers to desired dietary behaviour changes.

Further research to better understand and update knowledge on the attitudes and perceptions of SSA populations towards meat consumption is therefore recommended in order to inform policy. Research to understand how personal health, body image/weight, animal welfare and environmental sustainability concerns influence these attitudes will also shed more light on the direction of future policy and interventions. Ascertaining the level of awareness of individuals in the sub-region of the health and environmental impacts of their food choices would be a useful future research focus. Research on individuals' willingness to reduce starchy staples or increase/reduce meat consumption as well as increasing fruit and vegetable is also recommended. Finally, research towards standardized definitions for meat, fruit or vegetable is highly recommended to facilitate uniformity and consistency in research reporting and allow more realistic cross-regional comparison.

Conclusion

Given the low intake of plant-based foods it is likely that SSA populations may be deficient in high quality protein and micronutrient as suggested by the EAT-lancet commission. There is the need for promoting both the adequate supply and demand of plant-based protein and micronutrients including fruit, vegetables, nuts, seeds and legumes in SSA countries. While dietary changes in SSA may offer large absolute benefits, consideration of the magnitude of dietary change, particularly increasing or reducing meat consumption, will need to occur in a way that ensures that policy and interventions support the reduction of under-nutrition and micronutrient deficiencies without worsening NCD prevalence and environmental impacts. There is also the need for preventive action that ensures that SSA populations do not increase their meat consumption as disposable incomes increase and countries' economic development rise as seen in most countries undergoing economic transformation.

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Authors' contributions: DOM performed the searches and screening, quality appraisal, extracted data, performed the meta-regression, and wrote the first draft of the manuscript. TB screened titles and abstracts. OO screened full text articles, performed quality appraisal, extracted data and helped design meta-regression analyses. ARN screened full text articles, performed quality appraisal and extracted data. RL checked the manuscript. All authors contributed to conception and drafting the manuscript, and all read and approved the final manuscript.

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TABLE LEGEND

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FIGURE LEGEND

Figure 1: PRISMA 2009 flow chart of search and screening results

Figure 2: Mean meat intake by year of data collection

Figure 3: Mean meat intake & method of data collection

Figure 4: Mean meat intake & country economic classification

Figure 5: Mean meat intake by rural/urban residence

Figure 6: Mean vegetable intake by year of data collection

Figure 7: Mean vegetable intake & economic classification

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Figure 9: Mean fruit intake by year of data collection

Figure 10: Mean fruit intake & method of data collection

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Figure 12: Mean fruit & veg. intake by year of data collection

Figure 13: Mean fruit & veg. intake & method of data collection

Figure 14: Mean fruit & veg. intake by rural/urban residence

TABLES

Table 1: PICOS model

Mnemonic	**Adapted PICOS**	**Description**
P	**P**opulation or **P**articipants	Children (1 to 10 yos), Adolescents (11 to 19 yos), Adults (19+). Excluded patient population samples.
I	Phenomena of **I**nterest	Meat, Fruit and Vegetables consumption (quantity, portions, servings)
C	**Co**ntext	sub-Saharan Africa (World Bank, July 2018)
O		
S	**S**tudy design/type	**Quantitative Observational studies** (Cross-sectional, Longitudinal, Panel studies). **Experimental studies** with baseline data. All peer-viewed academic journals

Source: adapted from Methley et al., 2014[200]**; Pollock and Berge 2018**[201]

Table 2: Search strategy

	Summary of search terms for MEDLINE, EMBASE (countries searched individually after Pienaar et al. (2011) [202]**)**
1.	sub-Saharan africa.mp. or exp "Africa South of the Sahara"/
2.	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 "Cote d'Ivoire" or Djibouti or "Equatorial Guinea" or Eritrea or Ethiopia or Gabon or Gambia or Ghana or Guinea or Guinea-Bissau 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 Rwanda or "Sao Tome and Principe" or Senegal or Seychelles or "Sierra Leone" or Somalia or "South Africa" or "South Sudan" or Sudan or Swaziland or Tanzania or Togo or Uganda or Zambia or Zimbabwe
3.	1 OR 2
4.	meat/ or meat products/ processed meat or poultry/ or red meat/ or fish
5.	exp FRUIT/
6.	exp VEGETABLES/
7.	4 OR 5 OR 6
8.	3 AND 7
9.	consumption/ or intake or EATING/
10.	diet/ or portion size/ or serving size/ or frequency
11.	9 OR 10
12.	8 AND 11
13.	limit to humans
	Search terms for Google Scholar & POPLINE (countries searched individually after Pienaar et al. (2011) [202]**)**
	(sub-Saharan Africa or 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 "Cote d'Ivoire" or Djibouti or "Equatorial Guinea" or Eritrea or Ethiopia or Gabon or Gambia or Ghana or Guinea or Guinea-Bissau 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 Rwanda or "Sao Tome and Principe" or Senegal or Seychelles or "Sierra Leone" or Somalia or "South Africa" or "South Sudan" or Sudan or Swaziland or Tanzania or Togo or Uganda or Zambia or Zimbabwe) AND (meat or "meat products" or "processed meat" or poultry or "red meat" or fish or fruit or vegetable) AND (consumption or intake or diet) AND ("portion size" or frequency or quantity)

Table 3: Methodological Quality Appraisal Tool

Domain/Question	Explanation	Scoring algorithm
Statement of study objective/aim 1. Was the research objective clearly stated (to measure meat/fruits/vegetables consumption)?	This examines whether a paper spelt out exactly what it set out to do. That is, to measure meat or fruits or vegetables consumption or both, for this review.	A score 0—2 will be assigned. Where, 0—Not stated, 1—Not clearly stated and 2—Explicitly stated.
Clarity of study population definition 2. Was the study population clearly defined?	This assesses whether the authors specified the characteristics of respondents they sought to include in their research.	0—Not stated 1—Not clearly defined 2—Explicitly defined
Sampling method 3. Was the sampling method one that achieves a sample representative of the intended study population?	A. Non-probability sampling—such as quota, snowball, convenience and purposive sampling B. Probability sampling—such as simple random, cluster, systematic, stratified, two-stage, and multi stage sampling	Not Reported—0 Category A—1 Category B—2
Response rate 4. Was a response rate mentioned in the study?	Response Rate is reported if authors reported a precise rate or drop-outs & cancellation of interviews were reported. Compute Response Rate where enough information is reported but precise rate not reported.	Not reported—0 Reported (below 60%)—1 Reported (60% plus)—2
Reliability and accuracy of measurement technique 5. Was the measuring technique accurate and reliable?	This is to examine how susceptible the measuring tool used in a FV consumption study is to errors. This brings clarity to how accurate measurements are, and the level of confidence readers should put in the results of the review. D1—Single Dietary recall (e.g. 24-hour recall) D2—Food Frequency Questionnaire D3—Repeated/Multiple dietary recalls (e.g. food records, multiple pass recall, etc.) D4—Biomarkers (e.g. vitamin C, carotenoids, etc.)	D1—1 D2—2 D3—3 D4—4
Reporting of data	Researchers indicated the number of respondents with missing data/incomplete responses and	Not reported—0 Reported only—1

6.a. Missing Data-Were missing data and strategies for addressing missing data reported?	appropriate steps/methods for addressing same.	Reported and addressed—2
6.b. Presentation of data—Were data clearly and accurately reported	Data presented were clear and accurate. Data presentation is accurate if average consumption data (MEAN/MEDIAN) and measures of statistical dispersion (SD, Variance, Range/IQR) are all reported correctly, Score 2. Score 1 where there are anomalies in reported data or only consumption data is reported without any measure of dispersion or where consumption data is reported in a graph/figure only.	Not reported—0 Reported with error—1 Reported accurately—2
Class Scoring: Total score divided by total number of items multiplied by 100		
Methodological Appraisal Class Score		
Bad/Low	**Satisfactory**	**Good**
0—33%	34—66 %	67—100 %

Table 4: Meta-regression for meat consumption entering single covariates[2]

Covariate	Coefficient	CI	Standard error	p
Year of data collection	1.27	-2.33 to 4.87	1.81	0.49
Gender	-3.28	-44.54 to 37.99	20.75	0.88
Age (children/adults)	8.14	-71.86 to 88.13	40.22	0.84
Method of data collection	-45.45	-85.46 to -5.44	20.12	0.03
Economic development	44.32	16.82 to 71.82	13.83	0.00
Location (rural-urban)	35.80	7.81 to 63.78	14.07	0.01

Table 5: Meta-regression for meat consumption entering all covariates[3]

Covariate	Model 1 (including all studies)			Model 2 (excluding quality<34%)			Model 3 (including adults only)		
	Coefficient (95% CI)	**SE**	**p**	**Coefficient (95% CI) (M2)**	**SE**	**p**	**Coefficient (95% CI) (M3)**	**SE**	**p**
Year of data collection	0.63 (-3.51 to 4.77)	2.1	0.76	0.63 (-3.55 to 5.80)	2.08	0.76	-2.92 (-8.74 to 2.90)	2.91	0.32
Gender	3.03 (-34.64 to 40.70)	18.9	0.87	3.03 (-34.92 to 40.98)	18.92	0.87	4.86 (-34.04 to 43.76)	19.45	0.80
Age (children/Adults)	-14.64 (-100.82 to 61.02)	43.3	0.74	-14.64 (-101.46 to 72.19)	43.29	0.74	N/A	N/A	N/A
Method of data collection	-28.80 (-67.66 to 71.55)	20.8	0.17	-28.80 (-70.51 to 12.92)	20.80	0.17	-29.33 (-80.38 to 21.73)	25.53	0.26

[2] Entering single covariates: The covariates used in our analyses included: year of data collection, gender, age, method of data collection, economic development of included countries, and rural/urban residence. Only one covariate was entered at a time to test its effect on or association with meat consumption estimates of the population in the included studies.

[3] Entering all covariates: All six covariates were entered together at the same time to explore the role of year of data collection, gender, age, method of data collection, country's economic development, and rural/urban residence as sources of heterogeneity for the estimated meat intakes of the population in the included studies.

Economic Development	36.76 (2.61 to 70.91)	17.2	0.04	36.77 (2.36 to 71.17)	17.15	0.04	54.26 (13.68 to 94.83)	20.29	0.01
Location (Rural-Urban)	15.29 (-20.72 to 51.31)	18.1	0.40	15.29 (-20.99 to 51.58)	18.09	0.40	19.68 (-22.36 to 61.72)	21.02	0.35

Table 6: Characteristics of included studies

Country of study	Date of data collection	Study population/sample	Variable(s) of Interest Measured (Meat/ Fruit/ Vegetable)	Author's definition of variable(s)	Measurement method (FFQ/24H Recall/FBS/Portion Size)	Reference
Benin	January to May 2007	656 Secondary School adolescents 13 to 19 years randomly recruited from 12 randomly selected Secondary schools based on the Beninese Ministry of Secondary Education list of all private (n 109) and public (n 18) secondary schools in Cotonou.	Fruit, Vegetables and Vegetable products Meat & Meat Products	Adapted from FAO food composition table for use in Africa (Wu Leung et al., 1968). **FRUIT**: examples cited to include pineapples, mangoes, apples and oranges were present as fruit. **VEGETABLES**: green leafy vegetables consumed in sauces	24-hour dietary recall repeated on two non-consecutive school days. Standardised recipes and portion sizes (grams) were used for street foods.	Nago et al. (2010) [93]
Benin	Not Stated	200 men and women randomly selected in 10 neighbourhoods in Cotonou	Meat, Fruit, Vegetables	**MEAT**: Reported separately for White meat, red meat, and fish. **FRUIT** (not explicit): reports separately for Fruit, fruit juices. **VEGETABLES** (not explicit): Green leafy vegetables, other vegetables.	Three non-consecutive 24-hour recalls using food frequency questionnaire (FFQ). Local cups, bowls, spoons, plates and glasses commonly used in the study area served as visual aids to increase the accuracy of portion size estimations.	Sodjinou, Agueh, Fayomi, & Delisle (2009) [94]
Botswana	September 2006 to August 2007	79 adults (63 women, 16 men) aged 18 to 75 recruited--one from every second household in a larger epidemiological study in Kanye, a large village in southern Botswana	Meat, Fruit, Vegetables	**MEAT**: red meat, poultry and fish; **FRUITS**: (not defined), **VEGETABLES**: dark green leafy and yellow vegetables, other vegetables	4 repeated 24-hour recalls at 3 months intervals using FFQ, Cross sectional	Jackson et al. (2012) [105]

Botswana	June to August 2003	99 elderly persons aged 60-69 recruited and interviewed at local post offices or the Kgotla (traditional meeting place) by convenience sampling in Urban stratum (represented by Gaborone the capital city and Francistown); Urban village stratum (Kanye, Molepolole, and Mahalapye); and Rural villages (Makaleng, Molapowabojang, and Sebina)	Fruits, Vegetables, Meat (includes animal-sourced foods)	Followed the USDA Food Guide Pyramid. **MEAT:** meat, poultry, fish, dry beans, eggs, and nuts Definitions for Fruits and Vegetables were not explicitly stated but the USDA Food Guide defines. **FRUITS:** Orange, 100% fruit juices, apple, banana, etc. **VEGETABLES**: Sweet potatoes, corn, peas, tomatoes, onions, green beans, carrots, lettuce, green beans, spinach, romaine, broccoli	Multiple-pass 24-hour recalls. Followed USDA Food Guide Pyramid (1996) to estimate mean servings per day	Maruapula & Chapman-Novakofski (2007) [127]
Burkina Faso	December 2004	176 non-pregnant women conveniently selected and 218 randomly sampled pregnant women from two villages, Koho and Karaba, in the health district of Houndé, province of Tuy, Burkina Faso. (Data extracted for non-pregnant women)	Meat, Fruit, Vegetables	**MEAT (Meat/poultry/fish products)**: Dried fish, chicken, Sheep and goat, pork. **VITAMIN A-RICH FRUIT & VEGETABLES**: Baobab leaves, Cowpea leaves, Bush okra leaves, Kapok tree flowers, Sorrel leaves; **OTHER VEGETABLES**: okra, tomato, onion, and cabbage; **OTHER FRUIT**: Lemon, Orange. Data collected for "Other Fruits" but not presented because Medians and 25th and 75th percentiles are only presented if the at least 75% of sample consumed the food group	An interactive 24-hour recall survey	Huybregts, Roberfroid, Kolsteren, & Camp (2009) [116]
Burkina Faso, Burundi, Cameroon, Congo, Dem Republic of, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, Sudan, Uganda,	2001 to 2003	Multi-country analysis based on FAO data for SSA countries	Meat, Fruit, Vegetables	Not defined	Data from FAO balance sheets.	Premji et al. (2008) [135]

Tanzania, Zimbabwe						
Cameroon	November 2008	Randomly recruited 541 members of the defence force (including national gendarmerie, army, air force, navy and fire brigade) for 8 military institutions aged 21 to 59 years in Yaoundé, Cameroon.	Meat, Fruit, Vegetables,	**MEAT**: Beef, lamb, pork, smoked meat; Bush meat; Organ meats: Liver, kidney and other organ meats; Poultry. FISH and SEAFOOD: Fish, dry fish, shrimp, crab. **FRUITS and VEGETABLES**: Fresh fruits, yellow/dark-green vegetables (not explicitly); Fruit juices: Orange/pineapple/lemon/mango juices; Vegetable juices Red beet/folere juices	Self-administered validated FFQ. Frequency of intake and amounts consumed in grams per day.	Nkondjock & Bizome (2010) [136]
Equatorial Guinea	December 2003–March 2004	198 households randomly selected from 7 neighbourhoods within the city of Malabo, Bioko Island, Equatorial Guinea	Meat	Bush meat, Small livestock meats, Beef, and Fresh fish	24-hour recall. Consumption figures converted to per capita using Adult Male Equivalent (AME)	Albrechtsen, Fa, Barry, & MacDonald (2006) [137]
Ethiopia	July to August 2013	Random sample of 164 Non-pregnant women (159 Pregnant women) recruited from a subsistence farming community of Butajira district southern Ethiopia	Meat, Fruit, Vegetables	Based on Ethiopian & Ugandan Food Composition Tables definition: **MEAT (excludes FISH & seafoods):** Red meat, white meat, poultry, game, rodents, processed meats, organ meats (kidney, liver, mixed offals, intestines), blood, animal skin/ears/feet/head, insects **Fish (includes SEAFOODS)**: Whole fish, fish meat, eel, reptiles, shell fish. **FRUITS (includes FRUIT JUICES)**: Fresh fruits, dried fruits, undiluted pure fruit juices, starchy fruits (banana/plantain). **VEGETABLES**: Fresh vegetables, dried vegetables (excludes potatoes).	Multiple pass 24-hour recalls. Spoons and calibrated utensils used to estimate amount consumed in grams.	Asayehu, Lachat, Henauw, & Gebreyesus (2017) [138]

Ethiopia	April to June 2015	Random sample 9800 of 10,260 study participants aged 15 to 69 from 513 EA's in the 9 regions and the 2 Administrative cities (Addis-ababa and Dire Dawa) in Ethiopia based on 2007 Population and Housing Census. 60% participants were female	Fruit and Vegetables	**VEGETABLE**: Not defined. **FRUIT**: not explicit but lists include apple, banana, orange, fruit juice, cooked and canned fruit.	Weekly food recalls, "Asked for the number of days they ate fruit and vegetables in a typical week and on one of those days how many servings they ate". Serving size measured using pictorial show cards. The conversion 1 Serving= 80 grams. For raw green leafy vegetables, 1 serving = one cup; for cooked or chopped vegetables, 1 serving = ½ cup; for fruit (apple, banana, orange etc.), 1 serving = 1 medium size piece; for chopped, cooked and canned fruit, 1 serving = ½ cup; and for juice from fruit, 1 serving = ½ cup.	Gelibo et al. (2017) [139]
Ethiopia	July 2005	356 participants (71.3% female and 28.7% male) randomly selected from Gondar city, Northwest Ethiopia. Household level data collection. Only one adult individual was selected from a household.	Meat, Fruit, Vegetables	Not defined	Food frequency questionnaire and 24-hour dietary recall. Quantities of food consumed were estimated in household measures and a digital household dietary scale.	Amare et al. (2012) [95]

Gabon	Longitudinal Feb to May 2006, Sept to Dec 2006	1219 households in 121 Rural villages in the vicinity of three newly established national parks in rural Gabon: Biringou, Ivindo, and Monts de Cristal in Gabon. Data reported based on 751 adult respondents.	Bushmeat	Blue duiker (Philantomba monticola), Red duikers, Unidentified duikers (Cephalophus spp.), Sitatunga (Tragelaphus spekii), Brush-tailed porcupine (Atherurus africanus), Red river hog (Potamochoerus porcus), Monkeys (Cercopithecus spp.). Water chevrotain (Hyemoschus aquaticus), Bay duiker (Cephalophus dorsalis), Mandrill (Mandrillus sphinx), Gambian rat (Cricetomys gambianus), African palm civet (Nandinia binotata), Cane rat (Thryonomys swinderianus), Golden cat (Profelis aurata), Long-tailed pangolin (Manis tetradactyla), Leopard (Panthera pardus), Gabon viper (Bitis gabonica), Western lowland gorilla (Gorilla g. gorilla), Bushbuck (Tragelaphus scriptus), Sun-tailed guenon (Cercopithecus solatus)	Household heads recalled all produce, natural resources and manufactured foods consumed during the 48 hours prior to the survey. Estimated weights based on Wikie et al., 2005.	Foerster et al. (2012) [96]
Ghana	September to November 2008	Data from the 2008 Ghana Demographic and Health Survey. 4916 Women aged 15–49 years and 4568 Males aged 15–59 years selected in a two-stage sampling technique based on year 2000 Ghana Population and Housing Census	Fruit, Vegetables	No definition stated. But the GDHS from which data were used cites examples to include- **FRUIT**: mangoes, pawpaw, banana, orange, avocados, tomatoes, passion fruit, apples. **VEGETABLES**: kontomire, aleefu, ayoyo, kale, cassava leaves.	Household Questionnaire, Men/Women's Questionnaire to estimate Mean intake of fruits and vegetables: Captured as "in a typical week, on how many days do you eat fruit?" and "on a day when you eat fruit, how many servings do you eat on average" and similar for vegetables	Amo-Adjei & Kumi-Kyereme (2014) [97]
Ghana	September to November 2008	Data from the 2008 Ghana Demographic & Health Survey on 6193 young people aged 15 to 34 (45% Males, 55% Females Mean age: Females: 23.43, Males: 23.21 (S.D: 5.6) selected using a two-stage sampling design based on year 2000 Ghana Population and Housing Census	Fruit, Vegetables	Not defined but the GDHS from which data were used cites examples to include- **FRUIT**: mangoes, pawpaw, banana, orange, avocados, tomatoes, passion fruit, apples. **VEGETABLES**: kontomire, aleefu, ayoyo, kale, cassava leaves.	Household Questionnaire, Men/Women's Questionnaire to estimate Mean intake of fruits and vegetables: Captured as "in a typical week, on how many days do you eat fruit?" and "on a day when you eat fruit, how many servings do you eat on average" and similar for vegetables	Amoateng et al. (2017) [98]

Ghana	Not Stated (as of January 2014 had interviewed 3868 participants in all 4 centers out of which 1920 from Ghana site)	1619 Urban GH Adults (Kumasi, Obuasi) and 946 Rural GH Adults (Ashanti Region) selected in a random sampling design based on 2010 Ghana Population and Housing Census (part of RODAM multi-centre study Ghana, Berlin, London, Amsterdam).	Meat, Fruit, Vegetables	**MEAT**: Beef, goat, pork, bush meat, liver, and giblets. Data presented separately for poultry, processed meat products, fish, and mixed meaty dishes. **FRUITS (excludes FRUIT JUICES):** Orange, mandarin, kiwi, watermelon, mango, cantaloupe, pawpaw, pineapple, banana, plum, peach, apricot, nectarine, flat peach, apple, pear, strawberries, cherries, berries, grapes, and stewed fruit. Presents data on consumption of **fruit juices** together with SODAs. **VEGETABLES:** Green leaves, spinach, chard, lettuce, endive, chicory, Chinese and white cabbage, tomatoes, peppers, carrots, cucumber, eggplant, beans (green beans), onions and garlic. Excludes potatoes. Presents data on consumption of Vegetable soups, stews and sauces separately. **Vegetable soups, stews and sauces**: Palmnut soup, nkontomire stew, okro stew, tomato sauce and stew, vegetable soup.	Food Propensity Questionnaire (12-month food and 24-hour recalls). Ghanaian household utensils were used to estimate consumption in grams.	Galbete et al. (2017) [99]
Ghana	September 2005 to September 2006	Data on 5313 Ghanaian Households from the Ghana Living Standards Survey Round 5 (included a total of 8,687 households) recruited randomly	Meat	Pork, Beef, Chevron, Mutton, Game, and Chicken	Estimates mean intakes of meat using Ghana Living Standards Survey (GLSS) data. Survey questionnaire	Osei-Asare & Eghan (2014) [100]

Kenya	August to November 2012. Conducted in four districts of Vihiga County during a season of relatively high food diversity (August 2012) and in four districts of Kitui County at the end of the food shortage season (October/November 2012)	Random sample of children 6 to 23 months old recruited from 4 purposively selected districts in Vihiga County (Luanda, Emuhaya, East Tiriki and West Tiriki; n = 201) and Kitui County (Kitui Central, Lower Yatta, Mutomo and Kitui West; n = 200) Kenya. Data extracted for 12 to 23 months cohort: 8.2 % of 179 children from Kitui County and 6.4% of 156 children from Vihiga County.	Meat, Fruit, Vegetables	WHO et al., (2008) definition of fruit and vegetables	Four-pass 24-hour recalls, cross sectional, Portion sizes from weighing of foods. Dietary data collected through caregivers.	Ferguson et al. (2015) [101]
Kenya	Longitudinal Panel Survey: collected in 2000, 2005, and 2010	200 Households randomly selected from register of households in Siambu and Mbaringon Pastoralist communities. 100 from each community, Kenya. However, there was attrition: 2000: 199 households 2005: 186 households 2010: 159 households. Household heads interviewed.	Vegetable and Meat	**MEAT**: not explicitly defined but mentions cattle, chicken, or livestock ownership **VEGETABLES**: cabbage, kale.	Three waves of data using 24-hour recalls were collected in 2000, 2005, and 2010	Iannotti & Lesorogol (2014) [140]
Kenya	SI: July/Aug 2013 S2: Feb/Mar 2014	272 Rural Kenyan Women (Mean age: 40 years) randomly selected from household lists supplied by village elders of villages covering 5 different agro-ecological zones (AEZ) in the counties of Kakamega and Siaya in western Kenya	Fruit, Vegetables	Not explicitly defined but listed as follows: **FRUIT**: Mango, Cape gooseberry, Papaya, Passion fruit, Loquat, Guava, water melon, Orange, Jack fruit, Sweet banana, Avocado, Pineapple, Lemon, Tamarind, Custard apple, mulberry, Soursop	24-hour food recalls to capture fruit consumption in Rural Women	Keding et al. (2017) [102]
Kenya	November 2009 and February 2010	208 School-aged children aged 4 to 11 years randomly selected from four public primary schools in Dagoretti Division (including several unplanned settlements namely; Dagoretti Corner, Congo, Wanyee, Githembe, Ngando, Lenana, Waithaka and Gachui Village) in Nairobi, Kenya	Meat, Fruit, Vegetables	**MEAT:** chicken, fish, beef. **FRUIT** (not defined). **VEGETABLES:** listed in table to include Cabbage, kales, spinach. Excluded carrots and potatoes	24-hour recalls using FFQ used to obtain the foods consumed for breakfast, lunch and supper. Portions/grams. Amounts of foods/ meals served were approximated using standard cups, plates and measuring jug	Mwaniki & Makokha (2013) [103]

Kenya	Baseline study from July to August 1998	529 Grade 1 schoolchildren aged 6 to 14 from twelve primary schools selected based on size and accessibility for food delivery criteria that participated in the Child Nutrition Project study	Meat, Fruit, Vegetables	**MEAT**: Meat, fish, poultry and eggs reported together. **FRUIT**: Avocado, Ripe mangoes, Oranges, lemons, papaya. Fruit and vegetables intake reported together. **VEGETABLES**: Kales, cowpea leaves, green beans, onions.	Three non-consecutive 24-hour recalls in a randomized controlled feeding intervention study	Gewa et al. (2014) [104]
Mali	October to December 1998, March to May in 1999	34 women and 36 men aged 15–45 years, from 29 random selection of households (during a village meeting) in the village of Ouassala in the Kayes region, Western Mali	Meat, Fruit, Vegetables	**MEAT** not defined but meat estimates includes Eggs. **FRUIT**: Apple, banana, mandarin, lemon, date, guava, mango, orange, papaya, watermelon, sweetsop (Annona squamosa), sweet dattock (Detarium microcarpum), akee fruit (Blighia sapida), cashew fruit, jujube (Zizyphus spina-Christi), tamarind, shea-butterseed (Butyrospermum parkii), red sorrel (Hibiscus sabdariffa), baobab pulp (Adansonia digitata). **VEGETABLES**: Cassava, potato, sweet potato, yam, African fan palm (fruit and germinating radicle), cabbage, carrot, cucumber, eggplant, garlic, okra, onion, tomato, tomato paste, bitter tomato (Solanum incanum) and ginger; Green leaves: Lettuce, amaranth leaves, baobab leaves, onion leaves, mint leaves, horseradish-tree leaves (Moringa oleifera), cassava leaves and cow-pea leaves.	Quantitative Food Frequency Questionnaire (QFFQ) and Weighed Record (WR). Household measures typical of the area (plastic cup and aluminium serving), measuring tape and measuring jugs were used to estimate amounts of foods consumed.	Parr et al. (2002) [106]

Mali	October to December 1996	75 persons. 27 men and 48 women aged 15 to 59 years representing 18 households recruited from a small village, Kersignane, in the Cercle of Bafoulabe. Bafoulabe is in the Kayes Region of Western Mali.	Meat, Fruit, Vegetables	**MEAT AND FISH** reported together (meat not defined). **FRUIT AND VEGETABLES** (reported together): Pumpkin, lady fingers, bitter tomato (Solanum incanum), onion, tomato, pepper, sweet potato, cassava, yam, lemon, watermelon and monkey bread (Adansonia digitata); Green leaves (reported separately): Pumpkin leaves, baobab leaves (fresh and dried), onion leaves, bean leaves, amaranth leaves and sweet potato leaves.	QFFQ and Combined Weighed/Recalled Dietary Records. In QFFQs, volume measures of different sizes were used for estimating amounts eaten of non-solid foods, groundnuts and beverages. Digital scales were used to determine the weight equivalents of volumes. In the Combined weighed/recalled dietary records, ingredients of the dishes were weighed separately, using the same digital scales	Torheim et al. (2001) [107]
Namibia	September to October 2002, dry season	53 school children (Town: 43, Rural: 10) aged 8 to 15/Grades 1 to 4 randomly selected from a Primary school and 4 mobile school units in a small town and in two rural villages in the Kaokoland area, situated in north-west Namibia.	Meat, Fruit, vegetables	**Listed to include:** **MEAT**: in Town: beef, goat and chicken; in the Rural area: goat. **VEGETABLES**: including potatoes.	24-hour recall interviews. Local dishware, food photographs, and food models were used as aids for estimating food quantities.	Vähätalo et al. (2005) [108]
Namibia	Not stated	18 years or older adults sampled from Rural villages accessible by four-wheel drive vehicle based on ordinance survey maps of Hereroland and Kavangoland. Villages from Hereroland were Okakarara, Otumborom-bonga, Otjinene and Otijituo. Villages from Kavangoland: Rundu, Andara and Bagani	Meat, Vegetables	None was defined but examples include-**MEAT**: fresh or tinned; **FISH**: tilapia, tiger fish.	Food frequency questionnaire	O'Keefe, Rund, Marot, Symmonds, & Berger (1988) [109]

Nigeria	January to July 2003	50 fishing households and 50 Non-fishing households randomly selected from traditional fishing communities in the coastal state of Lagos and the inland state of Niger. Average 7 members per household.	Meat	39 species of fish (including Tilapia spp, Synodontis spp, Mormyrops spp, Citharinus spp, Clarias spp, Bagrus spp, Heteroitis niloticus, Gnathonemus spp, Hydrocynus spp, Clarotes spp, Titus ice fish, Petrocephalus spp, Snail, etc. and 16 types of meat including beef, goat, chicken, lamb, grasscutter and other bush meat	24-hour recalls. Portions obtained by weighing with weighing balance/scales.	Gomna & Rana (2007) [141]
Nigeria	June to September 2011	413 adult males and females aged 20 or older randomly selected from two Local Government Areas--Ibadan South-West and Ibadan North-West of Oyo state in Nigeria	Meat, Fruit and Vegetables	**MEAT**: Lean Beef. **VEGETABLES** (excludes/reports starchy tubers, legumes, etc. separately): Vegetable soup (Efo riro, Egusi and Efo). Fruit: Banana and Orange.	Interviewer-administered questionnaire with a 24-hour dietary recall. Amount of foods consumed at a sitting/portion size were determined using measuring guides (household measures).	Sanusi & Olurin (2012) [110]
Nigeria	October 1993 to April 1994	142 (out of 187) children recruited from 12 randomly selected schools (that included two private and ten public schools) in two Local Government Areas of Abeokuta Government Areas of Abeokuta, the capital of Ogun State, Nigeria. Male: 79, Female: 63	Meat, Fruit, Vegetables	Not explicitly defined but MEAT, FISH and EGG intake reported together. Vegetables and fruit intake also reported together	Repeated (3 times) 24-hour recalls. Estimates of serving sizes and quantities of foods eaten were based on common household measuring utensils	Oguntona & Kanye (1995) [111]
Senegal	Not Stated	Convenience sample of 50 Adult Men recruited at the Hôpital Général de Grand Yoff (but were not hospitalized) in Dakar, Senegal (n=40) and from neighbouring Sendou village (n= 10).	Meat, Fruit, Vegetables	Not explicitly stated but listed the following under various food groups. **MEAT:** Fish, Beef, Sausage, Chicken, Ox, Goat, Sheep, Pork, Eggs/Omelet, Chockpeas, Peanuts. **FRUITS** (excludes fruit juices listed separately): Mango, Coconot, Cola nut, Banana, Rasins, Papaya, Pear, Watermelon, Apple, Grapes, Sapoti, and Maad bi. **VEGETABLES** (excludes Vegetable juices. listed separately): Potato, Tomatoes, Lettuce, Carrot, Cabbage, Corn, Eggplant, Okra, Garlic, Onion, Potato, Turin, Cucumber, Green bean, Green pepper, Green pea,	Single 24-hour dietary recall. Estimated amount per day consumed	Anderson et al. (2010) [112]

				Petit pois, Broccoli, Green olive, Cowpeas.		
Senegal	Not Stated	20 adolescent girls (13–15 years) attending a high school in the city of Dakar. Sampling method not reported	Fruit and Vegetables	Not defined	24-hour recalls administered over a 3-day period before and after the implementation of the activities. Food quantities were estimated using local measures or weighted	Matsinkou et al. (2016) [113]
South Africa	January to March 1990	163 children (Boys: 93, Girls: 70) aged 3 to 6 years selected in a Stratified proportional sampling from all black residential areas of Cape Town, including squatter and formal housing areas	Meat, Fruit, Vegetables	No explicit definitions were stated. But Sweet potatoes and potatoes were included as vegetables. Portion sizes for food groups were estimated using Diabetic Exchange Lists Reference as set out in Langenhoven et al., 1989. One Meat portion was calculated as total protein from the meat group divided by 6 and 7 (6g of protein equals 1 egg and 7g of protein = 30g meat 125ml cooked legumes). For vegetables, total available carbohydrate minus sugar was divided by 5 to estimate the number of vegetable portions, and for fruit by 15 for number of portions (5 g carbohydrate represents one 125 ml vegetable portion and 15 g carbohydrate one fruit portion).	24-hour recalls combined with questions on habitual intake	Bourne, Langenhoven, Steyn, Jooste, Laubscher, et al. (1994) [130]
South Africa	February to October 2007	Caregivers of 400 children (2 to 5-year-old/ Grade 6 and 7 learners) selected randomly from 4 Primary Schools in the Mariannhill area, Pinetown in the KwaZulu-Natal Province, South Africa	Fruit, Vegetables	WHO 1990 definition of fruit and vegetables. Reports intake (grams) for FRUIT: Apple and Banana; VEGETABLES: Cabbage and Mixed vegetables.	24-hour recall repeated at one-week intervals	Faber et al. (2011) [115]

South Africa	A repeated cross-sectional study done during February, May, August, and November of 2005	2 to 5-year olds registered on the Community-based growth monitoring project in 2 neighbouring rural villages in KwaZulu Natal willing to be interviewed 5 consecutive times: February (n=79), May (n=74), August (n=75) and November (n=78). Caregivers interviewed.	Vegetables (Dark green leafy vegetables).	**Includes Spinach and Imifino. Imifino** is a collective term for various dark-green leaves that are eaten as a vegetable; the leaves either grow wild or come from vegetables such as pumpkin, beetroot and sweet potato	Five repeated 24-hour dietary recalls per study period. Food intake reported in household measures was converted into weight using the MRC Food Quantities Manual (Langenhoven et al., 1991a)	Faber et al. (2007) [117]
South Africa	October 2004 to December 2006	1057 grade 6 learners from 18 schools at baseline, 9 schools during 3 months, 6 months and 12 months follow-up. Random sampling of 9 pairs of schools from 17 matched pairs. Convenience sample of grade 6 learners based on parent consent and child assent then a random sample of those to reduce numbers	Fruit, Vegetables	FRUIT and VEGETABLES: 100% orange or grapefruit juice, other 100% juices, fruit, green salad, fried potatoes, other potatoes, and other vegetables	7 item FFQ in a Cluster randomised controlled trial	Jemmott-III et al. (2011) [118]
South Africa	May 2010 and August 2011	150 children aged 24 to 59 months recruited based on eligibility criteria Calvinia West, the disadvantaged section of the town Calvinia in the Hantam district of the Northern Cape Province. Mothers responded to questions	Liver (Meat)	Sheep's liver	24 hour recalls and a quantified liver frequency questionnaire. Frequency of consumption and Portion sizes.	Nel et al. (2013) [119]
South Africa	2008	3840 persons aged 50 years and older recruited randomly in a national population-based cross-sectional study in South Africa	Fruit, Vegetables	**FRUIT**: such as an apple, banana, or orange, cooked, chopped, or canned fruit; and fruit juice, not artificially flavored. Insufficient FV consumption was defined as less than five servings of fruits and/or vegetables a day. Not defined but lists examples to include the following: **VEGETABLES**: tomatoes, carrots, pumpkin, corn, Chinese cabbage, beans, or onions, vegetable juice.	Used questionnaire to estimate number of servings per day in a 24-hour recall. Fruit and vegetable consumption were assessed using two questions 'How many servings of fruit do you eat on a typical day?' and 'How many servings of vegetables do you eat on a typical day?'	Peltzer & Phaswana-mafuya (2012) [120]

South Africa	Consumption data since 1994. Intervals of 5 years were compared, from 1994 to 2009 for FAOSTAT FBS data and from 1999 to 2012 for Euromonitor PFBC data, with specific time overlaps in 1999, 2004 and 2009	South Africa	Meat, Fruit, vegetables	FAOSTAT: **MEAT**: Bovine data, Mutton and goat meat, Pig meat, Poultry meat, Meat (other). Reports data for Offal but not as part of meat. EUROMONITOR PASSPORT: not explicit on Offal as part of meat and does not report Offal separately. **FRUIT**: Oranges, mandarins, Lemons, limes, Grapefruit, Citrus (other), Bananas, Apples, Pineapples, Fruits (other). **VEGETABLE** (excludes Starchy roots (Potatoes, Sweet potatoes), Pulses and Nuts): Tomatoes, Onion, and Vegetables (other).	Used FAO food balance sheets (FBS) and Euromonitor International Passport data. Both sets of exported data (Euromonitor International Passport and FAOSTAT FBS) were converted to per capita consumption figures as this considers increases in population growth over time. Per capita intake is a crude estimate of consumption as it is the total amount consumed divided by the total population and does not take into account wastage, losses in storage, urban/rural distribution differences or distribution within households	Ronquest-Ross et al. (2015) [121]
South Africa	1998 to 1999 period	Food balance sheets published by the South African National Department of Agriculture's Directorate of Statistical Information	Meat, Fruit, Vegetables	**MEAT**: Beef and veal; Mutton and goat; Pork and Chicken. **VEGETABLES and FRUIT**: Potatoes, sweet potatoes, other vegetables, citrus, other fruit, and dry fruit and nut.	Used food balance sheets published by the National Department of Agriculture's Directorate of Statistical Information on the food supply in South Africa for the 1998/99 period. Consumption data were derived by taking total production of a specific food item in the country and by subtracting the total amount used for animal feed as well as the total amount of imports and exports of the specific food item. This amount was then divided by the total population in the country, thus obtaining the per capita availability of each food item	Steyn, Abercrombie, & Labadarios (2001) [122]

South Africa	Primary data from the National Food Consumption Survey (NFCS) in 1999 provided primary data on children. Data on adults: from 8 different studies (secondary sources) conducted from 1983 to 2000	Secondary data from various sources, including the National Food Consumption Survey (NFCS) in 1999 provided primary data on children. Data on adults: from 8 different studies conducted in different provinces and ethnic groups. Total sample not reported.	Meat, Fruit, Vegetables	**MEAT**: Beef & offal; Vension; Mutton/goat & offal; Pork & offal; and Chicken & offal. **FRUIT**: Pome, Tropical, Citrus, Stone, Berry, and Other. **VEGETABLES**: Stem, Brassica, Leaf, Fruiting, Cucrubits, Bulb, Green legumes, and Mixed vegetables.	Used National Survey data and secondary data from 8 cross-sectional studies conducted previously in addition to National Food Balance sheet. Only datasets collected by 24-hour recalls were used here, results of the frequency databases were excluded and reported elsewhere.	Steyn, Nel, & Casey (2003) [123]
South Africa	Not stated	50 children and 42 mothers/caretakers who were part of a school-based clinical trial in a low socioeconomic rural area, 60 km northwest of Durban, KwaZulu-Natal, South Africa.	Meat, Fruit, Vegetables	**MEAT**: beef, chicken, chicken pie, sausage. **FRUITS**: Apple, Pear, Avocado. **VEGETABLES**: Tomato, Cabbage, Onion, Mealie, Imifino, Pumpkin, Carrots, Onion, Potato.	24-hour recall and an unquantified food frequency questionnaire. Fresh food, food models, household utensils and sponge models were used for quantifying and recording food intake. In addition, dry samp (commercially available coarsely broken maize) was used to quantify portion sizes of dishes made with either samp or maize. Actual food intake reported in household measures was converted into weight using the MRC Food Quantities Manual (Langenhoven et al., 1992a)	Faber (1999) [124]
South Africa	Not stated	7-day Weighed Food Record: 74 (out of 85) volunteers (15 to 65-year-olds) recruited from participants in the THUSA study (n= 890). To test the relative validity of a culture sensitive Quantitative Food Frequency Questionnaire (QFFQ).	Meat, Fruit, Vegetables	Not defined	7-day Weighed Food Record: 74 participants Scales, measuring jug and set of measuring spoons were used to determine weight of foods consumed	Macintyre et al. (2000) [125]

South Africa	1996 (15 to 65-year-old participants) and in 1998 participants older than 65 years were recruited	Randomly recruited 1751 respondents (743 males and 1008 females), aged between 15 and 80 years and apparently healthy from 37 randomly selected sites representing the health districts in the North West Province	Meat, Fruit, Vegetables	**Listed examples of VEGETABLES**: Onion, Tomato, Cabbage; Fruit: Apple, Banana,	Quantitative Food Frequency Questionnaire (QFFQ) made of 145 food items. Photographs of commonly eaten foods in a validated food portion photograph book (FPPB), common utensils and containers were used to estimate portion sizes.	MacIntyre et al. (2002) [126]
South Africa	February 1994	115 black female students aged 17 to 34 years mean age: 21.4 years) attending a first-year pre-registration program at the University of the North.	Meat, Fruit, Vegetables	Not defined but list examples to include **MEAT**: poultry, red meat. **FRUIT**: Bananas. **VEGETABLES**: Spinach, pumpkin.	QFFQ gather data on each student's diet over 6 months prior to entering the University. Food models based on local foods were developed and used during the study along with other dietary aids, such as empty food containers and volume measures.	Steyn, Senekal, Brtis, & Dsc (2000) [128]
South Africa	2009	544 randomly selected 19 to 64 years old urban Africans participants living in the townships of Langa, Gugulethu, Khayelitsha, Crossroads and Nyangain in Cape Town	Meat, Fruit, Vegetables	Reports the following classifications but reports each sub-item separately: **MEAT** group: red meat, white meat, eggs, legumes. **VEGETABLES and FRUIT**: Vitamin C rich, Carotene rich, Potato/sweet potato, Other veg/fruit.	24-hour recall using the multiple pass method. Visual life-size photographs and sketches of foods and measures (such as cups, glasses) were used to identify portion sizes	Steyn et al. (2016) [129]
South Africa	1990	983 respondents (Female: 542. Male: 441) in Black residential areas of Cape Town aged 15 to 64 years randomly selected from sampling frame based on 1988 Human Sciences Research Council Census.	Meat, Fruit, Vegetables	**MEAT**: Red meat (beef, mutton, pork, and cold cuts made of these commercial pies). White meat (chicken and fish) and Organ meats. **VEGETABLE and FRUIT**: Vitamin C rich, Carotene rich, Potato and sweet potato, other vegetables and fruit.	24-hour recall method used in combination with questions on habitual intake. Household crockery and utensils used in serving meals, and the checking of food labels were adopted to estimate portion sizes.	Bourne, Langenhoven, Steyn, Jooste, Nesamvuni, et al. (1994) [130]
South Africa	1977	1977: 96 randomly selected lactating Xhosas (black race) women aged 16 to 44 years (mean age: 26) from rural and urban areas in Ciskei	Meat, Fruit, Vegetables	Not defined but vegetable and fruit consumption reported together. Meat and fish intake also reported together	24-hour recall and diet history methods	Langenhoven et al. (1988) [131]

	1979	Random sample of 1113 male and female (out of 7188 respondents) from three Rural Afrikaans speaking white communities aged 15 to 64 years	Meat, Fruit, Vegetables		24-hour recalls to collect dietary data and Food models and portions of real food used as visual aids to quantify food intake	
	1982	976 randomly selected healthy urban male and female coloured population in Cape Peninsula aged 15 to 64 years	Meat, Fruit, Vegetables		24 hour recalls and frequency questionnaire. Number of portions estimated based on the principle of food exchanges: milk and meat portions were based on protein content, vegetable, fruit and cereal portions based on carbohydrate content, and fat portions on fat content. Total protein from meat and fish was divided by 21g for number of portions estimate, total carbohydrate from vegetables divided by 5g, for fruit by 20g for number of portions.	
South Africa		42 men and 60 women (aged over 18 years) of the Isandhlwana area of rural district in Zululand. the sample was selected by travelling from one group of huts to another in a four-wheel drive vehicle to interview adults met at home or at work in the fields	Meat, vegetables	Not defined	Simple frequency questionnaire	O'Keefe, Ndaba, & Woodward (1985) [132]

Zambia	September 2012 to March 2013	938 Children aged 4 to 8 years (not attending school) recruited for an efficacy trial through a Door-to-door census of all households in towns or villages (accessible by vehicle all year round) in Mkushi, a rural district in central Zambia (baseline results used)	Vegetable, Meat (Chicken)	Based on Ugandan & Zambian Food Composition Tables. Most food items in the Zambian Food Composition Tables are presented in local languages. **MEAT** (excludes FISH & seafoods): Red meat, white meat, poultry, game, rodents, processed meats, organ meats (kidney, liver, mixed offals, intestines), blood, animal skin/ears/feet/head, insects. **Fish** (includes SEAFOODS): Whole fish, fish meat, eel, reptiles, shell fish. **FRUITS** (includes FRUIT JUICES): Fresh fruits, dried fruits, undiluted pure fruit juices, starchy fruits (banana/plantain). **VEGETABLES:** Fresh vegetables, dried vegetables (excludes potatoes).	24-hour recall tool on Android tablets	Caswell et al. (2015) [133]
Zambia	August 2012 to April 2013	200 Children (4 to 8 years not yet enrolled in school) in non-intervened group of an efficacy trial. Selected in a door-to-door census of all households in towns or villages (accessible by vehicle all year round) in northern Mkushi, a rural district in Zambia	Meat, Fruit, Vegetables	**MEAT**: small fish, tilapia or bream fish, chicken. **Other ASF**: milk, eggs, insects. **FRUIT**: mango, other fruit. **VEGETABLES**: tomato, onion, rape leaves, pumpkin leaves, beans, other dark green leafy vegetables, eggplant, cabbage, cassava.	Multipass 24-hour recall tool using Android tablets to estimate number of servings per day and quantity consumed per serving of 25 most frequently consumed foods. Photo aids used to estimate Portion size/Quantity in grams from Number of Servings per day. Caregivers of children answered. Randomised efficacy trial. But could use data for the non-intervened group.	Caswell et al. (2018) [134]

Table 7: Quality appraisal

Domain	**Statement of study objective/aim**	**Clarity of study population definition**	**Sampling method**	**Response rate**	**Reliability and accuracy of measurement technique**	**Reporting of data**		**Total Score (E)**	**Class Score Calc (%) E/19 x100**
Question	1. Was the research objective clearly stated (to measure meat/fruits/vegetables consumption)?	2. Was the study population clearly defined?	3. Was the sampling method one that achieves a sample representative of the intended study population?	4. Was a response rate mentioned in the study?	5. Was the measuring technique accurate and reliable?	**6.a.** Missing data-Were missing data and strategies for addressing missing data reported?	6.b. Presentation of data—Were data clearly and accurately reported		
Author(s)	0—Not stated, 1—Not clearly stated and 2—Explicitly stated.	0—Not stated 1—Not clearly defined 2—Explicitly defined * Clear definition of population/sample should be beyond country of study to include exact location, age cohort gender and other socio-demographic details.	Not Reported—0 Category A—1 Category B—2	Not reported—0 Reported (below 60%)—1 Reported (60% plus)—2 *Response Rate is reported if authors reported a precise rate or drop-outs & cancellation of interviews were reported. Compute Response Rate where enough information is reported but precise rate not reported.	D1—Single Dietary recall (e.g. 24-hour recall) D2—Food Frequency Questionnaire D3—Repeated/Multiple dietary recalls (e.g. food records, multiple pass recall, etc.)	Not reported—0 Reported only—1 Reported and addressed—2 **Apart from being explicitly stated, Missing data is reported if exclusions based on incompleteness of responses are reported	Not reported—0 Reported with error—1 Reported accurately—2 **Data presentation is accurate if average consumption data (MEAN/MEDIAN) and measures of statistical dispersion (SD, Variance, Range/IQR) are all reported correctly, Score 2. Score 1 where there are anomalies in reported data or only consumption data is reported without any measure of dispersion or where consumption data is reported in a graph/figure only.		
Amo-Adjei & Kumi-Kyereme (2014)	2	2	2	0	0	0	2	**8**	53
Albrechtsen, Fa, Barry, & MacDonald (2006)	2	1	2	0	1	0	2	**8**	**53**
Amare et al. (2012)	2	2	2	2	2	2	2	**14**	**93**
Amoateng et al. (2017)	2	2	2	0	0	0	0	**6**	**40**
Anderson et al. (2010)	2	2	1	0	1	0	1	**7**	**47**
Asayehu, Lachat, Henauw, & Gebreyesus (2017)	2	1	2	0	3	0	2	**10**	**67**
Bourne, Langenhoven, Steyn, Jooste, Laubscher, et al. (1994)	2	2	2	0	1	0	2	**9**	**60**
Bourne, Langenhoven, Steyn, Jooste, Nesamvuni, et al. (1994)	2	2	2	0	2	0	2	**10**	**67**
Caswell et al. (2015)	2	2	2	0	1	0	2	**9**	**60**
Caswell et al. (2018)	2	2	2	0	3	0	2	**11**	**73**
Faber et al. (2011)	2	1	1	0	2	0	1	**7**	**47**

Faber et al. (2007)	2	2	1	0	3	0	1	**9**	**60**
Faber (1999)	2	2	0	0	1	0	2	**7**	**47**
Ferguson et al. (2015)	2	2	1	2	3	0	1	**11**	**73**
Foerster et al. (2012)	2	1	1	2	1	0	2	**9**	**60**
Galbete et al. (2017)	2	2	2	0	2	0	1	**9**	**60**
Gelibo et al. (2017)	2	2	2	0	0	0	2	**8**	**53**
Gewa et al. (2014)	2	2	1	1	3	0	2	**11**	**73**
Gomna & Rana (2007)	2	2	2	0	1	0	1	**8**	**53**
Huybregts, Roberfroid, Kolsteren, & Camp (2009)	2	2	1	2	1	0	2	**10**	**67**
Iannotti & Lesorogol (2014)	1	2	2	0	1	0	1	**7**	**47**
Jackson et al. (2012)	2	1	1	2	3	0	2	**11**	**73**
Jemmott-III et al. (2011)	2	2	1	2	2	2	2	**13**	**87**
Keding et al. (2017)	2	2	2	2	3	0	2	**13**	**87**
Langenhoven et al. (1988)	2	2	2	2	1	0	2	11	73
MacIntyre et al. (2002)	2	2	2	2	2	0	2	**12**	**80**
Macintyre et al. (2000)	2	1	0	0	2	0	2	**7**	**47**
Maruapula & Chapman-Novakofski (2007)	2	2	2	2	3	0	2	**13**	**87**
Matsinkou et al. (2016)	2	2	0	0	3	0	2	**9**	**60**
Mwaniki & Makokha (2013)	2	2	2	0	1	0	1	**8**	**53**
Nago et al. (2010)	2	2	2	2	3	1	1	**13**	**87**
Nel et al. (2013)	2	2	1	2	1	0	2	**10**	**67**
Nkondjock & Bizome (2010)	2	2	2	0	2	2	1	**11**	**73**
Oguntona & Kanye (1995)	2	1	2	0	3	2	1	**11**	**73**
O'Keefe, Rund, Marot, Symmonds, & Berger (1988)	2	2	1	0	2	0	2	9	60
Osei-Asare & Eghan (2014)	2	1	2	0	1	0	1	**7**	**47**
Parr et al. (2002)	2	2	1	2	2	2	2	**13**	**87**
Peltzer & Phaswana-mafuya (2012)	2	2	2	2	1	0	2	**11**	**73**
Premji et al. (2008)	2	1	0	0	0	0	1	**4**	**27**
Ronquest-Ross et al. (2015)	2	1	0	0	0	0	1	**4**	**27**

Sanusi & Olurin (2012)	2	2	2	0	1	0	2	**9**	**60**
Sodjinou, Agueh, Fayomi, & Delisle (2009)	2	2	2	0	3	0	1	**10**	**67**
Steyn, Abercrombie, & Labadarios (2001)	1	1	0	0	0	0	1	**3**	**20**
Steyn, Nel, & Casey (2003)	2	1	0	0	1	0	2	**6**	**40**
Steyn et al. (2016)	2	2	1	0	3	2	2	**12**	**80**
Steyn, Senekal, Brtis, & Dsc (2000)	2	2	1	1	2	1	2	**11**	**73**
Torheim et al. (2001)	2	2	1	2	2	0	2	**11**	**73**
Vähätalo et al. (2005)	2	2	1	2	1	0	2	**10**	**67**
O'Keefe, Ndaba, & Woodward (1985)	2	2	1	0	2	0	2	9	60

Table 8: Meta-regression for vegetable consumption entering single covariates[4]

Covariate	Coefficient	CI	Standard error	p
Year of data collection	2.97	0.47 to 5.48	1.35	0.00
Gender	-5.40	-36.08 to 25.27	15.32	0.73
Age (children/adults)	171.20	-91.76 to 250.63	39.95	0.00
Method of data collection	0.77	-20.06 to 21.60	10.48	0.94
Economic development*	24.58	7.40 to 41.77	8.64	0.01
Location (rural-urban)	-3.83	-27.02 to -19.36	11.66	0.74

[4] Entering single covariates: Only one covariate was entered at a time to test its effect on or association with vegetable consumption estimates of the population in the included studies.

Table 9: Meta-regression for vegetable consumption entering all covariates[5]

Covariate	Model 1 (including all studies)			Model 2 (excluding quality<34%)			Model 3 (including adults only)		
	Coefficient (95% CI)	**SE**	**p**	**Coefficient (95% CI) (M2)**	**SE**	**p**	**Coefficient (95% CI)**	**SE**	**p**
Year of data collection	4.43 (1.74 to 7.12)	1.35	0.00	4.43 (1.72 to 7.14)	1.35	0.00	4.79 (2.05 to 7.53)	1.37	0.00
Gender	-0.18(-4.04 to 3.67)	1.94	0.93	3.029 (-4.07 to 3.70)	1.94	0.93	-.44(-6.71 to 5.84)	3.14	0.89
Age (children/adults)	80.32 (-10.62 to 171.27)	45.70	0.08	80.32(-11.26 to 171.90)	45.70	0.08	N/A	N/A	N/A
Method of data collection	1.75 (-8.73 to 12.22)	5.26	0.74	1.75 (-8.80 to 12.29)	5.26	0.74	3.44 (-7.59 to 14.47)	5.52	0.54
Economic development*	43.49 (25.96 to 61.03)	8.81	0.00	43.49 (25.84 to 61.15)	6.74	0.00	44.94(27.15 to 62.73)	8.90	0.00
Location (rural-urban)	-25.48 (-38.88 to -12.07)	6.74	0.00	-25.48 (-38.98 to -11.97)	6.74	0.00	-26.63(-40.51 to -12.75)	6.94	0.00

Table 9a: Model 4 (excluding starchy vegetables)

Covariate	**Entering Individual Covariates (Univariate Analysis)**			**Entering all Covariates (Multivariate Analysis)**		
	Coefficient (95% CI)	**SE**	**p**	**Coefficient (95% CI) (M4)**	**SE**	**p**
Year of data collection	2.15 (-0.74 to 5.04)	1.45	0.14	3.38 (-0.06 to 6.70)	1.66	0.05
Gender	-16.45(-60.96 to 28.06)	22.04	0.46	-5.45 (-31.57 to 20.67)	13.06	0.68
Age (children/adults)	156.45 (-66.88 to 246.02)	44.86	0.00	76.64 (-28.68 to 181.95)	52.67	0.15
Method of data collection	-44.91 (-67.67 to -22.14)	11.27	0.00	-22.96 (-46.79 to 0.87)	11.92	0.06
Economic development*	16.05 (-14.61 to 46.71)	15.36	0.30	43.85 (10.64 to 77.06)	16.61	0.01
Location (rural-urban)	-9.53 (-50.67 to 31.61)	20.61	0.64	1.50 (-37.68 to 40.68)	19.59	0.94

Table 10: Meta-regression for fruit consumption entering individual covariates[6]

Covariate	**Coefficient**	**CI**	**Standard error**	**p**
Year of data collection	2.46	1.33 to 3.58	0.57	0.00
Gender	-1.43	-21.80 to 18.94	10.24	0.89
Age (children/adults)	224.55	28.85 to 420.26	98.36	0.03
Method of data collection	-8.32	-12.07 to -4.57	1.87	0.00
Economic development*	5.30	-10.21 to 20.82	7.80	0.50
Location (rural-urban)	-16.60	-23.39 to -9.82	3.41	0.00

[5] Entering all covariates: All six covariates were entered together at the same time, adjusting for covariates, to explore the role of year of data collection, gender, age, method of data collection, country's economic development, and rural/urban residence as sources of heterogeneity for the estimated vegetable intakes of the population in the included studies. In Model 1 of the multivariable analysis, data extracted from all included studies were included. In Model 2, data from studies that scored less than 34% in quality appraisal were excluded. Model 3 included data extracted for adults only.

[6] Entering single covariates: Only one covariate was entered at a time to test its effect on or association with fruit consumption estimates of the population in the included studies.

Table 11: Meta-regression for fruit consumption entering all covariates[7]

Covariate	Model 1 (including al studies)			Model 2 (excluding quality<34%)			Model 3 (including adults only)		
	Coefficient (95% CI)	**SE**	**p**	**Coefficient (95% CI) (M2)**	**SE**	**p**	**Coefficient (95% CI)**	**SE**	**p**
Year of data collection	-1.55 (-6.30 to 3.21)	2.39	0.52	-1.55 (-6.36 to 3.27)	2.39	0.52	-1.41(-6.20 to 3.40)	2.40	0.56
Gender	-0.16 (-2.98 to 2.66)	1.42	0.91	-0.16 (-3.01 to 2.69)	1.42	0.91	-.162(-2.99 to 2.67)	1.42	0.91
Age (children/adults)	219.87 (23.42 to 416.33)	98.62	0.03	219.87 (21.25 to 418.50)	98.6 2	0.03	N/A	N/A	N/A
Method of data collection	-9.56 (-25.15 to 6.04)	7.83	0.23	-9.56 (-25.32 to 6.21)	7.83	0.23	-9.02(-24.77 to 6.73)	7.87	0.26
Economic development*	6.38 (-5.48 to 18.24)	5.95	0.29	6.38 (-5.61 to 18.37)	5.95	0.29	6.20(-5.72 to 18.12)	5.96	0.30
Location (rural-urban)	-9.24 (-23.35 to 4.88)	7.09	0.20	-9.24 (-23.51 to 5.04)	7.09	0.20	-9.36(-23.54 to 4.82)	7.09	0.19

Table 12: Meta-regression for fruit and vegetable consumption entering single covariates[8]

Covariate	**Coefficient**	**CI**	**Standard error**	**p**
Year of data collection	1.31	-2.59 to 5.21	1.97	0.51
Gender	21.51	-39.73 to 82.75	30.91	0.49
Age (children/adults)	-68.37	-201.33 to 64.59	67.07	0.31
Method of data collection	35.17	.255 to 70.09	17.62	0.05
Economic development*	-12.83	-57.77 to 32.12	22.69	0.57
Location (rural-urban)	-31.79	-78.28 to 14.70	23.46	0.18

Table 13: Meta-regression for fruit and vegetable consumption entering all covariates[9]

Covariate	Model 1 (including all studies)			Model 2 (excluding quality<34%)			Model 3 (including adults only)		
	Coefficient (95% CI)	**SE**	**p**	**Coefficient (95% CI)**	**SE**	**p**	**Coefficient (95% CI)**	**SE**	**p**
Year of data collection	1.82 (-2.477 to 6.12)	2.16	0.40	1.78 (-2.52 to 6.08)	2.16	0.41	2.49 (-1.66 to 6.65)	2.09	0.24
Gender	8.31 (-53.977 to 70.59)	31.32	0.79	8.41 (-53.91 to 70.72)	31.34	0.79	8.06 (-52.02 to 68.14)	30.22	0.79
Age	-72.96 (-218.36 to 72.46)	73.12	0.32	-72.52 (-217.98 to 72.93)	73.14	0.32	N/A	N/A	N/A
Method of data collection	32.58 (-2.34 to 67.50)	17.56	0.07	32.63 (-2.32 to 67.57)	17.57	0.07	27.47 (-6.52 to 61.47)	17.10	0.11
Economic development*	11.25 (-43.41 to 65.90)	27.49	0.68	10.92 (-43.70 to 65.54)	27.47	0.69	16.19(-35.09 to 67.46)	25.79	0.53
Location (rural-urban)	-34.57 (-82.10 to 12.97)	23.90	0.15	-34.39 (-81.92 to 13.14)	23.90	0.15	-37.20(-85.80 to 11.40)	24.45	0.13

[7] Entering all covariates: All six covariates were entered together at the same time, adjusting for covariates, to explore the role of each covariate as a source of heterogeneity for the fruit consumption estimates of the population in the included studies. In Model 1 of the multivariable analysis, data extracted from all included studies were included. In Model 2, data from studies that scored less than 34% in quality appraisal were excluded. Model 3 included data extracted for adults only.

[8] Entering single covariates: Only one covariate was entered at a time to test its effect on or association with fruit & vegetable consumption estimates of the population in the included studies.

[9] Entering all covariates: All six covariates were entered together at the same time, adjusting for covariates, to explore the role of each covariate as a source of heterogeneity for the fruit & vegetable consumption estimates of the population in the included studies. In Model 1 of the multivariable analysis, data extracted from all included studies were included. In Model 2, data from studies that scored less than 34% in quality appraisal were excluded. Model 3 included data extracted for adults only.

Table 13a: Model 4 (excluding starchy vegetables)

Covariate	Entering Individual Covariates (Univariate Analysis)			Entering all Covariates (Multivariate Analysis)		
	Coefficient (95% CI)	**SE**	**p**	**Coefficient (95% CI) (M4)**	**SE**	**p**
Year of data collection	0.93 (-3.09 to 4.96)	2.03	0.65	0.70 (-3.92 to 5.32)	2.33	0.76
Gender	16.00 (-47.29 to 79.30)	31.86	0.50	9.24 (-54.07 to 72.56)	31.85	0.77
Age (children/adults)	-77.78 (-217.07 to 61.51)	70.13	0.27	-135.06 (-294.19 to 24.06)	80.06	0.09
Method of data collection	-4.14 (-33.49 to -25.21)	14.76	0.78	-7.30 (-41.61 to 27.01)	17.26	0.67
Economic development*	-13.33 (-62.22 to 35.57)	24.62	0.59	17.28 (-49.17 to 83.72)	33.43	0.60
Location (rural-urban)	-54.05 (-108.42 to 0.33)	27.38	0.05	-60.75 (-126.98 to 5.47)	33.32	0.07

APPENDICES

Appendix 1: World Bank definition of sub-Saharan Africa as of July 2018

Angola
Benin
Botswana
Burkina Faso
Burundi
Cabo Verde
Cameroon
Central African Republic
Chad
Comoros
Democratic Republic of Congo
Congo Republic
Cote D'ivoire
Equatorial Guinea
Eritrea
Swaziland (now Eswatini)
Ethiopia
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Madagascar
Malawi
Mali
Mauritania
Mauritius
Mozambique
Namibia
Niger
Nigeria
Rwanda
Sao Tome and Principe
Senegal
Seychelles

Sierra Leone

Somalia

South Africa

South Sudan

Sudan

Tanzania

Togo

Uganda

Zambia

Zimbabwe

Appendix 2: Conversion **methods for standardizing data**

Conversion	Estimation Method	Explanation	Source
Median to mean	$(q1 + m + q3)/3$	Where q1=the first quartile, q3=the third quartile, m=median	after Wan et al., 2014
IQR to SD	$\frac{q3 - q1}{1.35}$	Where q1=the first quartile, q3=the third quartile	after Higgins et al., 2008 (Cochrane Handbook)
SE to SD	$SD = SE \times \sqrt{N}$	SE=Standard Error, N=Sample size	after Higgins et al., 2008 (Cochrane Handbook)
CI to SD	$SD = \sqrt{N} \times (\text{upper limit} - \text{lower limit})/3.92$	For 90% confidence intervals 3.92 should be replaced by 3.29, and for 99% confidence intervals it should be replaced by 5.15	after Higgins et al., 2008 (Cochrane Handbook)
Ounze (meat, fish) to gram	1Oz= 28.35g*	Reported number of ounze multiplied by 28.35g	*
Kilogram to gram	1kg= 1000g	Consumption reported in kg is multiplied by 1000 to achieve gram values	
Portion/Serving of fruit/veg. to gram	1 portion/serving= 80g**	Reported number of portions/servings multiplied by 80g	**
Cup of fruit juice to gram	1 cup= 250ml=250g	Reported number of cups multiplied by 250g	*
Cup of orange vegetable (e.g. carrot, pumpkin) to gram	1 cup= 150g	Reported number of cups multiplied by 150g	*
Cup of raw leafy vegetable (leafy) to gram	1 cup= 40g	Reported number of cups multiplied by 40g	*
Portion/Serving of meat (cooked) to gram	1 portion/serving= 100g	Reported number of portions/servings multiplied by 100g	*
Portion/Serving of poultry (cooked) to gram	1 portion/serving= 80g	Reported number of portions/servings multiplied by 80g	*

Portion/Serving of fish (cooked) to gram	1 portion/serving= 100g	Reported number of portions/servings multiplied by 100g	*
Per week to day	1 week= 7 days	Consumption reported as g/week is divided by 7 to achieve g/day values.	
Per month to day	1 month= 30 days	Consumption reported as g/month is divided by 30 to achieve g/day values	
Per year to day	1 year= 365 days	Consumption reported as g/month is divided by 30 to achieve g/day values	

**WHO recommendation *after Saxelby 2009

Appendix 3: Extracted Data

Extracted Data .xlsx

NB: Double-click MS Excel icon to open data file