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## Research Article

# Risks of oesophageal cancer in Zimbabwe: Eating habits and indoor air pollution from firewood smoke

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## Abstract

**Background:** Oesophageal cancer is among the top five (5) cancers in Zimbabwe, and it has a high mortality rate. Several studies have alluded to the association between exposure to firewood smoke and this cancer. This study assessed the association between firewood smoke exposure, consumption of hot beverages, and food with oesophageal cancer among cancer patients in Zimbabwe.

**Methods:** This study was quantitative in nature and adopted a cross-sectional design. A matched case-control approach with 95 pairs of cases and controls from Parirenyatwa Group of Hospitals' Radiotherapy Centre, a major referral hospital in Zimbabwe was used. A total of 190 participants were interviewed using a questionnaire administered via telephone by trained interviewers. Secondary data using histology results and radiology reports were obtained from the patient's medical records. SPSS version 27 was used to perform the descriptive analysis for variables such as age, marital status, exposure to firewood smoke, and thermal burns. Bivariate and multivariate analyses were used to examine the relationship between oesophageal cancer and dependent variables.

**Results:** The ratio of male to female OC cases was 1.4 to 1, with a mean age of 63 for males and 60 years for females. The OC was significantly associated with the usage of firewood smoke as a major source of cooking energy (OR: 2.961; 95 % CI 1.46 - 6.03) (AOR: 4.22; 95% CI 1.22 - 14.59) with a *p* - value of 0.043. Also, the OC was significantly associated with high consumption of sweet potatoes (OR: 3.26; 95 % CI: 1.67 - 6.55) (AOR: 3.47; 95% CI: 1.07 - 11.23) with a *p* - value of 0.001. The usage of the kitchen as a dining room was associated with OC (OR: 2.65; 95% CI: 1.44 - 4.88), no association was found (AOR: 0.98; 95% CI: 0.34 - 2.72) after adjusting for confounders. Risk factors such as age, alcohol intake, smoking, HIV status, and marital status were not associated with OC.

**Conclusion:** The use of firewood for cooking and the consumption of sweet potatoes are the major contributors to OC among Zimbabweans. Awareness of the eating habits of sweet potatoes and using the kitchen as a dining area could significantly reduce cases of OC among Zimbabweans.

## Introduction

Oesophageal Cancer (OC) is the 4<sup>th</sup> most common cancer among male Zimbabweans and 3<sup>rd</sup> most common cancer among female Zimbabweans according to the Zimbabwe Cancer Registry data [1]. Worldwide it is the 8<sup>th</sup> most common cancer and the 6<sup>th</sup> cause of death amongst cancer patients. About 80% of OC are diagnosed in developing countries. According to

GLOBOCAN 2020, Sub-Saharan Africa recorded approximately 4,000 new oesophageal cancer cases per week. Additionally, oesophageal cancer overall ranked 7<sup>th</sup> in cancer incidence and 6<sup>th</sup> in the cancer-related mortality ranking in Sub-Saharan Africa [2].

The incidence rates of this cancer are high in developing countries with high poverty levels as compared to the developed world. The major risk factors cited for this cancer include

cigarette smoking, alcohol use, and gastro-oesophageal reflux disease [3]. These risk factors are however not significantly high in developing countries to account for the huge disparity in the incidence rates of this cancer [4]. Oesophageal burns from hot beverages have been recently cited as a risk of oesophageal cancer. Countries that are noted to have high incidences of this cancer have in common poor access to electricity and high usage of biomass fuel. Exposure to smoke from biomass fuel has been shown to increase the risk of oesophageal cancer by a number of studies [5,6]. Firewood is the most commonly used biomass fuel in Zimbabwe like most Sub-Saharan African countries; hence firewood smoke exposure is common through inhalation of smoke-polluted air and through ingesting fire-roasted or preserved food due to lack of refrigeration [7].

Co-usage of the kitchen as dining increases the exposure to firewood smoke for the whole family. This is usually the setup in most rural homes. Open-plan modern designs of homes are also now very common and preferred. In these designs, the kitchen, dining, and lounges are not divided by any walls, they are open [8]. This, however, has been noted to increase indoor air pollution. The eating habits of people in Zimbabwean communities may also be a cofactor in the development of oesophageal cancer, with thermal injuries to the oesophagus from consumption of fire-roasted maize and sweet potatoes, potentially being more common and severe than that of hot beverages as reported in recent finding [9]. Oesophageal thermal burns can also occur from food substances other than hot beverages documented in developed countries to be associated with Oesophageal cancer. The different climatic, cultural, and traditional value systems affect dietary difference preferences in communities [10,11]. These differences may also affect the incidences of thermal Oesophageal burns between developed and developing countries.

Smoking and alcohol intake, the significant risk factors for oesophageal cancer in developed countries, is also not a common practice or habit in developing countries. Therefore, other risk factors could be driving the high incidence rate of Oesophageal cancers in developing countries like Zimbabwe [12]. This study sought to determine if there is an association between oesophageal cancer and firewood smoke. It will also try to evaluate some of the potential cofactors that may relate oesophageal cancer to firewood use. Identifying the risk factors may allow the targeted screening of the high-risk subpopulation, leading to possible early diagnosis and reduction mortality rate of this cancer in Zimbabwe. This study aimed to establish if firewood smoke and eating habits are the cause of oesophageal cancer among cancer patients attending Parirenyatwa Group of Hospital's Radiotherapy treatment.

## Methodology

This study was quantitative and adopted a cross-sectional design. A matched case-control approach was used to enrol cancer patients referred to Parirenyatwa Group of Hospital's (PGH) Radiotherapy treatment. Approval of the study was granted by the Joint Parirenyatwa College of the Health Sciences University of Zimbabwe and the Medical Research Council of Zimbabwe, Consecutive consenting patients with oesophageal

cancer seen at PGH were enrolled. Controls were patients seen at the PGH for other illnesses than cancer. Furthermore, cases and controls were matched for gender and age (within +/- 5 years), at a ratio of 1:1. The cases were recruited from the cardiothoracic clinics, where they are referred to for diagnosis and/or surgical treatment, and from the oncology clinics, where patients diagnosed from inside and outside the hospital were referred for oncology services that are chemotherapy and/or radiation treatment services or best supportive care.

Only consenting patients who were aged 18 years and above with a histological diagnosis of oesophageal cancer were included in this study. In the control cohort, only non-oncology patients above the age of 18 were included. Cases without a histologically confirmed diagnosis of oesophageal cancer or whose origin of cancer cannot be differentiated between stomach or oesophagus were excluded from the study. In the control cohort, patients with symptoms of oesophageal cancer but not yet been investigated for this condition were also excluded. The participants for this study were interviewed using a questionnaire administered via telephone by trained interviewers. Proxies were interviewed in cases where the patient was unable to respond personally. The histology results and radiology reports were obtained from the patient's medical records for those patients who would have consented to participate in the study.

## Data analysis and general analysis

The study sample size was estimated at 190 and comprised 95 cases and 95 controls based on a two-sided confidence level of 95% and 80% power of detecting Oesophageal cancer amongst people exposed to firewood smoke, a ratio of control of cases of 1:1.

Descriptive statistical analysis was used to identify the frequencies and percentages of the variables such as age, marital status, exposure to firewood smoke, and thermal burns. Bivariate and multivariate analyses were used to examine the relationship between oesophageal cancer and dependent variables, including firewood smoke exposure and dietary habits. Odds ratios and 95% confidence interval were used to determine the association between oesophageal cancer and the variables. Univariate and logistic regressions were performed using SPSS version 27. A significant association was found if the confidence interval did not contain a null value, a zero.

## Results

Although we had proposed 190 patients, a total of 101 patients were identified. Of these identified controls, 6 refused to take part and 3 were excluded because they could not be adequately matched according to our matching criteria. In total 92 pairs were included in the final data analysis (Figure 1). There were more males (58.7%) with oesophageal cancer as compared to females (41.3%) at a ratio of 1.4 to 1. The most common age group was the 60 years - 69 years age group constituting 29.3% of the cases and 28.3% of the controls. The mean age in the case group was 62.5, with a standard deviation of 13. Most of the cases were married individuals (64%), followed by the widowed (26%). The unemployment



rate was high in both groups, 70% in the cases group and 65% in the control group (Table 1). The p-value presented in Table 1 corresponds to the comparison between the control and cases, and in this study, the method employed to determine the p-value for the comparison between the control group and cases was the chi-squared test. Most of the study participants were from Harare (40.2% cases and 30.3% controls) 27.3% were from outside Harare. The least number of patients (2.2%) came from Bulawayo province.

### Sociodemographic oesophageal cancer risk

Patients in the age groups above 50 were more likely to have OC than those in the 30-49 age group, however; this was not statically significant. Patients with OC were 0.2 times less likely to have been employed than the unemployed, and after adjusting for the confounders, patients with OC were 2.8 more likely to be employed than unemployed; however, the differences were not statistically significant (Table 2). Patients with OC were 1.02 more likely to be HIV positive than those with similar health status. This difference was not statistically significant. The OC patients were 1.5 more likely than the controls to be smokers, and in the adjusted analysis; they were 2.9 more likely to the smokers, but this difference was statistically non-significant. Also, the OC patients were 1.14 times more likely than the controls to have been consumers of alcohol as compared to those who never took alcohol. In the adjusted analysis, the likelihood of them having been alcohol consumers increased to 1.4 likelihood (Table 3).

### Firewood smoke and oesophageal cancer risk

The difference among patients who used firewood as a source of energy was statistically significant (p-value of 0.043). The OC patients were 2.3 times more likely to have used firewood as the major source of cooking energy (OR: 2.27, 95% CI 1.4 - 6.03) and the odds increased to 4.22 (AOR: 4.22, 95% CI 1.22 - 14.59) (Figure 2). There was no association between OC and the co-use of the kitchen as a dining area. Interestingly, OC patients were 2.7 times more likely than controls to have a co-used kitchen as a dining area.

Table 1: Patient Characteristic.

	Total n (%)	Cases n (%)	Controls n (%)	p value
Gender				
Female	92 (41.3)	38 (41.3)	38 (41.3)	1
Male	92 (58.7)	54 (41.3)	54 (58.7)	
Age group				
30-49	34 (18.5)	14(15.2)	20 (21.7)	0.460
50-59	52 (28.3)	26 (28.3)	26 (28.3)	
60-69	54 (29.3)	26 (28.3)	28 (30.4)	
>70	44 (23.9)	26 (28.3)	18 (19.6)	
Marital status				
Single	6 (3.3)	1 (1.1)	5 (5.4)	0.150
married	112 (60.9)	59 (64.1)	53 (57.6)	
divorced	18 (9.8)	6 (6.5)	12 (13)	
widowed	48 (26.1)	26 (28.3)	22 (23.9)	
Employment				
No	123 (67.2)	64 (69.6)	59 (64.8)	0.496
Yes	60 (32.8)	28 (30.4)	32 (35.2)	
Matabeleland	6 (3.3)	2 (2.2)	4 (4.3)	
Midlands	15 (8.2)	7 (7.6)	8 (8.7)	
HIV status				
No	81 (65.9)	42 (65.6)	39 (66.1)	.956
Yes	42 (34.1)	22 (34.4)	59 (33.9)	
Alcohol				
No	108 (58.7)	57 (62)	51 (55.4)	0.369
Previous/current	76 (41.3)	35 (38)	41 (44.6)	
Smoking				
No	144 (78.3)	69 (75)	75 (81.5)	0.284
yes	40 (21.7)	23 (25)	17 (18.5)	

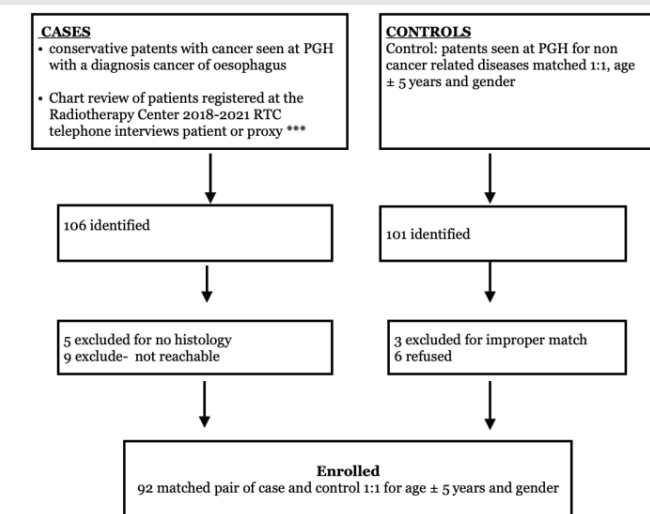


Figure 1: Study Implementation.

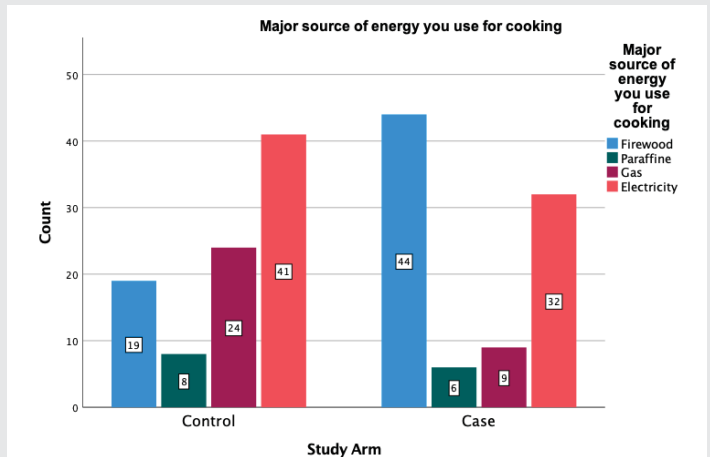


Figure 2: Major source of cooking energy.

OC patients were 1.76 times more likely to have a lifetime personal view of moderate to a lot of firewood smoke exposure than those whose views were of never being exposed or exposed for a short time than the controls. This difference was not statistically significant even after adjusting for confounder.



**Table 2:** Association between oesophageal cancer with eating habits and smoke exposure.

	Total n (%)	Cases n (%)	Control n (%)	p - value
Preference for tea or coffee				
I prefer it very hot	71 (38.6)	37 (40.2)	34 (37)	0.739
I prefer it warm	110 (59.8)	53 (57.6)	57 (62)	
I prefer it cold	3 (1.6)	2 (2.2)	1 (1)	
Sweet potatoes consumptions				
Never	13 (7.1)	2 (2.2)	11 (12)	<0.001
Sometimes	119 (65.4)	53 (58.9)	66 (71.7)	
A lot	50 (27.5)	35 (38.9)	15 (16.3)	
Hot drink burn				
Never	71 (41.8)	29 (36.7)	42 (46.2)	0.435
A few times	86 (50.6)	44 (55.7)	42 (46.2)	
Many times,	13 (7.6)	6 (7.6)	7 (7.7)	
Fire-roasted maize intake				
Never/Sometimes	132 (71.7)	61(66.3)	71 (77.2)	0.102
A lot	52 (28.8)	31 (33.7)	21 (22.8)	
The major source of energy you use for cooking				
Electricity	73 (39.9)	32 (35.2)	41 (44.6)	<0.001
Paraffine	14 (7.7)	6 (6.6)	8 (8.7)	
Gas	33 (18)	9 (9.9)	24 (26.1)	
Firewood	63 (34.4)	44 (48.4)	19 (20.7)	
A personal view of lifetime exposure to firewood smoke				
Never/short	68 (37)	28 (30.4)	40 (43.5)	0.067
Moderately/a lot	116 (63)	64 (69.6)	52 (56.5)	
Co usage of the kitchen as a dining room				
Yes	73 (37.4)	47 (51.1)	26 (39.7)	<0.001
No	67 (36.4)	20 (21.7)	47 (36.4)	
Sometimes	44 (23.9)	25 (27.2)	19 (23.9)	

**Table 3:** Multivariate Logistic Regression Analysis: Odds Ratios for Oesophageal Cancer

	Crude Odds Ratios	95% CI	Adjusted Odds Ratios	95% CI
Age of patient				
30 - 49	Reference	Reference	Reference	Reference
50 - 59	1.429	0.597 - 3.420	1.574	0.488 - 5.079
60 - 69	1.327	0.558 - 3.156	1.474	0.400 - 5.426
>70	2.063	0.831 - 5.125	0.846	0.156 - 4.597
Sex of patient				
Female	Reference	Reference	Reference	Reference
Male	1.000	0.556 - 1.798	1.242	0.476 - 3.240
Married				
No	Reference	Reference	Reference	Reference
Yes	1.316	0.727 - 2.382	1.903	0.708 - 5.111
Employment status				
Unemployed	Reference	Reference	Reference	Reference
Employed	0.807	0.435 - 1.497	1.132	0.389 - 3.292
HIV Status				
Negative	Reference	Reference	Reference	Reference
Positive	1.021	0.484 - 2.154	0.813	0.309 - 2.141
Smoking				
No	Reference	Reference	Reference	Reference
Yes	1.471	0.725 - 2.982	2.852	0.796 - 10.226
Alcohol intake				
No	Reference	Reference	Reference	Reference
yes	1.142	0.559 - 2.334	1.419	0.413 - 4.882
Hot drink burns				
No	Reference			
Yes	1.478	0.798 - 2.736	0.860	0.340 - 2.176
Preference for tea or coffee				
cold/warm	Reference			
very hot	1.148	0.634 - 2.079	1.086	0.431 - 2.737
Sweet potatoes consumption				
Never/Sometimes	Reference			
A lot	3.267	1.627 - 6.558	3.475	1.075 - 11.234
Fire - roasted maize intake				
no/sometimes	Reference			
A lot	1.718	0.896 - 3.295	0.594	0.181 - 1.948
The major source of energy you use for cooking				
Electricity	Reference			
Paraffin	0.961	0.303 - 3.050	2.103	0.383 - 11.545
Gas	0.480	0.196 - 1.176	0.737	0.186 - 2.915
Firewood	2.967	1.460 - 6.031	4.220	1.220 - 14.591
Co usage of the kitchen as a dining room				
no/sometimes	Reference			
yes	2.651	1.439 - 4.883	0.958	0.337 - 2.721
A personal view of lifetime exposure to firewood smoke				
never/short time	Reference			
moderately/a lot	1.758	0.959 - 3.223	0.503	0.161 - 1.571

Variable(s) entered in step 1: Sex of patient, Smoking, Preference for tea or coffee, age of patient, HIV Status, Sweet potatoes consumption, Hot drink burns, Alcohol intake, employment status Married, Personal view of lifetime exposure to firewood smoke, Co usage of the kitchen as a dining room, Major source of energy you use for cooking, Fire roasted maize consumption

### Eating habits and oesophageal cancer risk

Patients with OC were 1.5 times more likely to have had a history of hot drink burns as compared to those who did not. The difference was statistically non-significant. The preference for tea or coffee was not associated with OC. When compared to non or sometimes consumption of sweet potatoes, the odds of OC with a lot of consumption of sweet potatoes was 3.3 times more than controls (OR 3.27, CI 1.627 - 6.558) (AOR 3.47, CI 1.075 - 11.24), and the association was significant ( $p$  - value of 0.001). Patients with OC were 1.7 more likely to have consumed a lot of fire-roasted maize than those who had not or had moderately consumed. After controlling for another confounder, no association was found.

### Discussion

#### Patients' sociodemographic and oesophageal cancer risk

The mean age of oesophageal cancer patients was 62.5 for both sexes, and males were slightly older at diagnoses than females at 63 and 61 years, respectively. This difference was not statistically significant.

In this study, the male-to-female ratio of OC was 1.4:1 for the study participants. This was the same ratio noted in a study done in South Africa [13]. This ratio was much different in other countries and settings. The ratio of males to females in one USA state cancer oncology centre was 3:1 [14]. The South African authors explained this difference due to the high prevalence of oesophageal cancer in South African women. However, this difference may be because more males have OC in the USA and the risk of OC in the developed world's settings is much more driven by the high alcohol and smoking rates [15]. There were very few smokers in both the males and females in this study.

The relatively high number of female patients with OC in some developing countries was also noted in a review paper done by Middleton et al. and this paper also suggests that this may have been due to increased access to healthcare facilities by women, a possible reflection of the closure in the gap for inequalities in healthcare access.

Several studies have proposed a link between high rates of smoking and alcohol intake among individuals with certain eating habits and exposure to indoor air pollution, particularly drawing comparisons between single and married individuals [16]. Some investigations have even suggested elevated mortality rates among individuals with poor eating habits and exposure to indoor air pollution who are single compared to their married counterparts [17]. In the present study, a notable proportion of the cohort with poor eating habits and exposure to indoor air pollution was married, although this difference did not reach statistical significance. Contrary to findings in other studies, which have demonstrated a significant association between being single and having poor eating habits and exposure to indoor air pollution, our study did not observe a similar pattern. Importantly, our study did not examine the survival outcomes of individuals with poor eating habits and exposure to indoor air pollution.

There was no association between employment status and OC in this study. However, some studies have reported an association between employment status and OC, with the odds of OC being noted to be high in the unemployed as compared to the employed [18]. The reason why there may have been no association between employment status and OC in this study may be because of the generally low income of those people who are currently employed in Zimbabwe [19].

This study did not find an association between HIV and OC. Other studies have shown no association between HIV and OC [20,21]. However, older studies have shown an association between HIV status and OC [22]. The failure to show any association between HIV and OC in this study could be because of the high treatment rates of those patients who are positive in Zimbabwe.

There were slightly more smokers and alcohol use in the OC patients when compared to the controls. However, this association was not found to be significant with a p-value of 0.369. This is different from many studies that have shown a significant association between smoking and alcohol intake [7,23]. Alcohol intake and smoking are generally low in the

Zimbabwean population, mainly due to cultural and religious beliefs. Despite the fact that Zimbabwe is one of the world's top producers of tobacco, smoking is generally not a common habit (Li, et al. 2020).

The study found no significant association between the province of origin and the incidence of OC. Although one might have anticipated a higher prevalence of OC cases originating from rural areas, where the use of firewood is more common due to limited access to electricity in some households, the data did not support this expectation. It is noteworthy that Harare, being the smallest province in Zimbabwe, is highly urbanized, potentially influencing the distribution of OC cases across provinces. While the study did not identify a significant association between the province of origin and OC occurrence, it is important to consider that urban areas, such as Harare, may have additional factors contributing to OC beyond the use of firewood smoke. Urban lifestyles, environmental exposures, and socioeconomic factors prevalent in densely populated areas could potentially contribute to the observed distribution of OC cases.

While the current study did not reveal a notable association between the province of origin and the incidence of OC, it is essential to acknowledge the possibility of a gender-based disparity in firewood exposure and its potential implications for OC prevalence. In many settings, traditional gender roles may lead to differential exposure to indoor air pollution, with women often being more involved in cooking activities using firewood. As such, further investigation into the gender-specific patterns of firewood use and their relationship to OC prevalence could provide valuable insights. Understanding and addressing these potential disparities is crucial for developing targeted interventions to reduce OC risk factors, particularly in regions where the use of firewood is prevalent.

Several factors may contribute to the observed outcome regarding age in patients with OC. Firstly, the average age of individuals diagnosed with OC was approximately 60. It is plausible that many of these individuals were exposed to firewood smoke during their earlier years, especially considering that a significant portion of the population grew up in rural areas, a common scenario in pre-independence Zimbabwe. Zimbabwe gained independence in 1980, and prior to that, only a minority of black natives resided in urban areas. The limited access to electricity during that period, as indicated by the World Bank Global Electrification Database [24], could have influenced the reliance on alternative cooking methods, such as firewood, in both rural and urban settings. The urban setting of Harare has numerous areas lacking access to electricity. This persistent lack of electrification in certain regions might contribute to sustained dependence on traditional cooking methods, potentially influencing the age-related patterns observed in OC cases.

### Firewood smoke exposure and oesophageal cancer risk

There was a significant association between the usage of firewood as a source of cooking energy and OC. In this study, Oesophageal cancer was significantly associated with the usage

of firewood as a major source of cooking energy. This association has also been found in several studies, including one from Lusaka Zambia, which was looking at the association between oesophageal cancer and domestic biomass smoke exposure. This study again was a case-control study like this study [6] in this Zambian study, the association of oesophageal cancer with domestic exposure to biomass smoke was significant, with the odds ratio relatively similar to this Zimbabwean study (OR: 3.1; 95% CI: 1.7 – 5.6 and AOR: 2.1; 95% CI: 1.1 – 3.8

There is, however, a major difference between Zimbabwe and Zambia in terms of the type of biomass fuel used. Zambian's charcoal is significant with approximately half of the urban population using Charcoal for cooking [25]. In Zimbabwe, on the other hand, the use of Charcoal was minimal only through, only through smuggling as its use production and use were outlawed.

The odds of OC were found to be 2.65 times higher amongst those who used the kitchen as a dining room; however, after adjusting for confounders, this association was found not to be significant. Some studies have shown poor air quality in the open plan system, the same set-up as the usage of the kitchen as a dining area [26,27].

In rural areas, the usage of a kitchen as a dining and living room is a common phenomenon. This likely increases the exposure rate of firewood smoke in people in such households.

The open-plan type of housing is becoming more popular in Zimbabwe in urban areas. The poor access to cleaner energy in Zimbabwe will mean that they may be more exposed to biomass indoor air pollution in our setting as compared to the developed world where such housing plans are common and cleaner energy highly accessible.

The personal view of lifetime exposure to firewood smoke was not found to be associated with OC. It was postulated that there would be an association since firewood smoke exposure was proven to be associated with OC. The failure to prove this association may be because this measure of this variable was very subjective. Because of different backgrounds and personal opinions, there may have been some bias among those who responded to this question. A prospective measure of the air quality and air pollutants, metabolite (Biomarkers of smoke exposure) would need to be done as it correlated better with the personal view of those exposed to smoke. This has been done in some studies [28] and it allows better quantification of smoke exposure.

### Eating habits and oesophageal Cancer risk

There was no association found between the consumption of hot teas and coffees with OC in this study. This is contrary to a number of studies that have shown this association [9,29]. This may have been because this study was retrospective and the measure of the hotness of these drinks was subjective. In the other study, the researchers measured the temperatures of the teas to determine the real temperatures of these drinks [30]. Again, the frequency of tea drinking in Zimbabwe could be lower as compared to other countries where hot beverages

are taken frequently. There are generally fewer coffee and tea restaurants in Zimbabwe as compared to other countries. Again, Zimbabwe is a generally hot country, and consumption of hot beverages would generally be low as compared to cold climate countries [31].

There was a significant association between lots of consumption of sweet potatoes and OC, even after adjusting for confounders. This high association may be due to the fact that sweet potatoes are relatively difficult to swallow food substances [32]. This is highly likely to increase the risk and duration of thermal injuries if these potatoes are consumed hot. Again because of their mass effect as compared to teas and coffee, the temperature of the potatoes is likely to be higher than that of the fluids [33]. The longer transit time of these solids is likely to cause more extensive burns as compared to fluids [34]. There is scant information about the role of sweet potatoes as a risk factor for OC in the literature. Consumption of sweet potatoes is relatively common as shown in this study; there is, therefore, a need to evaluate its association even further.

This study however found no association found between the consumption of firewood roasted maize intake and OC. We had postulated that the consumption of firewood roasted maize would increase the risk of thermal injuries to the oesophagus if it were consumed hot. Again, it was postulated that the local thermal burns from hot maize would cause more injuries when compared to that of hot beverages because of the high transit time of solids as compared to fluids. Again it was postulated that consumption of firewood roasted maize would additionally expose the consumer to higher levels of Polycyclic Aromatic Hydrocarbons (PAHs) known carcinogens increasing the risk of OC [35,36].

This study had some limitations. Firstly, the study relied heavily on the memory of the participants about some of the important information. Secondly, the COVID pandemic challenges also prevented us from attaining the intended sample size required, so the power of this study may have been reduced.

To comprehensively analyze the interplay of various factors in OC, exploring structural modeling or other advanced statistical techniques could be beneficial. Structural modeling, such as Structural Equation Modeling (SEM) or Path Analysis, allows for the examination of complex relationships among multiple variables. Multivariate Regression Analysis can be used to assess the simultaneous influence of multiple independent variables on the dependent variable (OC) to understand the combined effects. Machine Learning Approaches can be applied using techniques like Random Forest, Gradient Boosting, or Neural Networks which can capture nonlinear relationships and interactions among variables, providing a more nuanced understanding of the factors contributing to OC.

### Conclusion

The use of firewood as a primary cooking fuel remains prevalent in many Zimbabwean communities. The study revealed associations between the use of firewood for cooking



and the consumption of sweet potatoes with the occurrence of esophageal cancer (OC). Conversely, traditional risk factors for OC, including smoking, alcohol consumption, and the intake of hot beverages, did not exhibit significant associations in this study. It is imperative to intensify efforts to identify alternative, cleaner energy sources such as solar and wind power.

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