A Comprehensive Meta-Analysis of Dietary and Culinary Practices on Esophageal Cancer Incidence in the East African Corridor

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Abstract

Background: Maintaining good health and ensuring proper bodily function are contingent upon dietary choices. Excessive or regular consumption of specific foods can have adverse effects, including an exponential rise in the incidence of esophageal cancer in Africa.

Objectives: This study aims to identify diet-related risk factors predisposing populations in this geographical area to esophageal cancer.

Materials and methods: This study conducted an exhaustive computerized search of databases, including Medline/PubMed, Embase, Web of Science, Scopus, Cochrane Library, and African Journals Online to identify eligible studies up to December 2023 using PRISMA guidelines.

Results: Results from 18 included studies showed a strong correlation between certain foods and esophageal cancer risk. Locally produced tea showed a noteworthy association with esophageal cancer risk (OR=2.06; 95%CI, 1.28–3.33), followed by hot foods/beverages with an OR of 1.84 (95%CI, 1.37–2.47), and maize meal and its derivatives with an OR of 2.30 (95%CI, 1.17–4.53). The risk of esophageal cancer was also associated with frequent consumption of geophagia clay, with an ORs of 1.49 (95%CI, 1.19–1.85). Additionally, esophageal cancer risk was strongly linked to cooking methods using charcoal or wood as fuel (OR = 2.43; 95%CI, 1.50–3.93).

Conclusion: This systematic review and meta-analysis established causal links between regular consumption of locally produced tea, hot beverages/foods, maize meal and its derivatives, geophagia clay, and the use of coal/wood as fuel, and risk of esophageal cancer in the East African corridor. However, further research is essential to investigate the potential mechanisms underlying this relationship.

Keywords: Esophageal cancer; Dietary habits; Culinary methods; Systematic review; Meta-analysis; Africa.

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Introduction

Esophageal cancer ranks as the eighth most common cancer globally and is the sixth leading cause of cancer-related deaths **(Ferlay et al., 2015)**. Typically, it remains asymptomatic during the early stages of the disease. As the disease progresses, dysphagia with or without weight loss becomes apparent **(Bray et al., 2018)**. The prevalence of esophageal cancer has increased significantly worldwide in recent years. According to the GLOBOCAN 2020 report, there were 0.6 million new cases and 0.54 million deaths worldwide in 2020 **(Sung et al., 2021)**. GLOBOCAN 2020 predictions estimate approximately 739,666 new cases and 723,466 deaths in 2030, and 987,723 new cases and 914,304 deaths worldwide in 2040 if no action is taken **(Sung et al., 2021)**. The progression of this malignant tumor is particularly high in less developed regions, accounting for 80% of cases globally **(GBD, 2020)**, with Africa recording around 49% of cases worldwide **(Bray et al., 2018)**. This disease poses a significant challenge for health authorities in African countries, specifically for the countries of the East African corridor, stretching from Ethiopia to South Africa **(Ndebia and Kamsu, 2023)**. This corridor, encompassing the countries of eastern and southern Africa, is the main area of endemicity on the continent **(Sammon and Ndebia, 2019)**.

Globally, numerous individual observational studies have investigated the association between dietary factors and the incidence of esophageal cancer. Most of these studies have been summarized in systematic reviews and meta-analyses, including the work of Qin et al. **(2022)** focusing on studies conducted in Asia and Sun et al. **(2020)** covering studies from Asia, Europe, and America. None of these studies, however, specifically addressed the case of Africa, which is the focal point of the disease worldwide. Only the literature review published by Ghosh and Jones **(2022)** mentioned the case of Africa, albeit in a literal and summary way, without conducting a quantitative analysis or stratification according to the main food groups consumed. Moreover, the aforementioned study did not assess potential risks of study bias (e.g., meta-bias, selection bias), thereby diminishing the strength of the aggregated scientific evidence. Therefore, it is crucial to evaluate the strength of evidence before using it to inform public health policy.

Recognizing that the rich diversity of African cultures has given rise to a multitude of dietary habits, with variations in composition and culinary techniques for the same staple food from one village/country/region to another, the complexity of this diversity makes it more challenging to establish the connection between diet and esophageal cancer **(Oniang'o et al., 2003)**. This necessitates more targeted research. Thus, to shed light on the increasing incidence of esophageal cancer in Southern and Eastern Africa, our study conducted a comprehensive qualitative and quantitative analysis of all the literature related to the association between dietary and cooking habits and esophageal cancer in highly endemic areas of Africa. This systematic review, covering studies published up to December 2023, aimed to answer the following key questions: What are the main foods consumed in the East African corridor that expose populations to esophageal cancer? What culinary techniques are closely associated with this outbreak of the disease in this geographical area? Hence, the general aim of this study was to provide information to guide public health initiatives and interventions tailored to this high-risk population in terms of nutrition.

Materials and methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, PRISMA for abstract **(Page et al., 2021)**, and PRISMA for searching **(Rethlefsen et al., 2021)** were used to plan, conduct, and report the current study. Prior to its realization, the review protocol for this work has been registered in the Prospective International Register of Systematic Reviews (PROSPERO) under number CRD42023493539.

Data sources and searches: The systematic literature searches were carried out in five electronic databases (Web of Science, Scopus, Cochrane Library, Medline/PubMed, and African Journal Online). The search included studies published up to November 2023, with no restrictions in terms of publication date or language. The search strategies used for the searches included the following terms: "Dietary pattern" OR "Food" OR "African foods" OR "Risk factors" AND "Esophageal neoplasm" OR "Esophageal cancer" and their synonyms.

These searches were then adapted to the requirements of each specific database (i.e. the use of operators and symbols). Details of the search strategy are given in (**Table.S1**). In addition, a manual search in Google Scholar, as well as in the references of the selected articles, was performed to identify other eligible studies.

Study Selection: The identified studies were first exported to EndNote, where duplicates were removed, and then to Rayyan software to better organize the selection and review process **(Kufe et al., 2019)**. After removing duplicates, when studies found didn't meet the following inclusion criteria, they were excluded from our study: (1) Observational studies reported the associations between dietary patterns and esophageal cancer. (2) If the diagnosis of EC patients was confirmed by pathological biopsies or other standard methods, with healthy participants (with no antecedent cancer) as comparators. (3) If they provided relative risks (RR), hazard ratios (HR), or odds ratios (OR) and their corresponding 95% confidence intervals for dietary patterns/cooking mode. (4) We included the most often identified dietary patterns across studies to reduce the possibility of misclassifications, and we made sure that the selected dietary patterns were specified consistently in terms of factor loadings of the most frequently consumed foods as much as feasible. (5) Studies must have been conducted on the African continent and involve African adults only (≤18 years).

The authors (EJN & GTK) initiated the selection process by independently evaluating the titles and abstracts of previously identified studies. Subsequently, a second independent selection was conducted by carefully examining the full text of articles that met the initial eligibility criteria, identifying those where eligibility remained unclear. Finally, the two authors rigorously and jointly assessed the eligibility of each study, particularly those with uncertain eligibility, to determine their inclusion in the systematic review and meta-analysis. At each stage of study selection, any disparities were addressed through a consensus-seeking discussion before progressing to the next stage.

Data extraction: Data extraction from the included studies was carried out as follows: first author's last name; year of publication; country; study design; sample size; diagnostic criteria; age of participants; number of cases of esophageal cancer; number of controls; dietary patterns; collection period; data collection methods; RRs, HRs, or ORs and the corresponding 95% CIs for dietary patterns/cooking mode. The authors were contacted by email at least twice, one week apart, when the full text of a paper was unavailable or if any essential information was missing in the provided data. Studies conducted across multiple countries **(Masukume et al., 2022)** were disaggregated by country, with the author's name duplicated and followed by the country's initials.

Quality assessment: The authors proceeded to independently assess the quality of the studies using the Newcastle-Ottawa Scale (NOS) tool for case-control studies. This assessment was based on the NOS's three dimensions: (I) selection of study groups; (II) comparability of the groups; and (III) assessment of outcomes **(Stang, 2010)**. The study quality classification system outlined by Stang was utilized for this study. As per this system, the highest possible NOS score is 9 points, with studies scoring 7 to 9 points being classified as high quality; those scoring 4 to 6 as moderate quality; and those scoring 0 to 3 as low quality **(Stang, 2010)**. Any disagreements between authors were resolved through consensus.

Publication bias assessment: The authors proceeded to independently assess possible publication bias was assessed by visual scrutiny of the funnel plot. Subsequently, the Egger regression test **(Egger, 1997)** was employed to statistically assess any asymmetry detected in the funnel plot. Publication bias was acknowledged when the P-value falls below 0.10 **(Tegegne et al., 2017)**. Then, the Trim and Fill test was used to confirm that the asymmetry of the funnel diagram is not linked to the publication bias of the studies **(Merga et al., 2023)**. Risk of bias assessment was performed using STATA version 17.0 (StataCorp LP, Texas) software for Windows.

Certainty of evidence: The certainty of evidence for dietary patterns, in association with esophageal cancer recurrence was evaluated using the Grades of Recommendation, Assess-

ment, Development, and Evaluation (GRADE) approach **(Schunemann et al., 2019)**. The GRADE approach allows for consideration of the within-study risk of bias, inconsistency, indirectness and imprecision between the studies, publication bias, magnitude of the effect, and dose- response relationship. The GRADE approach classifies the certainty of evidence into one of four levels: high, moderate, low, and very low. Authors independently rated the certainty of evidence, with disagreements being resolved by consensus.

Statistical Analysis

In this work, the temperatures of beverages and foods were classified into three groups: warm, hot, and extremely hot, based on the information found in the included articles. Warm food had a temperature of 30 to 40 degrees Celsius (temperature taken as a reference), while hot food had a temperature of 50 to 65 degrees Celsius. Very hot food could cause burns on the tongue and throat after consumption.

For qualitative analysis, EJN and GTK meticulously extracted qualitative data from various studies and subjected them to systematic analysis. The summarized outcomes of these analyses are presented in Table 1. For quantitative synthesis, statistical analyses were carried out using Review Manager Web (RevMan Web) software (Cochrane, London, UK) for Windows. Dichotomous data linking dietary/culinary habits to esophageal cancer were portrayed as odds ratios (OR) with corresponding 95% Confidence Intervals (95% CI) in a forest plot. Eating status was employed for data stratification into subgroups, and random-effects meta-analyses were performed to accommodate inherent differences in the study populations.

Heterogeneity among the included studies was evaluated using the I^2 statistic, with significance set at $P < 0.05$, as described by Higgins and Thompson **(2003)**. An I^2 value between 75% and 100% indicated substantial heterogeneity. Subgroup analysis considered the different types of food consumed (tea, hot drinks/foods, porridge, smoked meat/fish, spicy foods, maize and maize derivatives, salty foods, geophagia clay) and the different cooking techniques (charcoal or wood, electricity, gas) frequently used by the populations to identify those with a low risk of esophageal cancer. Differences between subgroups were assessed through visual inspection of confidence intervals and P value. The odds ratio was utilized as a measure of risk for the subgroup and the overall association between dietary/culinary and esophageal cancer.

Results

Literature search results

The electronic yielded a total of 107,199 studies and manual searches have not provided any additional research. After eliminating duplicates (65,062 studies), a thorough review was conducted on 42,137 titles/abstracts. Following this review, 553 studies were selected for full-text examination. Subsequently, 535 studies were excluded for reasons such as non-alignment with the geographical focus of the study, comments, abstracts from conferences, and inadequate data even after a request to the corresponding author. Finally, 18 studies that fully met our inclusion criteria were selected for qualitative and quantitative analysis (**Fig.1** and **Table.1**).

Study characteristics and quality assessment

The 18 included studies, all case-control studies, encompassed a combined sample of 13,596 individuals, consisting of 5,606 cases and 7,990 control individuals. These participants were sourced from seven countries (South Africa, Ethiopia, Malawi, Zambia, Kenya, Tanzania, and Mozambique) **(Table.1)** and belonging to the Eastern and Southern African sub-regions. The cases comprised patients diagnosed endoscopically and confirmed either histologically, through CT scans, or imaging (barium swallow) for esophageal cancer or those meeting clinical criteria for esophageal cancer. The control group comprised healthy volunteers recruited from the hospital setting with no family history or affiliation with any form of cancer. Nutritive factors across these studies were collected through questionnaires. All the studies included were of high quality for the most part and of moderate quality for some.

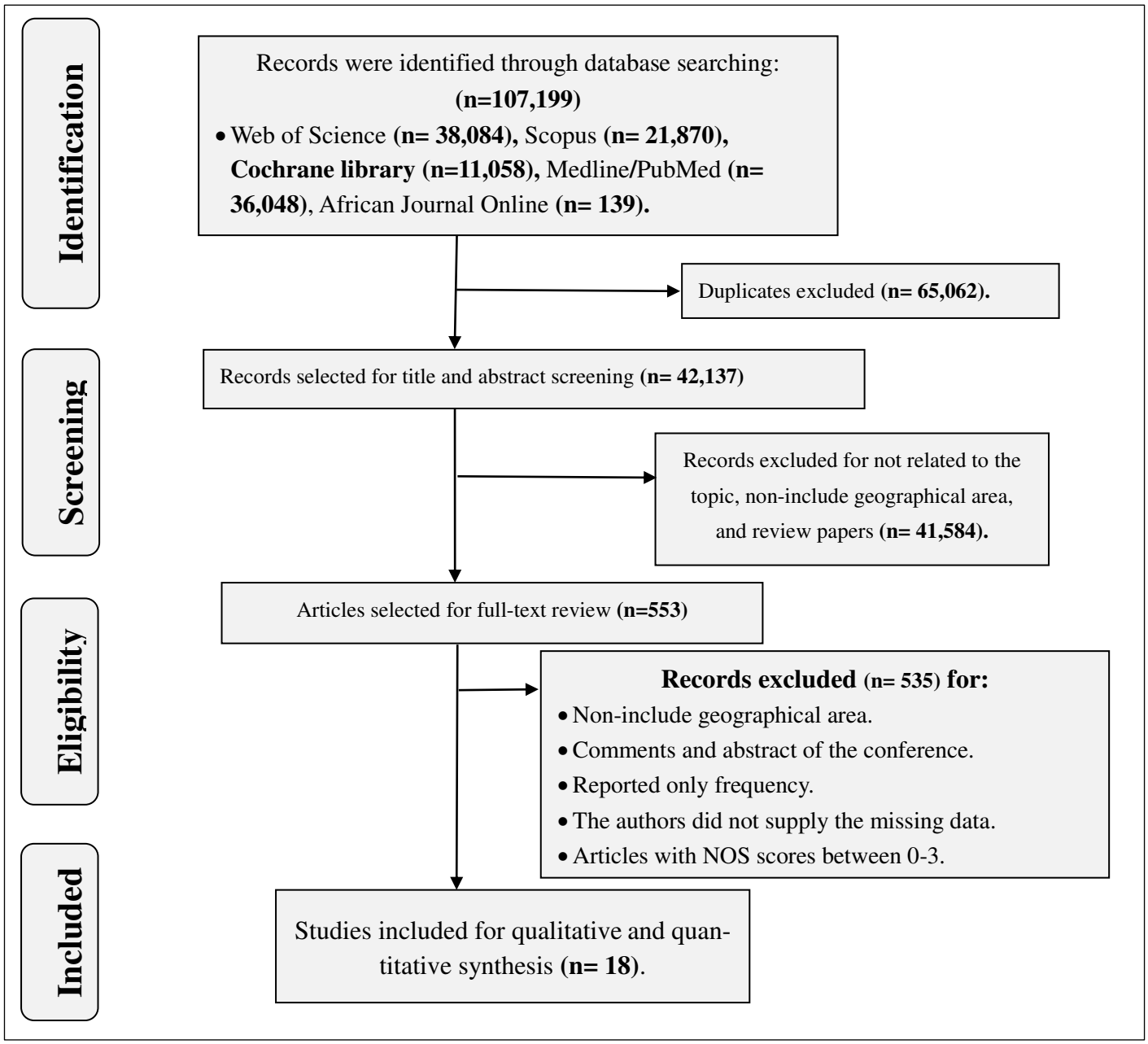

Fig.1. Schematical flow diagram for the selection of study included in the systematic review and meta-analysis

Table 1. Characteristics of the different case-control studies included for meta-analysis

Author's (Date)	Country	study population	Cases/ controls	Nutritive and culinary factors evaluate	Period of collect	Data collection methods	NOS
Cunha et al. (2022)	Mozambique	Adults (≥ 18 years)	143/212	Tea, coffee, Hot beverages, Fruit and vegetables, Smoked meat or fish.	Between 2006 and 2010	Standardized questionnaire	5
Dandara et al. (2006)	South Africa	Adults (≥ 18 years)	245/288	cooking fuel.	Between 1997 and 2003	Questionnaire	6
Dessalegn et al. (2022)	Ehiopia	Adults (≥ 18 years)	338/338	Hot beverages (Tea & coffee), cereals (Maize, Sorghum, Wheat, Barley), Porridge, food temperature, raw meat, fruit and vegetables.	February 2019 to August 2020	Questionnaire	5
Deybasso et al. (2022)	Ethiopia	Adults (≥ 18 years)	104/208	Cereal foods, Egg and poultry intake patterns, Fruit and vegetables, Porridge, food temperature, coffee, hot coffee, and cooking fuel.	From June 1, 2019, to June 30, 2020	Administration of questionnaire	6
Geßner et al. (2021)	Malawi	Adults (≥ 18 years)	157/70	Hot food or hot tea, Spicy food, Smoked fish, Vegetables, Maize porridge.	In 2010 and between 2014–2016	Questionnaire	4
Kaimila et al. (2022)	Malawi	Adults (≥ 18 years)	300/300	Ate Soil, Mold on stored grain, Tea, Tea temperature, and cooking fuel.	Between 2017 and 2020	Interviewed using a structured questionnaire	7
Kayamba et al. (2015)	Zambia	Adults (≥ 18 years)	50/50	Cooking fuel.	October 2013 to May 2014	Simple questionnaire	5
Kayamba et al. (2022)	Zambia	Adults (≥ 18 years)	131/235	Consumption of hot drinks, and cooking fuel.	Between October 2018 and May 2021.	Interviewer-administered questionnaires	6
Leon et al. (2017)	Ethiopia	Adults (≥ 18 years)	73/133	Maize, Porridge, Green vegetables, and salted food.	Between May 2012 and May 2013	Questionnaire	5
Machoki et al. (2015)	Kenya	Adults (≥ 18 years)	78/162	Cooking fuel.	Between August 2008 and April 2009	Administration of the standardized questionnaire	4
Masukume et al. (2022)	Malawi, Tanza-	Adults (≥ 18 years)	539/593 310/	Tea/coffee use, Hot drinks (tea/coffee), Porridge, food temperature.	Malawi (2017-2020) and Tanza-	Administration of questionnaire	7

	nia		313		nia (2015-2019)		
Mlombe et al. (2015)	Malawi	Adults (≥ 18 years)	96/180	Maize storage, Source of maize, Type of maize, Water source.	From January 2011 to February 2013	Administration of questionnaire	5
Mmbaga et al. (2021)	Tanzania	Adults (≥ 18 years)	471/471	Preferred beverage temperature, Ate soil/clay, Reused cooking oil, Preservation of grain/nuts, Consume beans and Magadi, Gourd or calabash bowl use, water source, cooking fuel, Rice, Wheat/bread/pasta, Chipsi, Fruit, vegetables, Smoked fish/meats, Spicy food, Cassava, Maize, Milk, and Salted foods.	Between 2013 and 2015	Administration of questionnaire	6
Narh et al. (2021)	Tanzania, Malawi Kenya	Adults (≥ 18 years)	310/313 539/593 95/97	Ate geophagia clay/soil	2015-2018 in Kenya, 2015-2020 in Tanzania and 2017-2020 in Malawi	Interviews with questionnaire	5
Pacella-Norman et al. (2002)	South Africa	Adults (≥ 18 years)	405/2174	Cooking fuel.	Between March 1995 to April 1999	Interviews with questionnaire	5
Patel et al. (2013)	Kenya	Adults (≥ 18 years)	159/159	Cooking, Take hot beverage.	Between June 2003 and July 2006	Administration of questionnaire	5
Sammon (1998)	South Africa	Adults (≥ 18 years)	130/130	Maize, Beans, and Pumpkin.	Between 1987 - 1988	Interviews	4
Van Rensburg et al. (1985)	South Africa	Adults (≥ 18 years)	211/211	Tea, Margarine/butter, and Maize.	During the period 1978-1981	Interviews were conducted by a trained African social worker.	4

Newcastle-Ottawa Scale: NOS.

Effect of Tea and Coffee drinker on esophageal cancer risk

Random-effects meta-analysis of Tea/Coffee consumption and the risk of EC were shown in (**Fig.2**). These results showed that Tea/coffee drinkers compared with not tea/coffee had a significant association with esophageal cancer risk in the overall analysis (pooled OR = 1.66, 95% CI = 1.21–2.27, I^2 = 78%, P<0.001). Hierarchical analyses by type of

beverage were performed, the association was not significant with coffee drinker (pooled OR = 1.15, 95% CI = 0.88–1.52). However, tea drinker could significantly increase the risk of esophageal cancer in Est Africa corridor (pooled OR = 2.06, 95% CI = 1.28–3.33) compared with non-tea drinkers. The Egger test yielded a p-value of 0.9554, suggesting the absence of publication bias (**Fig.S1**).

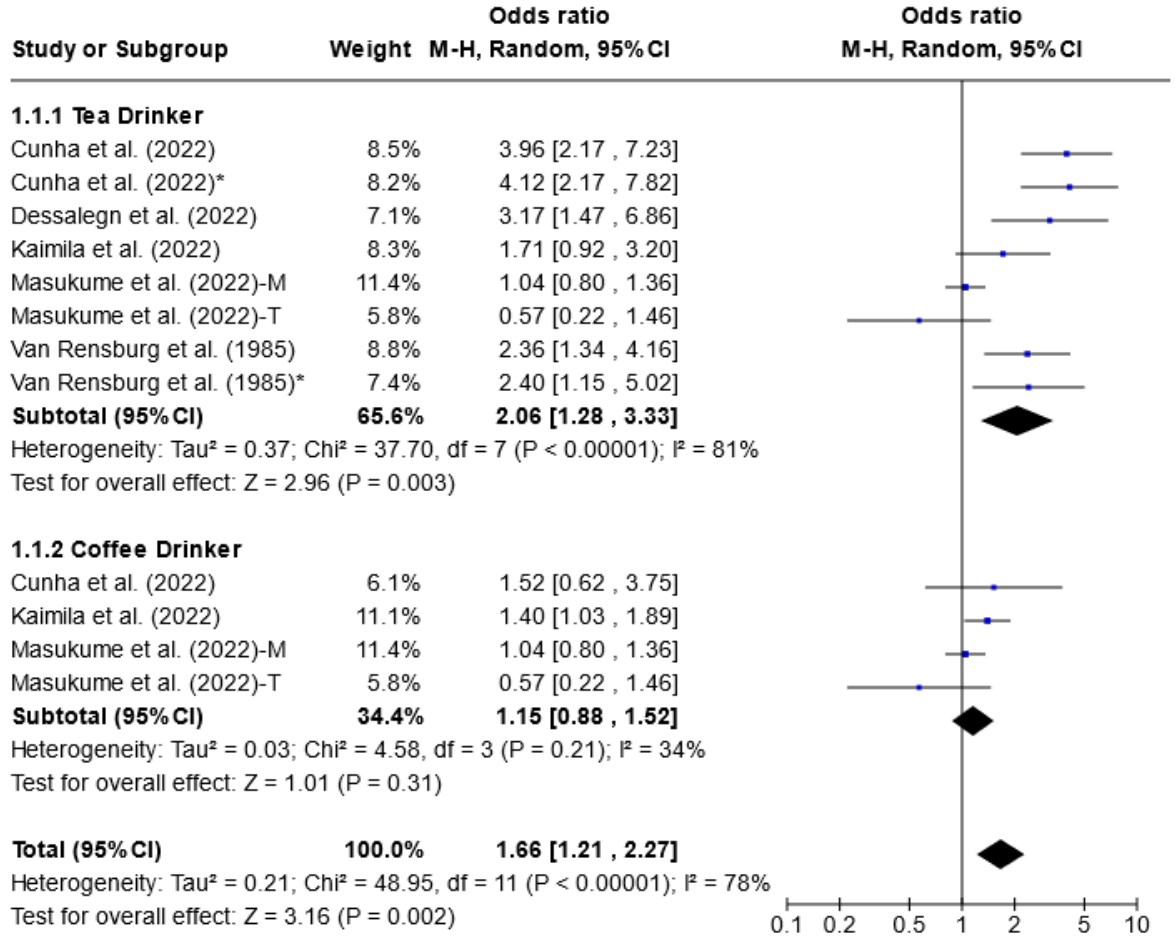

Fig. 2. Forest plot of the association between Tea/Coffee intake and esophageal cancer risk.

Effect of hot beverage (Tea and Coffee) and food consumption and esophageal cancer risk

Random-effects meta-analysis of hot beverage and food consumption and the risk of EC were shown in (**Fig.3**). This figure suggested a positive relation between hot beverages (Tea and Coffee) and food consumption, and EC risk compared with people consuming normal-temperature (lukewarm) beverages/food. The overall pooled OR for hot beverage and food was 1.84(95% CI, 1.37–2.47), with a high heterogeneity (I^2 = 86%, p < 0.001). Consumption of very hot drinks showed a greater risk [OR= 2.00 (95% CI, 1.25–3.18, I^2 = 89%, p < 0.001)] than hot drinks [OR= 1.49 (95% CI, 1.14–1.94, I^2 = 32%, p = 0.22)]. However, the pooled OR of available studies did not show a significant [OR= 1.84 (95% CI, 0.88–3.81, I^2 = 90%, p < 0.001)] relationship between consumption of hot food and EC risk. The Egger test yielded a p-value of 0.5790, suggesting the absence of publication bias (**Fig.S2**).

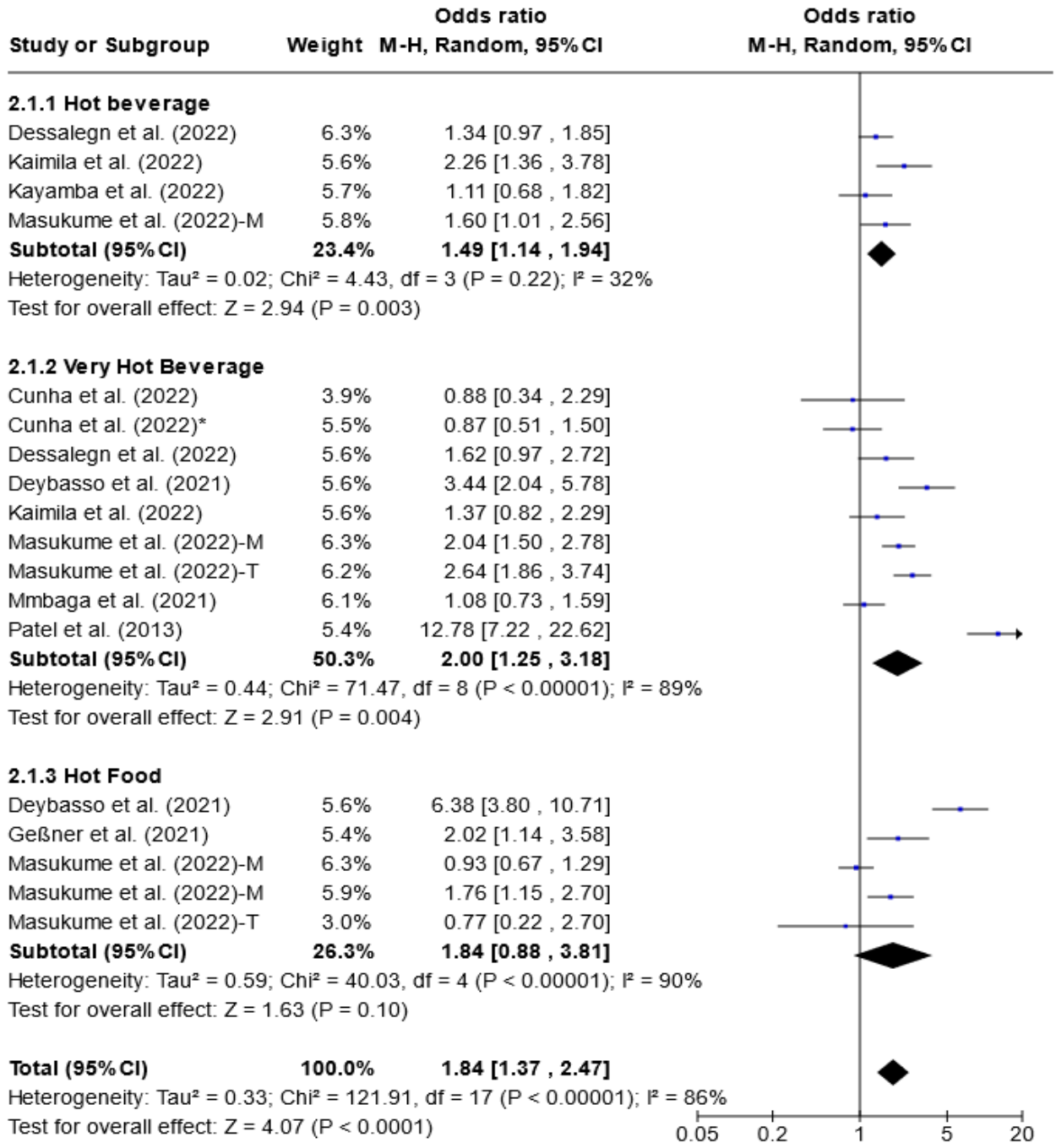

Fig. 3. Forest plot of studies linking hot beverage/food consumption and the risk of esophageal cancer.

Effects of main food consumed on esophageal cancer risks

(Table.2) presents the results of the meta-analysis of the main food groups consumed in the East African corridor and their relationship with the risk of esophageal cancer. Analysis of this table showed that consumption of cereals in general (OR=1.62 [95%CI, 1.15 - 2.28]) and maize meal in particular (OR=2.30 [95%CI, 1.17 - 4.53] significantly increased the risk of esophageal cancer in this geographical area. an association was also observed between esophageal cancer and daily consumption of geophagia clay, with ORs of 1.49 [1.19 - 1.85]. Additionally, the Egger test for cereals, maize meal, and geophagia clay, yielded a p-value > 0.05, suggesting the absence of publication bias. However, no significance was obtained with the consumption of fruits/vegetables, local spicy foods, and smoked fish/meat.

Table 2. Summarized results of the dietary habits and esophageal cancer risk

Foods categories	No. of Studies	Heterogeneity (P-value)	Effects (OR with [95%CI])	P-value of effects	P-value of Egger Test
Overall Cereals	12	I^2 = 74% (P < 0.000)	1.62 [1.15 - 2.28]	0.005	0.3466
Maize meal	6	I^2 = 78% (P = 0.000)	2.30 [1.17 - 4.53]	0.02	0.8992
Cereals other than maize	6	I^2 = 0% (P = 0.53)	1.20 [1.00 - 1.44]	0.05	0.7012
Porridge	5	I^2 = 91% (P < 0.000)	2.04 [0.98 - 4.24]	0.06	0.6049
Fruits and vegetables	11	I^2 = 82% (P < 0.000)	0.91 [0.66 - 1.26]	0.57	0.5713
Smoke fish/meats	4	I^2 = 75% (P = 0.007)	1.10 [0.72 - 1.66]	0.67	0.0090
Spicy food	4	I^2 = 60% (P = 0.06)	1.23 [0.89 - 1.69]	0.21	0.7040
Ate Geophagia Clay	5	I^2 = 8% (P = 0.36)	1.49 [1.19 - 1.85]	0.0004	0.2757

Effects of cooking mode on esophageal cancer risk

Random-effects meta-analysis of cooking mode and the risk of EC were shown in (**Fig.4**). These results showed that Firewood/Charcoal users compared with Electricity/Gaz users had significant association with esophageal cancer risk in Est African corridor (pooled OR = 2.43, 95% CI = 1.50–3.93, I^2 = 88%, P<0.001). The Egger test yielded a p-value of 0.3571, suggesting the absence of publication bias (**Fig.S3**).

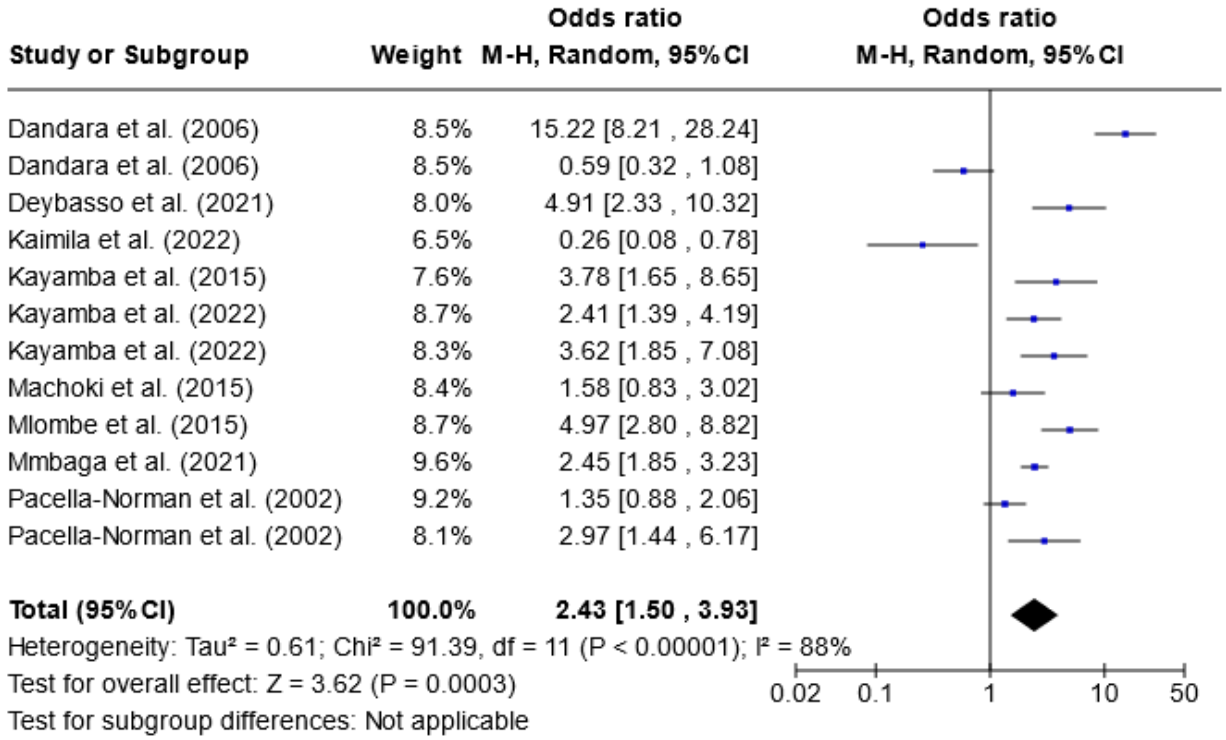

Fig.4. Forest plot of the association between cooking mode and esophageal cancer risk.

Discussion

To maintain good health and keep the body functioning, eating is crucial (**Ahmad et al., 2021**). Excessive or regular consumption of certain foods can lead to harmful effects (**Sammon and Iputo, 2006**). This could be the cause of the figurative increase of esophageal cancer, a non-communicable disease in the East African corridor. Given that the current millennium slogan is "Health through diet, the challenge for the years to come", this work aims to identify dietary risk factors other than alcohol-

ism in the East African corridor, which predispose its populations to esophageal cancer.

The results of this work show that the populations living in the East African corridor, which includes the countries of East and Southern Africa, share a common set of dietary habits and practices. Meta-analysis of available studies on these habits and practices shows that consumption of locally produced tea is closely associated with esophageal cancer. This result contradicts the work of Zheng et al. **(2012)**, which showed a non-significance [OR=0.76(95% CI, 0.49-1.02)] between tea consumption and esophageal cancer in China. Similarly, consumption of beverages (local tea and coffee) and hot foods increased the risk of esophageal cancer with an OR of 1.84(95% CI, 1.37-2.47). These results support those of Zhong et al. **(2022)** and Simba et al. **(2023)**, who obtained ORs of 2.04 (95% CI, 1.78-2.31) and 1.68 (1.13-2.49) respectively, reflecting the high significance of hot food and drink consumption. According to the International Agency for Research on Cancer, hot foods/beverages (>65°C) are considered Group 2A carcinogens for humans, as they cause thermal damage to the cells of the esophageal mucosa, which mutate over the long term **(Loomis et al., 2016; IARC, 2020)**. The biological mechanisms by which thermal injury in general could increase the risk of EC are multiple. Firstly, inflammatory processes associated with chronic irritation of the esophageal mucosa caused by local hyperthermia could stimulate the endogenous formation of reactive nitrogen species and nitrosamines **(Mirvish et al., 1995)**. The latter, in excess, will induce mutations at the origin of the cancerous tumor **(Wang et al., 2002)**. On the other hand, during thermal injury, the barrier function of the esophageal epithelium may be impaired, resulting in increased exposure to intraluminal carcinogens or carcinogens associated with the individual's lifestyle (tobacco, alcohol, etc.) **(Tobey et al., 1999)**. The link between tea consumption and esophageal cancer may be due either to the fact that tea is consumed very hot, or to the presence of as-yet unidentified carcinogens in locally produced teas.

This meta-analysis showed a very high risk of developing esophageal cancer in people who regularly consumed maize (corn) meal and its derivatives (OR = 2.30 [1.17 - 4.53]). Maize meal being the staple food in this geographical area, its strong association with esophageal cancer would be due to nutritional deficiencies in the subjects and the rapid chemical and microbial degeneration of ground maize meal **(Sammon and Ndebia, 2021)**. This chemical and microbial degeneration results in an alteration in the nutritional quality of maize meal (denaturation of nutrients) and the development of carcinogenic mycotoxins (**Sammon and Iputo, 2006**). According to Sammon and Ndebia **(2019)** and Sammon **(1998)**, nutritional deficiency from an early age is the main cause of endemic levels of esophageal cancer in the East African corridor.

Our meta-analysis showed that regular consumption of geophagia clay or soil (OR= 1.49 [1.19 - 1.85]) was linked to the risk of esophageal cancer. According to Nkansah et al. **(2016)**, geophagia clay contains large quantities of toxic metals such as lead (Pb), arsenic (As), mercury (Hg) and cadmium (Cd), which have serious consequences for the health of consumers. Consumption of geophagia clay samples can have serious health consequences for consumers due to the presence of toxic metals such as lead (Pb), arsenic (As), mercury (Hg) and cadmium (Cd). According to the International Agency for Research on Cancer (IARC), its elements are designated as heavy metals and potentially carcinogenic **(Sammon, 2021)**. Daily oral consumption (ingestion) of clay containing them could lead to lesions on the esophageal mucosa, and thus to cancer.

The main culinary technique in the East African corridor is that using wood/charcoal as fuel as the main energy source for cooking **(Deybasso et al., 2021; Kayamba et al., 2022; Mmbaga et al., 2021; Pacella-Norman et al.,**

2002). A strong association (OR = 2.43; 95% CI = 1.50-3.93) was established between the cooking technique using charcoal or wood as fuel and esophageal cancer, compared with the cooking technique using gas/electricity. Considered a dirty fuel **(WHO, 2006)**, their combustion produces numerous particles, which contain products of incomplete combustion, such as Polycyclic Aromatic Hydrocarbons (PAHs), a widespread environmental carcinogen **(Mwachiro et al., 2021; Idowu et al., 2023)**. The PAH then binds to DNA and induces cancer **(Baird et al., 2021)**. Similar work has reported the association between wood/coal burning and esophageal cancer in China, Iran, and Brazil **(Murphy et al., 2017; Okello et al., 2019)**.

Global comparisons and several subgroup analyses in this study showed significant heterogeneity between the studies. Differences in the amount of food consumed per intake and the frequency of its consumption, as well as the frequency and duration of exposure to wood/coal fumes during cooking could explain the significant heterogeneity between the included studies. In addition, the high heterogeneity could be attributed to variations in population characteristics (comorbidities, cancer stage, age, climate or geographical area, etc.), and lifestyle (alcoholism, smoking, eating habits, and others) **(Ayaz et al., 2020)**. In addition, variation can be attributed to study characteristics, such as context, sample size, outcome measurement, participant difference and risk of study bias, and study design **(Nunes et al., 2021)**.

Several limitations were identified in conducting this study. Firstly, the included studies comprised case-control designs, which are generally susceptible to recall and selection bias. Additionally, while all the studies addressing eating and culinary patterns and EC risk originated from East and Southern Africa, the limited number of studies per country hindered a comprehensive assessment stratified by countries. Lastly, the absence of studies from other African regions underscores the need for further research in those areas. Additionally, the absence of available data prevented the execution of a meta-analysis of certain foods, such as rice, fats, soft drinks, etc. The precision of the risk assessment was limited by both the small number of studies and the relatively modest size of the population studied. Finally, the absence of nutritional and culinary data from other countries belonging to the East African corridor underlines the need for further research in these regions, which are also affected by the disease. Furthermore, we believe that a study that considers all the limitations mentioned above would result in a stronger link between dietary and culinary habits and esophageal cancer.

Conclusions

In conclusion, this systematic review and meta-analysis demonstrate a significant association between certain dietary and culinary habits and the EC risk in the East African Corridor. The risk increases significantly with regular consumption of tea, hot drinks/foods, maize and maize derivatives, salty foods, geophagia clay, and the use of charcoal or wood as cooking fuel. Countries in this geographical area should design and implement rigorous policies to raise awareness of the dangers of consuming salty foods, geophagia clay, tea, and hot drinks. A more vigorous initiative to supplement maize and its derivatives should be considered before they are marketed. Governments should also initiate operations to facilitate access to domestic gas for poor populations, to reduce the risks associated with the use of charcoal or wood as fuel. Future research is planned to study the composition of teas produced locally and used by the populations of this geographical area.

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