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A Case-Control Study of Risk Factors for Colorectal cancer in an African population

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Abstract

The interplay between hereditary and environmental factors in the causation of colorectal cancer in sub-Saharan Africa is poorly understood. We carried out a community based case-control study to identify the risk factors associated with colorectal cancer in Zimbabwe. We recruited 101 cases of colorectal cancer and 202 controls, matched for age, sex and domicile. Potential risk factors including family history, socio-economic status, urbanisation, diabetes mellitus, and prior schistosomiasis were evaluated. Conditional logistic regression was used to estimate the odds ratios associated with the different factors. Cases were more likely to have a tertiary education (32.7% vs 13.4%, $p < 0.001$) and a higher income (18.8% vs 6.9%, $p = 0.002$). After multivariate analysis, diabetes mellitus [OR 5.3 (95% CI 1.4 – 19.9), $p = 0.012$], previous urban domicile [OR 2.8, (1.0 -7.8), $p = 0.042$], prior schistosomiasis [OR 2.4 (1.4 – 4.2) $p = 0.001$] and cancer in a first degree relative [OR 2.4 (1.2 – 4.8) $p = 0.018$] were independently associated with colorectal cancer. Our findings suggest that family history, diabetes mellitus, prior schistosomiasis, and approximation to a western lifestyle are the predominant associations with colorectal cancer in Africans. This offers opportunities for targeted prevention, and hypothesis driven research into the aetiology of colorectal cancer in this population.

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Conflict of interest

No conflicts of interest were declared.

Keywords

Colorectal neoplasms; Africa South of the Sahara; risk factors; incidence

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Introduction

Colorectal cancer in sub-Saharan Africa often presents with advanced disease, with a high mortality amongst affected individuals (Chalya *et al.*, 2013). It is increasingly recognised as a significant contributor to cancer burden in the region, and is the sixth most common cancer (Parkin *et al.*, 2014; Katsidzira *et al.*, 2017). In Zimbabwe, the incidence of colorectal cancer has been increasing steadily over the past two decades (Chokunonga *et al.*, 2013; Katsidzira *et al.*, 2016). The age standardised incidence rate per 100,000 (ASR) in Zimbabwe increased from 8.1 in men and 8.2 in women in 1991-95 to 14.9 in men and 14.2 women in 2010 (Chokunonga *et al.*, 2013).

While improved diagnosis undoubtedly contributes to the rise in the incidence of colorectal cancer in sub-Saharan Africa, other possible reasons have also been advanced (Katsidzira *et al.*, 2017). It has been postulated that the rising incidence reflects the extent to which associated risk factors are becoming prevalent. However, the burden of colorectal cancer in sub-Saharan African remains significantly below what is reported in high income countries. The ASR of colorectal cancer in men and women in different countries in Europe in 2012 was as follows: Denmark (69.4; 53.4), United Kingdom (55.6; 36.7), France (53.8; 36.9) and Germany (59.7; 34.8) (Ferlay *et al.*, 2013).

Estimates from these high incidence countries suggest that 65% of colorectal cancers are sporadic, driven by dietary and lifestyle factors, and 5% are caused by specific germline disorders such as Lynch syndrome and familial adenomatous polyposis (Lichtenstein *et al.*, 2000). The extent to which these environmental and genetic elements contribute to colorectal cancer in Africa is unclear. It has been suggested that hereditary factors are predominant in Africa, since 25% of affected individuals are under the age of 40 years (Cronje *et al.*, 2009; Katsidzira *et al.*, 2017). The tumours in these young individuals often display signet ring cell or mucinous histology. These features are associated with Lynch syndrome, and young age of onset is generally associated with familial cancers (Umar *et al.*, 2004). The presence of an inherent susceptibility among Africans is further supported by a high frequency of early onset colorectal cancer among African-Americans (Agrawal *et al.*, 2005).

However the much higher frequency of colorectal cancer among African-Americans also emphasizes the impact of environmental factors. The ASR in African-Americans is estimated to be 58.3 and 42.7 in males and females between 2009 and 2013 (Siegel *et al.*, 2017). In Zimbabwe, the recent increase in the incidence of colorectal cancer is more apparent among older adults, which is consistent with environmental causes (Katsidzira *et al.*, 2016). In order to clarify these uncertainties in the African context, we performed a case-control study to determine the risk factors associated with colorectal cancer among black Zimbabweans.

Materials and Methods

Study population

In Zimbabwe, tertiary health care services, including pathology laboratories are centralised in the two largest cities, Harare and Bulawayo. Harare referrals come from the northern two thirds of the country, where roughly 70% of the population lives. This health services structure allows the identification of most confirmed cases of colorectal cancer from this region, at the various clinical and laboratory facilities in Harare. Therefore, a network of clinicians, hospitals and laboratories involved in the diagnosis and management of colorectal cancer was set up in Harare, to identify incident cases for a case-control study. Participants were recruited using these colorectal cancer referral pathways. Age and sex-matched control participants were identified from the communities where the cases resided.

Case and control selection

All black Zimbabwean patients older than 18 years of age with an index diagnosis of confirmed colorectal cancer were considered for recruitment. The principal investigator (LK) was informed whenever a new case of colorectal cancer was identified. All patients were contacted as soon as possible after being identified, and no later than 6 months after diagnosis. Patients with cognitive impairment or recurrent colorectal cancer were excluded. The permanent home address of each patient was identified with reference to the Zimbabwean 2012 national census enumeration maps. Two controls were randomly selected from households in the corresponding enumeration area for each case. These were matched for sex and age to within 5 years. Individuals with a history of gastrointestinal cancer or unexplained gastrointestinal symptoms were excluded as controls. Informed written consent was obtained from all participants.

Data collection

All participants were interviewed for specific risk factors related to colorectal cancer. Cases were interviewed either in hospital or at home after discharge, and all controls were interviewed at home. The questionnaire covered demographic and socio-economic characteristics including level of education, employment status, income, and domicile at different stages of life. Any place where a participant lived continuously for at least 12 months was recorded. A comprehensive medical history was obtained including the use of non-steroidal anti-inflammatory drugs (NSAIDs), the presence of diabetes mellitus, schistosomiasis, or inflammatory bowel disease, smoking and alcohol use. An affirmative answer to prior schistosomiasis was assumed to indicate prior exposure to *Schistosoma haematobium* and *Schistosoma mansoni*. Participants who had stopped drinking alcohol or smoking within 12 months of the interview were considered to be current users. A family history of cancer and colorectal cancer in 1st and 2nd degree relatives was also obtained.

Statistical analysis

A sample size of 100 cases and 200 controls was calculated to have at least 80% power to detect an absolute difference of 20% in exposure rates between the two groups using a two-sided α of 0.05. Baseline characteristics were compared using the chi-squared test or the

student t-test for categorical or continuous variables, respectively. Conditional logistic regression was used to determine the independent associations of colorectal cancer. Odds ratios (OR) and their 95% confidence intervals (CI) were calculated. Initially, univariate analysis was used for all potential factors. Statistically significant factors on univariate analysis ($p < 0.05$), or biologically plausible factors were further analysed using multivariate conditional logistic regression. A p-value of less than 0.05 was considered significant. All statistical analyses were performed using Stata/MP version 12.0 (College Station, Texas).

Ethical approval

The study was approved by the Medical Research Council of Zimbabwe (MRCZ/B/357).

Results

A total of 101 cases of colorectal cancer and 202 controls were recruited between November 2012 and December 2015. Figure 1 outlines the participant recruitment process. The response rate for eligible individuals approached to participate was 91% for cases and 90% for controls. There were 75 left-sided and 22 right sided cases. The location could not be verified in three cases, and one case had synchronous tumours in the rectum, and at the hepatic flexure. Table 1 shows the baseline characteristics of the cases and controls. As expected, the mean age, gender distribution and domicile were similar between cases and controls. There was a high proportion of early onset colorectal cancers, with 20% of cases under the age of 40 years. Cases were more likely to have a tertiary education (college, polytechnics, university) compared to controls [32.7% versus 13.4%, $p < 0.001$], and to be in the highest income bracket (earning $> \text{USD } \$1000$ per month) [18.8% versus 6.9%, $p = 0.002$]. The average monthly income in Zimbabwe is USD \$298 per month (Zimbabwe National Statistical Agency, 2013).

Tables 2 and 3 show the univariate and multivariate analyses respectively. As expected, there were no differences in the domicile of the cases and controls at the time of recruitment. However, having lived in an urban area for at least one year was associated with colorectal cancer on univariate analysis [OR 2.84, (95%CI 1.04-7.78), $p = 0.042$]. This remained significant on multivariate analysis [OR 3.65 (95% CI 1.09 – 12.24) $p = 0.036$]. Although a higher level of education and income were associated with colorectal cancer on univariate analysis, this effect was not evident after multivariate analysis.

Diabetes mellitus was significantly associated with colorectal cancer on univariate analysis [3.5 (OR 1.2-10.3) $p = 0.025$], and after multivariate analysis [OR 5.4 (1.4 – 19.9) $p = 0.012$]. A history of schistosomiasis was also associated with colorectal cancer on univariate analysis [OR 2.4 (1.4 – 4.2) $p = 0.001$], and multivariate analyses [OR 2.4 (1.3 – 4.3) $p = 0.006$]. The use of NSAIDs, alcohol or smoking was not associated with colorectal cancer in this study.

A history of any cancer among first degree relatives was associated with colorectal cancer on univariate analysis [OR 2.4 (1.2 – 4.8) $p = 0.018$]. This remained significant after multivariate analysis [OR 3.2, (95%CI 1.4 – 7.6) $p = 0.007$]. However, there was no

association with colorectal cancer among first degree relatives [OR 1.5 (0.1 – 25.5) $p = 0.090$].

Discussion

This is the first study to investigate factors associated with colorectal cancer in an African population using confirmed neoplasia as the endpoint. The results show that diabetes mellitus, urban domicile, schistosomiasis and a family history of cancer are associated with colorectal cancer in this population. Our findings imply that the rising incidence of colorectal cancer in Zimbabwe is partly related to the emerging epidemic of diabetes mellitus, on a background of increasing urbanisation. The association of schistosomiasis with colorectal cancer is surprising, but this could contribute to the frequent early onset colorectal cancers, together with hereditary factors.

Diabetes mellitus is a recognised risk factor for colorectal cancer, independent of diet, physical exercise, smoking, obesity or the metabolic syndrome (Yuhara *et al.*, 2011, Jarvandi *et al.*, 2013). This effect is probably mediated by the high levels of insulin and insulin-like growth factors. Hyperinsulinaemia potentiates the activation of the ras pathway, while insulin-like growth factors inhibit apoptosis of the colonic epithelial cells (Guo *et al.*, 1992; Leitner *et al.*, 1997). In animal studies, insulin stimulates aberrant crypt foci and promotes the development of colonic tumours (Tran *et al.*, 1996; Corpet *et al.*, 1997). There is a growing diabetes epidemic in sub-Saharan Africa, which is driven by rising levels of obesity, particularly among the affluent (Bailey *et al.*, 2016). Obesity is also an independent risk factor of colorectal cancer (Renehan *et al.*, 2008). We did not assess the effect of obesity on colorectal cancer in our study because of difficulties in estimating the pre-morbid body mass index in the cases. Our findings imply that the rising incidence of diabetes mellitus contribute to the rising incidence of colorectal cancer.

There was an association between having lived in an urban area at any point in life, and colorectal cancer in our study. Urbanisation in Africa is associated with dietary changes, particularly an increased intake of meat, meat products, and energy dense foods, with a reduction in the consumption of staple starches, and plant based foods (Vorser *et al.*, 2011). A high intake of meat and processed meat products is an established risk factor for colorectal cancer (Bouvard *et al.*, 2015). Urbanisation is also associated with sedentary lifestyle, which is independently associated with colorectal cancer (Wolin *et al.*, 2009).

The high frequency of relatively early-onset colorectal cancer in sub-Saharan African has consistently raised questions about the role of hereditary factors in this population (Cronje *et al.*, 2009). Specifically, it has been suggested that there is a higher than expected frequency of Lynch type syndromes. This is consistent with the high frequency of mismatch repair protein deficiency in colorectal cancers in the region, albeit in a limited number of studies (Cronje *et al.*, 2009). In our study, any cancer in first degree relatives was associated with a threefold increase in the risk of colorectal cancer. However, there was no association with colorectal cancer in first degree relatives, which could be due to the relatively small sample size. Molecular genetic studies are underway in our cohort to determine the frequency of common familial syndromes and their relationship to phenotype.

A surprise finding was the association of previous schistosomiasis with colorectal cancer. It is likely that the participants remembered *Schistosoma haematobium* infection rather than *Schistosoma mansoni*. However, it is reasonable to assume that they were exposed to both parasites, as co-infection is common in the endemic areas in Zimbabwe (Midzi *et al.*, 2014). Mechanistically, *S. mansoni*, which causes chronic colonic inflammation, is a more plausible cause of colorectal cancer than *S. haematobium*, which infests the bladder. While *S. haematobium* is an established cause of bladder cancer, the role of *S. mansoni* as a carcinogen is uncertain, due to lack of well-designed studies (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 1994). The frequency of schistosomiasis in patients with colorectal cancer in Egypt was comparable to the general population (Soliman *et al.*, 2001). Cases of concomitant colorectal cancer and schistosomiasis have been reported to be younger and more likely to have mucinous morphology, than those with colorectal cancer alone (Madbouly *et al.*, 2007). These studies were small, and not designed to substantiate an association between colorectal cancer and schistosomiasis. While our study has a well selected control group, this does not conclusively prove a causal relationship. Moreover, we could not confirm the prior schistosomiasis diagnosis in both cases and controls. Thus further studies, with more objective measures of exposure to schistosomiasis, are needed to corroborate our findings.

Our study has some limitations, which must be taken into account when interpreting the results. As stated earlier, the effect of obesity was not accounted for, and this could have magnified the impact of diabetes mellitus and urbanisation. It is also possible that the role of hereditary factors could simply reflect a clustering of cancers in families due to shared environmental factors. This was minimised by including most of the putative risk factors of colorectal cancer in the regression models. Case control studies have an inherent susceptibility to recall bias. This can be minimised by ensuring that data is obtained in the same way in both cases and controls. In our study, there was no reason to believe that cases had a heightened awareness of the potential risk factors of colorectal cancer. In addition, the questionnaire was structured in a way that made the recall as objective as possible. Although the interviewer was not blind to the status of each participant, there is little reason to suspect that this influenced data collection.

In conclusion, we have established the factors associated with colorectal cancer in an African population. Key among this is diabetes mellitus, which is a major contributor to the growing burden of non-communicable diseases in sub-Saharan Africa (Dalal *et al.*, 2011). Thus, primary prevention programmes against diabetes mellitus, principally targeting obesity, can have far reaching benefits. Our findings on the role of schistosomiasis require confirmation, but lend support for the intensification of existing eradication programs. The role of genetic susceptibility requires further characterisation using molecular genetic techniques. While population based colorectal cancer screening programs are not feasible in low income countries, our findings identify opportunities for targeted screening. These could potentially be offered to patients with type 2 diabetes mellitus, first degree relatives of patients with colorectal cancer and individuals with previous schistosomiasis.

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Fig. 1.
Flowchart outlining the participant recruitment process.

Table 1
Participant characteristics

Characteristics	Cases (n, %) (N=101)	Controls (n, %) (N=202)	P-value
Gender			
Males	51	102	
Females	50	100	
Mean age , years (S.D)	53.2 (14.9)	52.6 (14.6)	
Current Residence			
Urban	68	136	
Rural	33	66	
Education			
Primary	40 (39.6)	78 (38.6)	0.868
Secondary	28 (27.7)	96 (47.5)	0.001
Tertiary	33 (32.7)	28 (13.4)	0.000
Monthly income (USD)			
< 200	39 (38.6)	75 (37.1)	0.801
201-500	29 (28.7)	84 (41.6)	0.029
501-1000	14 (13.9)	29 (14.4)	0.907
>1000	19 (18.8)	14 (6.9)	0.002

Table 2
Univariate analysis of associations of colorectal cancer

Variable	Odds Ratio	95% CI	P value
Residence in Childhood			
Rural	1.0	-	-
Urban	0.9	0.5 – 1.6	0.648
Mixed	1.9	0.6 – 6.0	0.266
Residence in Adult life			
Rural	1.0	-	-
Urban	0.6	0.2 – 1.7	0.332
Mixed	0.8	0.3 – 2.0	0.568
Ever-lived in rural area	1.3	0.5 – 3.3	0.556
Ever-lived in an urban area	2.8	1.0 – 7.8	0.042
Ever lived abroad	0.7	0.36 – 1.4	0.288
Highest level of education			
Primary	1.0	-	-
Secondary	0.6	0.3 – 1.1	0.098
Tertiary	2.9	1.3 – 6.2	0.008
Currently employed	1.1	0.7 – 2.0	0.637
Monthly income (USD)			
<200	1.0	-	-
201-500	0.7	0.4 – 1.3	0.243
501-1000	1.0	0.4 – 2.5	0.999
>1000	3.2	1.2 – 8.5	0.019
Current alcohol use	0.7	0.4 - 1.2	0.158
Ever used alcohol	0.8	0.5– 1.4	0.509
Currently smokes	0.5	0.2-1.2	0.132
Ever smoked	0.9	0.5 -1.7	0.833
Diabetes Mellitus	3.5	1.2 – 10.3	0.025
HIV infection	0.9	0.4 – 2.0	0.821
Previous Schistosomiasis	2.4	1.4 – 4.2	0.001
NSAIDs use	1.3	0.5 – 3.2	0.627
Cancer in 1 st degree relatives	2.4	1.2 – 4.8	0.018
Colorectal cancer in 1 st degree relatives	1.5	0.1 – 25.5	0.090

Table 3
Independent associations of colorectal cancer after multi-variate analysis

Variable	Odds Ratio	95% CI	P value
Ever lived in town	3.6	1.1 – 12.2	0.036
Monthly income (USD)			
201- 500	0.6	0.3 – 1.3	0.165
501- 1000	0.6	0.2 - 1.7	0.291
> 1000	1.8	0.5 – 6.3	0.379
Highest level of education			
Secondary	0.5	0.2 - 1.2	0.111
Tertiary	1.6	0.6 – 4.3	0.320
Ever used alcohol	0.9	0.4 – 1.9	0.764
Ever smoked	0.8	0.4 – 1.9	0.693
Diabetes Mellitus	5.3	1.4 – 19.9	0.012
Previous schistosomiasis	2.3	1.3 – 4.3	0.006
Cancer in 1 st degree relatives	3.2	1.4 – 7.6	0.007