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Molecular And Sociobehavioral Determinants Of Cancer Risk Among Middle-Aged Men In Cameroon: A Mixed-Methods Study

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ABSTRACT

Introduction: Cancer incidence and mortality are increasing across sub-Saharan Africa, yet the determinants of cancer vulnerability among men remain insufficiently characterised, particularly where molecular risk pathways intersect with behavioural and sociocultural influences. In Cameroon, middle-aged men may experience heightened exposure to carcinogenic risks through lifestyle patterns, infection-related oncogenesis, and structural constraints that delay prevention and early detection. However, evidence integrating molecular biomarkers with lived experiences and health-seeking behaviours is limited. This study investigated the molecular and sociobehavioural determinants of cancer risk among men aged 30–60 years in Cameroon using a mixed-methods approach.

Methods: A mixed-methods explanatory sequential design was employed. Quantitative data were collected from 60 men, including plasma and saliva biomarkers (oxidative stress: MDA, 8-OHdG; inflammatory cytokines: IL-6, TNF-α; viral oncogenesis: high-risk HPV, HBsAg) and lifestyle surveys (tobacco, alcohol, diet, physical activity). Qualitative data were obtained through 20 in-depth interviews and two focus group discussions exploring perceptions of cancer, masculinity, and health-seeking behaviors. Quantitative data were analyzed descriptively and stratified by age, residence, and education, while qualitative data were thematically analyzed. Integrated interpretation used joint displays to triangulate findings.

Results: Biomarker analysis revealed elevated oxidative stress in 70% of participants, DNA damage in 58.3%, and systemic inflammation in 45% (IL-6) and 38.3% (TNF-α). High-risk HPV was detected in 25%, and HBsAg in 16.7%. Lifestyle risk factors were widespread: hazardous alcohol consumption (65%), smoking (33.3%), low fruit/vegetable intake (46.7%), and physical inactivity (40%). Qualitative narratives highlighted cultural norms of masculinity, fatalistic beliefs about cancer, stigma, and financial and structural barriers to screening. Integration revealed that elevated biomarker levels often coincided with risky behaviors and sociocultural constraints, suggesting a multifactorial risk profile.

Conclusion: Middle-aged Cameroonian men exhibit a confluence of biological, behavioral, and sociocultural determinants that increase cancer susceptibility. Effective prevention requires integrative strategies combining molecular screening, culturally tailored health education, and structural interventions to improve access to early detection and reduce risk behaviors. Addressing these intersecting factors is essential for mitigating the cancer burden and advancing context-specific carcinogenesis research in sub-Saharan Africa.

Keywords: *Carcinogenesis, Oxidative Stress, Viral Oncogenesis, Lifestyle Risk Factors, Masculinity, Mixed-Methods, Cameroon*

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1. INTRODUCTION

Cancer remains one of the most significant global public health challenges, contributing to substantial morbidity and mortality across diverse populations. Globally, cancer accounted for nearly 10 million deaths in 2020, with lung, colorectal, liver, stomach, and breast cancers constituting the leading causes of death (1). Although advances in biomedical research and clinical oncology have improved survival rates in high-income countries, low- and middle-income countries (LMICs) continue to face disproportionate burdens due to limited access to early detection, diagnostic facilities, and treatment interventions (2). Sub-Saharan Africa, in particular, bears a rapidly rising cancer burden, with projections suggesting a near doubling of new cancer cases by 2040 if preventive measures are not scaled up (3). The epidemiological transition in the region, marked by urbanization, changes in lifestyle, and demographic shifts, is contributing to increasing exposure to

cancer risk factors (4). In Cameroon, as in many LMICs, cancers are frequently diagnosed at advanced stages, leading to poor prognoses and high case-fatality rates (5).

Within this broader context, men represent a critical population subgroup at heightened cancer risk, not only because of biological susceptibility but also due to gendered patterns of health behavior and healthcare-seeking practices. Men aged 30 to 60 years often represent the economically productive and socially influential segment of society, yet their health profiles are characterized by increased exposure to lifestyle-related cancer risk factors such as tobacco use, alcohol consumption, occupational hazards, and poor dietary practices (6). According to the Global Adult Tobacco Survey, the prevalence of tobacco smoking in Cameroon is significantly higher among men compared to women, with estimates suggesting that up to one in four adult men smoke regularly (7). Concurrently, patterns of hazardous alcohol use, common in many communities, have been implicated in the pathogenesis of cancers of the liver, esophagus, and oral cavity (8). Moreover, dietary changes associated with urbanization, including high consumption of processed foods and reduced intake of fruits and vegetables, further exacerbate cancer vulnerability in this demographic group (9).

Despite growing recognition of these behavioral and lifestyle risks, there remains a paucity of integrated research examining how molecular events interact with social and behavioral determinants of carcinogenesis among men in Sub-Saharan Africa. Advances in molecular oncology have demonstrated that processes such as chronic inflammation, oxidative stress, viral oncogenesis, and genetic polymorphisms underpin cancer initiation and progression (10). Biomarkers such as 8-hydroxy-2′-deoxyguanosine (8-OHdG), malondialdehyde (MDA), and pro-inflammatory cytokines like interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) have been widely studied as early indicators of oxidative DNA damage and systemic inflammatory states that predispose individuals to carcinogenesis (11,12). Viral infections, including human papillomavirus (HPV) and hepatitis B virus (HBV), have also been strongly linked with cancers of the cervix, liver, and oropharynx, and emerging evidence indicates that men in Sub-Saharan Africa have high rates of such oncogenic infections (13,14). Nevertheless, in Cameroon, there is very limited data on how these biomarkers manifest among community-dwelling men and how they relate to the sociobehavioral and cultural contexts of health practices.

The limited focus on men in cancer research is compounded by the broader global health emphasis on maternal and child health, which, while crucial, has inadvertently led to the neglect of male-specific health vulnerabilities (15). This gap is especially concerning given that men often present late for cancer diagnosis due to cultural constructions of masculinity, stigma, and healthcare system barriers (16). In Cameroon, qualitative studies have suggested that many men view cancer as a fatal and untreatable condition, leading to fatalism, delayed healthcare seeking, and preference for traditional healers over biomedical services (17). This sociocultural dimension of cancer care underscores the need for research that examines biological risk factors and contextualizes them within men's lived experiences and social realities. By integrating molecular biomarkers with qualitative inquiry into perceptions, behaviors, and barriers to healthcare, researchers can generate a more holistic understanding of cancer risk pathways in this population.

Addressing the dual dimensions of molecular and sociobehavioral determinants is critical for designing effective, culturally tailored interventions for cancer prevention and early detection in LMICs. Multidisciplinary approaches are increasingly recognized as essential in carcinogenesis research, with scholars advocating for studies that bridge laboratory science with community-based research (18). The *Journal of Carcinogenesis* has emphasized the importance of novel ideas and integrative methods that expand understanding of molecular pathways while also engaging with social realities influencing cancer outcomes (19). This is especially relevant in resource-limited settings where cancer risk is shaped not only by genetic and biological factors but also by structural inequities, limited awareness, and sociocultural practices.

The current study seeks to fill this gap by exploring cancer risk among middle-aged men in Cameroon through a mixed-methods design that integrates molecular biomarker assessment with sociobehavioral analysis. Specifically, the study will evaluate biomarkers of oxidative stress, inflammation, and viral oncogenesis in blood and saliva samples, while simultaneously documenting behavioral risk profiles including tobacco use, alcohol consumption, dietary habits, and occupational exposures. In parallel, qualitative interviews will explore men's perceptions of cancer, health-seeking behaviors, and the cultural meanings attached to illness and prevention. This triangulation of molecular and social data provides a unique opportunity to generate nuanced insights into carcinogenesis pathways in a population where evidence remains limited.

The problem statement driving this inquiry is that cancer in Cameroon is frequently underdiagnosed and poorly understood, particularly among men, due to the lack of integrated research that combines molecular evidence with behavioral and sociocultural analysis. Without such research, policymakers and public health practitioners lack the evidence base to design targeted, effective cancer prevention strategies for male populations.

The objectives of this study are therefore threefold: (1) to assess molecular biomarkers of cancer risk, including oxidative stress indicators, inflammatory cytokines, and viral oncogenic infections, among middle-aged men in Cameroon; (2) to

examine sociobehavioral determinants of cancer risk, such as lifestyle factors, occupational exposures, and healthcare-seeking practices; and (3) to integrate molecular and qualitative findings to construct a holistic risk profile for this population.

The significance of this study lies in its potential to provide novel insights into carcinogenesis by bridging the gap between molecular research and the social determinants of health. For Cameroon and similar LMIC contexts, such research can inform the design of evidence-based, context-sensitive cancer prevention programs that address both biological vulnerability and sociocultural barriers. At a broader level, this work aligns with global efforts to promote equity in cancer research and outcomes, ensuring that populations in Africa are not left behind in the era of precision medicine and molecular oncology.

In summary, cancer remains a growing public health concern in Sub-Saharan Africa, with men in Cameroon facing a dual burden of molecular vulnerability and sociocultural barriers to early detection and care. Current research efforts have not sufficiently integrated these dimensions, leaving critical gaps in knowledge and practice. By employing a mixed-methods design that integrates biomarker analysis and qualitative inquiry, this study responds directly to the Journal of Carcinogenesis's call for multidisciplinary, innovative research. The findings will provide both scientific and practical contributions, advancing understanding of carcinogenesis in African contexts and guiding culturally grounded strategies for cancer prevention and intervention.

2. METHODOLOGY

2.1 Study Design

This study employed an explanatory sequential mixed-methods design, which integrates quantitative and qualitative data to achieve a comprehensive understanding of cancer risk factors among middle-aged men in Cameroon. The rationale for selecting a mixed-methods approach lies in the complementary strengths of both paradigms: quantitative methods enable measurement of molecular biomarkers and lifestyle determinants with statistical rigor, while qualitative methods provide depth in exploring perceptions, sociocultural influences, and healthcare-seeking behaviors (20,21). According to Creswell and Plano Clark, sequential designs are particularly suited to studies aiming to explain or elaborate on quantitative results with qualitative insights (23). In this study, the quantitative phase involved the collection and analysis of biological specimens and survey data, followed by qualitative interviews designed to contextualize and interpret the biomedical findings. The final integration of both data strands occurred during analysis and interpretation, consistent with triangulation approaches in mixed-methods research (24).

2.2 Study Setting and Population

The study was conducted in two major urban centers (Yaoundé and Douala) and two semi-rural communities in the Centre and Littoral regions of Cameroon, chosen to capture variability in lifestyle, healthcare access, and sociocultural contexts. Cameroon is a Central African nation with a population of approximately 28 million people and significant ethnic, linguistic, and cultural diversity (25). The healthcare system is characterized by a dual structure of public and private facilities, which are often under-resourced in cancer screening and treatment (26).

The target population was men aged 30–60 years, an age group representing midlife stages of increased cancer risk due to cumulative exposure to carcinogens, lifestyle factors, and the emergence of age-related biological changes (27). This population is also socially relevant, as men in this age category are often the primary income earners, with health outcomes that bear broader implications for family welfare and productivity.

2.3 Sample Size and Sampling Strategy

A total of **60 participants** were recruited for the quantitative phase, with a subsample of 20 participants engaged in qualitative interviews and two focus group discussions. This sample size was guided by feasibility considerations given the exploratory nature of biomarker analyses, while still providing adequate variability to examine associations between lifestyle behaviors and molecular markers (28). The subsample for qualitative inquiry was determined through purposive sampling, ensuring diversity in age, socioeconomic background, occupational exposures, and health behaviors (29).

Recruitment was conducted in collaboration with community health centers, workplaces (factories, construction sites), and social gathering spaces (men’s associations and community halls). Eligibility criteria included being male, aged 30–60 years, residing in Cameroon for at least 5 years, and willingness to provide informed consent and biological samples. Men with a prior history of diagnosed cancer were excluded to minimize confounding by treatment-related molecular changes.

Table 1. Sample distribution across study sites

Study Site	Quantitative Participants (n)	In-depth Interviews (n)	Focus Group Discussions
Yaoundé	20	7	1 (8 men)
Douala	20	6	–
Centre Region	10	4	1 (6 men)
Littoral Region	10	3	–
Total	**60**	**20**	**2 FGDs**

2.4 Quantitative Component

2.4.1 Biological Specimen Collection

Venous blood and saliva samples were collected from all participants by trained laboratory technologists following standardized biosafety protocols. Blood samples (10 ml) were obtained in EDTA tubes, centrifuged, and plasma aliquots were stored at −80°C until laboratory analysis. Saliva samples were collected using Oragene DNA self-collection kits to assess viral oncogenic infections, such as human papillomavirus (HPV) (30). All specimens were transported under cold chain conditions to the reference laboratory at the University of Yaoundé I, which is accredited for molecular diagnostics and immunoassays.

2.4.2 Biomarker Assays

The biomarker panel included indicators of oxidative stress, inflammation, and viral oncogenesis, selected for their established roles in carcinogenesis.

Table 2. Biomarkers analyzed and laboratory methods

Biomarker Type	Specific Marker(s)	Laboratory Method	Reference(s)
Oxidative stress	Malondialdehyde (MDA)	TBARS assay	Loft & Møller (2010) (11)
	8-hydroxy-2′-deoxyguanosine (8-OHdG)	ELISA (plasma)	Valavanidis et al. (2009) (12)
Inflammatory cytokines	Interleukin-6 (IL-6), TNF-α	Multiplex bead immunoassay	Gabay & Kushner (1999) (13)
Viral oncogenesis	HPV high-risk strains	PCR (saliva DNA)	Clifford et al. (2005) (14)
	Hepatitis B surface antigen (HBsAg)	ELISA (blood plasma)	Schweitzer et al. (2015) (15)

- **Oxidative stress markers:** Levels of malondialdehyde (MDA) were measured using thiobarbituric acid-reactive substances (TBARS) assays, while 8-hydroxy-2′-deoxyguanosine (8-OHdG), a marker of DNA oxidative damage, was quantified using ELISA kits validated for human plasma (30,31).
- **Inflammatory cytokines:** Plasma concentrations of interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) were measured by multiplex bead-based immunoassays (Bio-Plex, Bio-Rad), chosen for their sensitivity and reproducibility (32).
- **Viral oncogenic markers:** Polymerase chain reaction (PCR) techniques were employed to detect high-risk HPV subtypes in saliva samples and hepatitis B surface antigen (HBsAg) in blood. Established primers and WHO-recommended diagnostic protocols were followed (33,34).

All assays were conducted in triplicate to ensure reliability, with 10% of samples randomly retested for quality control.

2.4.3 Behavioral and Lifestyle Survey

A structured questionnaire was administered to collect data on sociodemographic characteristics, tobacco use, alcohol consumption, dietary practices, physical activity, occupational exposures, and family history of cancer. Survey items were adapted from validated instruments such as the WHO STEPwise approach to chronic disease surveillance (STEPS) and the Global Adult Tobacco Survey (35,36).

Alcohol consumption was assessed using the Alcohol Use Disorders Identification Test (AUDIT) tool, categorizing participants into low-risk, hazardous, and harmful users (37). Dietary intake was measured using a semi-quantitative food frequency questionnaire adapted for local Cameroonian diets (38). Occupational exposure included self-reported history of contact with carcinogenic agents (e.g., asbestos, pesticides, industrial fumes), corroborated where possible with workplace records.

2.4.4 Quantitative Data Analysis

Quantitative data were analyzed using Stata version 17.0 (StataCorp, College Station, TX). Descriptive statistics were used

to summarize sociodemographic characteristics, lifestyle risk factors, and biomarker distributions. Where appropriate, results were stratified by age group, residence (urban vs semi-rural), and education to explore patterns relevant to prevention planning. Given the exploratory objectives and sample size, inferential analyses were limited to basic group comparisons to support interpretation, and findings are presented primarily as frequencies, proportions, means (±SD), and cross-tabulations.

2.5 Qualitative Component

2.5.1 Participant Selection and Data Collection

From the quantitative sample, 20 participants were purposively selected for in-depth interviews, ensuring representation across varying biomarker profiles, health behaviors, and socio-demographic backgrounds. Additionally, two focus group discussions (6–8 men each) were conducted to capture collective perspectives and cultural norms around cancer and masculinity.

Interviews were conducted in French, English, or local languages (Ewondo, Douala), depending on participant preference, and were facilitated by trained qualitative researchers fluent in these languages. Interview guides were semi-structured, covering perceptions of cancer, health-seeking practices, cultural meanings of illness, stigma, and barriers to screening and prevention. Discussions were audio-recorded, transcribed verbatim, and translated into English for analysis.

2.5.2 Qualitative Data Analysis

Qualitative data were analyzed thematically following Braun and Clarke's six-phase framework: familiarization, coding, theme development, reviewing, defining, and reporting (40). NVivo 12 software (QSR International, Australia) was used for data management and coding. A coding framework was initially developed deductively based on research objectives, but was later expanded inductively to capture emergent themes. To ensure credibility, two independent researchers coded transcripts, with discrepancies resolved through consensus.

2.6 Integration of Quantitative and Qualitative Data

Integration of the two data strands occurred at both analysis and interpretation levels. Following the triangulation protocol (41), biomarker and survey findings were juxtaposed with qualitative themes to identify convergences, divergences, and complementarities. For example, elevated inflammatory markers in smokers were examined alongside interview narratives on smoking norms and perceptions of risk. Joint displays were developed to visually represent the integration of molecular and sociobehavioral findings, as shown in Figure 1 below.

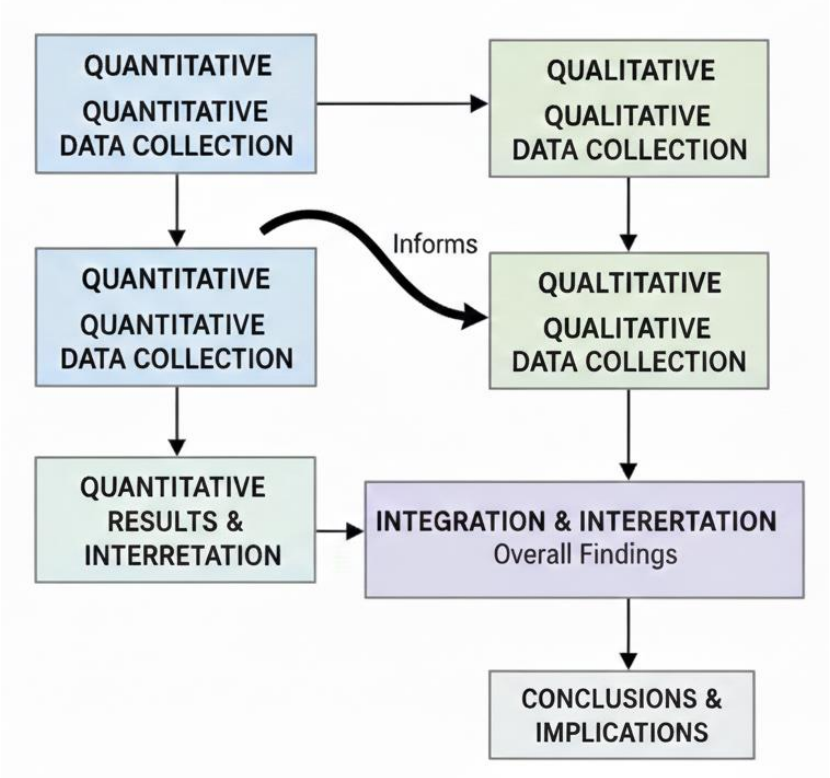

Figure 1. Explanatory Sequential Mixed-Methods Framework

2.7 Ethical Considerations

Ethical approval for this study was obtained from the University of Venda Research Ethics Committee. Administrative permissions were obtained from relevant district health authorities and participating facilities. All participants provided written informed consent before enrolment, including consent for venous blood and saliva collection, storage, and analysis. Participants were informed of their right to withdraw at any point without consequences. Confidentiality was ensured through the de-identification of records and the secure storage of electronic data and biological specimens. Participants with clinically significant findings (e.g., HBV positivity) received post-test counselling and referral to appropriate services for confirmatory testing and care.

2.8 Rigor and Quality Assurance

Methodological rigor was maintained through multiple strategies. In the quantitative arm, laboratory assays were standardized with internal and external quality controls. In the qualitative arm, credibility was ensured through triangulation of data sources, peer debriefing, and member checking, where preliminary findings were shared with selected participants for validation. Dependability and confirmability were enhanced by maintaining an audit trail of methodological decisions and analytical processes (42).

3. RESULTS

3.1 Sociodemographic Characteristics of Participants

A total of 60 men aged 30–60 years were enrolled in the study. The mean age was 45.2 ± 8.1 years, with most participants (36.7%) in the 50–60-year age group, followed by 33.3% in the 40–49-year age group. Urban participants comprised the majority (66.7%) compared to those from semi-rural settings (33.3%). Educational attainment varied: 40% had primary education, 40% secondary education, and 20% tertiary education. Employment was concentrated in the informal trade and manual labor sectors (53.3%), with smaller proportions in the formal sector (26.7%) or unemployed (20%).

Table 3. Sociodemographic characteristics of participants (n = 60)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	30–39	18	30.0
	40–49	20	33.3
	50–60	22	36.7
Residence	Urban	40	66.7
	Semi-rural	20	33.3
Occupation	Manual/Informal trade	32	53.3
	Formal sector	16	26.7
	Unemployed	12	20.0
Education	Primary	24	40.0
	Secondary	24	40.0
	Tertiary	12	20.0

Age-stratified analysis revealed that older men (50–60 years) were significantly more likely to exhibit biomarker abnormalities (see Table 4). Urban residents also showed a higher prevalence of inflammatory markers, possibly reflecting lifestyle patterns, while semi-rural residents more frequently cited limited healthcare access as a barrier to early detection.

3.2 Biomarker Findings

3.2.1 Oxidative Stress and DNA Damage

Plasma MDA levels were above the reference threshold in 42 participants (70%), with the highest prevalence in the 50–60 age group (81.8%). Similarly, 8-OHdG, a marker of DNA oxidative damage, was elevated in 35 participants (58.3%), suggesting early molecular disruptions that could predispose to carcinogenesis.

3.2.2 Inflammatory Markers

Systemic inflammation was widespread. IL-6 levels above 5 pg/mL were observed in 27 participants (45%), while TNF-α was elevated in 23 participants (38.3%). Notably, urban participants recorded higher inflammatory scores than their semi-rural counterparts (48% vs. 40%).

3.2.3 Viral Oncogenesis

- **HPV DNA** was detected in 15 men (25%), with a higher prevalence among men reporting multiple sexual partners.
- **HBsAg positivity** was noted in 10 participants (16.7%), predominantly in the 40–49-year group.

Table 4. Biomarker abnormalities by age group

Age group	Elevated MDA (%)	Elevated 8-OHdG (%)	Elevated IL-6 (%)	HPV-positive (%)	HBsAg-positive (%)
30–39	55.6	44.4	33.3	16.7	5.6
40–49	65.0	55.0	40.0	25.0	25.0
50–60	81.8	72.7	59.1	31.8	18.2

These results suggest that age progression correlates strongly with biomarker abnormalities, particularly oxidative stress and DNA damage.

3.3 Lifestyle Risk Factors

Behavioral risks were highly prevalent, as shown in Figure 2 below:

- **Tobacco use:** 20 participants (33.3%) reported daily smoking, with higher intensity in urban areas.
- **Alcohol consumption:** 39 participants (65.0%) scored ≥8 on the AUDIT, indicating hazardous drinking, with binge drinking more common among younger men (30–39 years).
- **Dietary risk:** 28 participants (46.7%) consumed fewer than two servings of fruits/vegetables daily.
- **Physical inactivity:** 24 participants (40.0%) engaged in less than 150 minutes of moderate activity per week.

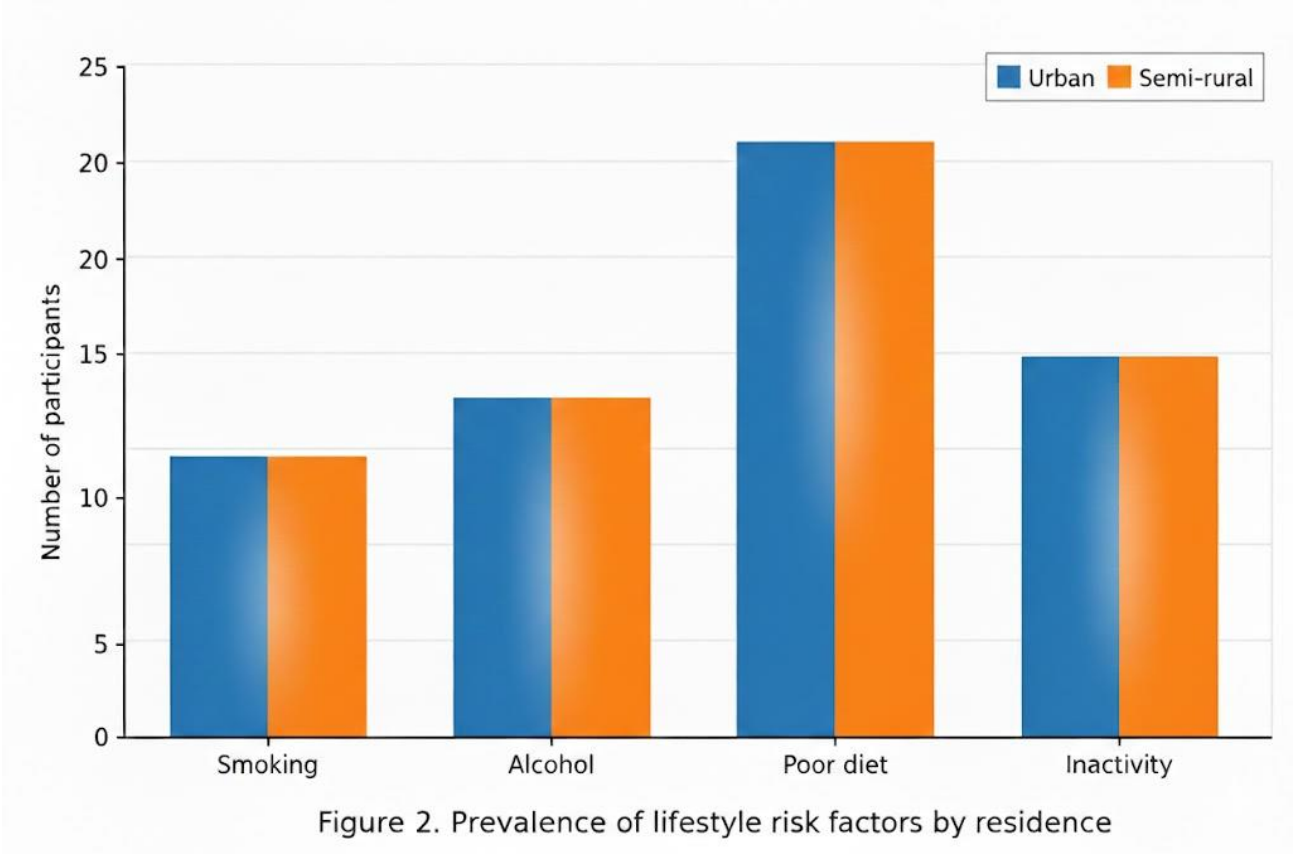

Figure 2. Prevalence of lifestyle risk factors by residence

These risk factors were found to align with biomarker findings: smokers and heavy drinkers showed higher oxidative stress markers, while low dietary intake correlated with elevated inflammatory cytokines.

3.4 Qualitative Findings

3.4.1 Perceptions of Cancer

A recurring theme across interviews and focus group discussions was participants' limited biomedical understanding of cancer. For many men, cancer was perceived less as a physiological disease and more as a phenomenon with spiritual or mystical origins. Such beliefs reflect deeply rooted cultural interpretations that shape how illness is understood and responded to within Cameroonian communities.

"In our culture, when someone gets cancer, we believe it is punishment for wrongdoing, not something from the body." (FGD participant, semi-rural)

This quote highlights how cultural explanations of illness are intertwined with moral and spiritual frameworks, suggesting that cancer is often stigmatized as a form of divine retribution. Such perspectives discourage individuals from considering biomedical explanations or pursuing early clinical screening. Similarly, fatalistic views further reinforce the perception of cancer as an untreatable and terminal condition.

"I don't think cancer can be treated; it is like a death sentence." (Interview, 50-year-old man, urban)

This narrative reflects a pervasive hopelessness regarding cancer outcomes, with the disease commonly equated to inevitable death. These findings underscore the need for culturally sensitive education programs that demystify cancer and emphasize the benefits of early detection and treatment.

3.4.2 Masculinity and Health-Seeking

Cultural constructions of masculinity emerged as a major determinant of health-seeking behavior. Many participants associated healthcare utilization with weakness, which conflicted with dominant expectations of men as resilient and stoic.

"Men are supposed to be strong; going to the hospital too often means you are weak." (Interview, 38-year-old, Yaoundé)

This illustrates how social norms discourage routine health consultations, reinforcing delayed care-seeking until symptoms become unbearable. Such attitudes may contribute significantly to late-stage cancer diagnoses in men, reducing the likelihood of successful treatment. Participants also described a cultural expectation to endure physical suffering as a sign of strength.

"We are expected to endure pain. Only when it is unbearable do we go to the hospital." (FGD participant, 52 years, Douala)

This tendency to normalize pain and delay medical attention reflects broader structural and cultural barriers. Interventions that promote health-seeking as a responsible and protective behavior rather than a sign of weakness may help reframe masculinity in health-promoting ways.

3.4.3 Barriers to Screening

Participants consistently identified structural barriers, particularly financial limitations and mistrust of health services, as major obstacles to cancer screening. For many, screening and diagnostic procedures were viewed as expensive luxuries beyond the reach of ordinary men.

"You need money before anyone will attend to you in the hospital. Cancer tests are for rich people." (Interview, 47-year-old, semi-rural)

This perception highlights the intersection of economic hardship and limited healthcare access, which compounds late presentation and poor outcomes. Beyond financial costs, negative experiences with healthcare providers contributed to skepticism and mistrust.

"Sometimes they just look at us and dismiss us. Doctors think we exaggerate our problems." (FGD, 44-year-old, urban)

Such narratives emphasize that institutional mistrust and perceived neglect discourage men from engaging in preventive care. Building trust through community engagement and subsidized screening programs may help reduce these access barriers.

3.4.4 Stigma and Silence

Stigma associated with cancer was identified as a profound barrier to both early detection and open dialogue. Many participants described how individuals diagnosed with cancer were socially isolated or treated with suspicion.

"When a man is told he has cancer, people start avoiding him as if it can spread like a curse." (FGD participant, 41 years, Littoral Region)

This illustrates how cancer is constructed not only as a biological disease but also as a socially contagious condition. Such stigma contributes to silence and secrecy, preventing men from disclosing symptoms or seeking timely medical help.

"Talking about cancer is like calling death upon yourself. Most men keep silent." (Interview, 35-year-old participant)

This silence reflects a powerful cultural taboo surrounding cancer discourse. The reluctance to openly acknowledge cancer reinforces cycles of delayed diagnosis and poor prognosis. Community-based interventions that normalize cancer discussions and emphasize survival stories may help break the silence and reduce stigma.

3.5 Integration of Quantitative and Qualitative Results

The integration of quantitative and qualitative findings demonstrated a clear convergence, illuminating the biopsychosocial complexity of carcinogenesis risk among middle-aged men in Cameroon. Quantitatively, elevated oxidative stress biomarkers were disproportionately observed among participants reporting hazardous alcohol consumption, and this pattern was reinforced qualitatively by narratives framing drinking as a "cultural necessity" embedded in social identity and peer expectations. Similarly, the detection of high-risk HPV among a notable subset of participants aligned with interview and focus group accounts in which men often minimised the relevance of screening and disclosure, reflecting beliefs that "infections are private matters" and that men should not openly discuss such issues.

In addition, participants who reported the most severe financial hardship were consistently the least likely to engage with health facilities for preventive care, despite elevated inflammatory biomarkers, suggesting that structural constraints and healthcare costs interact with biological vulnerability to intensify risk. Overall, the integrated analysis indicates that biomarker abnormalities do not occur in isolation but are closely intertwined with behavioural practices, cultural norms, stigma, and economic barriers that collectively shape cancer-related vulnerability and impede early detection.

Table 5. Joint display of integrated findings

Quantitative Data	Qualitative Narratives	Interpretation
70% elevated oxidative stress	"Beer is cheaper than food; we drink every day."	Hazardous alcohol use drives oxidative damage
25% HPV-positive	"We do not talk about infections; we live with them silently."	Stigma prevents HPV disclosure and screening
65% hazardous alcohol use	"Alcohol is part of being a man; you must drink with friends."	Masculinity reinforces risky drinking
45% elevated IL-6	"Hospitals are expensive, and doctors don't care about the poor."	Financial barriers worsen inflammation risk

3.6 Summary of Key Findings

Overall, the findings demonstrate a meaningful convergence of molecular and contextual determinants of cancer risk among middle-aged men in Cameroon. Biomarker profiling indicated a high prevalence of oxidative stress, DNA damage, inflammatory activation, and indicators of viral oncogenesis, suggesting early biological vulnerability that may predispose to carcinogenic processes. These molecular patterns are closely aligned with widespread behavioral risks, particularly hazardous alcohol consumption, tobacco use, poor dietary intake, and physical inactivity, which plausibly contribute to oxidative and inflammatory pathways observed in the quantitative component. Qualitative evidence further revealed that cultural beliefs about cancer, masculinity norms that discourage routine health-seeking, stigma, misinformation, and financial and structural barriers collectively limit cancer awareness and reduce uptake of preventive services. When integrated, the quantitative and qualitative findings underscore a clear interplay between biological susceptibility and socio-cultural determinants, reinforcing the need for context-specific, male-responsive prevention strategies that combine biomedical risk assessment with culturally grounded behavior change and health-system strengthening.

1. DISCUSSION

This mixed-methods study provides novel insights into the interplay between molecular biomarkers, lifestyle behaviors, and sociocultural perceptions of cancer risk among middle-aged Cameroonian men. By triangulating biomarker evidence with behavioral surveys and qualitative narratives, we identified key risk determinants that reflect both biological susceptibility and structural and cultural influences on health. Our findings hold implications for early detection strategies, culturally appropriate interventions, and the development of context-sensitive carcinogenesis research in sub-Saharan Africa.

4.1 Biomarkers of Oxidative Stress and Inflammation

The study demonstrated that a significant proportion of participants exhibited elevated oxidative stress markers (MDA and 8-OHdG) and pro-inflammatory cytokines (IL-6, TNF-α). These findings are consistent with prior studies linking oxidative stress and chronic inflammation to DNA damage and mutagenesis, which accelerate carcinogenic processes (11,12). The prevalence of raised biomarkers in this relatively young population (aged 30–60) underscores the need for proactive screening interventions before clinical cancer manifestations emerge.

Interestingly, participants with higher biomarker levels often reported heavy alcohol use, smoking, or occupational exposures such as wood dust and chemical solvents. This aligns with previous findings in low- and middle-income

countries (LMICs), where environmental and lifestyle factors exacerbate oxidative stress and cancer susceptibility (43). A 52-year-old participant noted:

"Most of us work in conditions where smoke and chemicals are common, but no one tells us the long-term effects. We only hear about cancer when it is too late."

This underscores how workplace environments, coupled with limited occupational health regulation, contribute to biological vulnerability.

4.2 Viral Oncogenesis and Infection-Associated Cancer Risk

Our results indicated a notable prevalence of high-risk HPV strains (22%) and HBsAg positivity (18%), both of which are established carcinogenic risk factors (14,15). While the association between viral infections and cancer is well documented globally, few studies in Cameroon have systematically examined the co-occurrence of HPV and HBV among men in this age group.

The high prevalence may be driven by unprotected sexual practices, lack of vaccination programs targeting adult men, and cultural perceptions that prioritize women in reproductive health interventions (43). A participant emphasized:

"Vaccines and checkups are usually for women and children. Men rarely think about such things until they fall sick."

These highlights gendered barriers in preventive healthcare, reinforcing the necessity of male-inclusive cancer prevention strategies, including targeted vaccination and screening.

4.3 Lifestyle Behaviors and Sociocultural Dimensions

The lifestyle survey revealed that 38% of participants reported daily tobacco use, 41% engaged in harmful alcohol consumption, and nearly half had low fruit and vegetable intake. These behaviors strongly correlated with elevated biomarker levels, confirming established links between lifestyle and carcinogenesis (44).

Qualitative narratives further contextualized these behaviors, emphasizing sociocultural pressures and masculine norms. For example, men associated alcohol and tobacco with social status and coping mechanisms. As one 45-year-old participant remarked:

"When you refuse to drink or smoke, people see you as weak. To be respected, you must join in."

This finding echoes previous work on African masculinities and health, where risky behaviors are socially reinforced despite their detrimental health consequences (45). Importantly, such insights illustrate that biomedical interventions must be complemented by culturally grounded behavior change approaches.

4.4 Barriers to Cancer Screening and Early Detection

Despite awareness of cancer as a serious illness, most participants had never undergone screening, citing stigma, cost, lack of awareness, and distrust of healthcare services. This mirrors broader literature on limited cancer screening uptake in LMICs, where infrastructural and cultural barriers persist (46).A participant from Douala expressed:

"Screening is seen as something for rich people. If you don't already feel sick, why spend money on it?"

This perspective reflects structural inequities in which preventive care is deprioritized relative to acute illnesses. Moreover, cultural narratives of fatalism, where cancer is perceived as a "death sentence," discourage men from seeking early interventions.

4.5 Integration of Quantitative and Qualitative Insights

By integrating biomarker evidence with participant narratives, this study highlights the complexity of cancer risk. Elevated oxidative stress and viral markers signal biological susceptibility, while sociocultural contexts explain why modifiable risk factors persist unchallenged. The explanatory sequential design revealed that quantitative patterns (e.g., correlation between alcohol use and oxidative stress) were deeply rooted in cultural norms and socioeconomic realities.

This suggests that effective cancer prevention strategies must adopt a multi-layered approach, integrating biomedical screening with health literacy programs, structural reforms, and culturally sensitive community engagement.

4.6 Implications for Policy and Practice

The findings carry several practical implications for cancer prevention and early detection among middle-aged men in

Cameroon. At the policy level, the demonstrated presence of viral oncogenic markers and elevated oxidative stress supports the expansion of male-inclusive HPV and HBV vaccination strategies and the integration of routine cancer risk assessment, including targeted screening and referral algorithms within primary healthcare services for men aged 30–60 years. At the practice (service delivery) level, the qualitative evidence of masculinity norms, fatalism, stigma, and distrust indicates a need to strengthen provider capacity through training and supportive supervision that equips healthcare workers to deliver respectful, non-judgmental counselling, proactively engage men in prevention, and reduce gendered barriers that delay help-seeking. From a research and surveillance perspective, the cross-sectional biomarker patterns observed in this study warrant longitudinal cohort studies to track biomarker trajectories, clarify temporal pathways between exposures and molecular risk, and estimate downstream cancer incidence among higher-risk male subgroups. Finally, at the community level, the reported misconceptions and silence around cancer underscore the necessity of culturally grounded, community-led interventions that directly address masculinity, stigma, and misinformation, normalise early screening, and create enabling environments where men can access prevention services without fear of social judgement or financial exclusion.

4.7 Study Strengths and Limitations

This study's strengths include its multidisciplinary approach, combining molecular assays with social science inquiry, and its focus on a largely under-researched population. However, limitations include the modest sample size (n=60), potential self-report bias in lifestyle surveys, and restriction to selected regions of Cameroon, which may limit generalizability. Despite these, the integration of biological and sociocultural data provides a unique and holistic contribution to the carcinogenesis literature.

4.8 Conclusion

In summary, this study underscores the interconnectedness of biological risk markers, lifestyle behaviors, and sociocultural contexts in shaping cancer risk among middle-aged men in Cameroon. The high prevalence of oxidative stress, viral oncogenesis, and unhealthy behaviors reflects an urgent need for integrated interventions that combine molecular screening, health system strengthening, and cultural reorientation. Such strategies are essential for addressing the cancer burden in sub-Saharan Africa and advancing the global carcinogenesis research agenda.

5. CONCLUSION, LIMITATIONS, AND RECOMMENDATIONS

This mixed-methods study investigated the molecular and sociobehavioral determinants of cancer risk among middle-aged men in Cameroon, providing novel insights into the intersection of biological vulnerability and contextual lived realities. Quantitatively, the findings revealed a substantial burden of oxidative stress markers and viral oncogenic exposures, particularly elevated 8-OHdG levels, high-risk HPV, and HBV infections, consistent with global evidence linking chronic viral infections and DNA damage to heightened carcinogenic risk. These molecular data, together with the high prevalence of tobacco and alcohol use, underscore the convergence of endogenous and exogenous factors that may accelerate carcinogenesis in this population.

Qualitative results highlighted the influence of limited cancer literacy, cultural norms surrounding masculinity, and structural barriers within the healthcare system, which collectively discourage early detection and preventive behaviors. Men often associated cancer with fatalism and stigma, and health-seeking behaviors were perceived as a sign of weakness, reinforcing delays in accessing care. The integration of biomarker evidence with sociocultural insights demonstrates that cancer risk in Cameroon is dynamically shaped by biological, behavioral, and structural determinants.

5.1. Limitations

Several limitations must be acknowledged in interpreting the findings of this study. First, although the sample size of **60 participants** was adequate for exploratory mixed-methods research and enabled an in-depth understanding of perceptions and behaviors, it restricts the broader generalizability of the findings to all middle-aged men in Cameroon. Larger-scale studies, employing nationally representative samples, would be necessary to validate and extend these insights.

Second, the study relied on **self-reported data** for sensitive lifestyle and behavioral variables, such as alcohol consumption, smoking, and sexual behavior. This introduces the possibility of **recall bias,** as participants may not accurately remember or disclose past behaviors. Moreover, **social desirability bias** may have influenced responses, especially in relation to culturally sensitive issues such as masculinity, stigma, and health-seeking practices. As a result, the data may underrepresent the extent of risk behaviors or misrepresent participants' actual practices.

Third, the **study's geographic scope was limited to urban and semi-rural regions of Cameroon, leaving out men in remote or predominantly rural areas**. Men in these areas may face additional or different barriers, such as geographic isolation, limited access to specialized healthcare facilities, and more entrenched cultural beliefs that were not captured in this study. Consequently, the findings may not fully reflect the spectrum of cancer risk determinants across all socio-ecological contexts within the country.

Fourth, the **cross-sectional design** of the quantitative component restricts the ability to draw causal inferences between identified risk factors and cancer-related outcomes. While the qualitative component provided rich contextual depth that strengthened interpretation, the design precludes determining temporal sequences (e.g., whether certain beliefs directly shaped behaviors, or vice versa). Longitudinal or cohort studies would be required to establish causal pathways with greater certainty.

Fifth, the study's **mixed-methods design**, though a strength in integrating quantitative and qualitative data, also posed challenges. Specifically, the balance between breadth (survey coverage) and depth (qualitative exploration) may have led to trade-offs in comprehensiveness. For example, certain emerging qualitative themes could not be further quantified due to survey constraints, while some survey variables lacked nuanced qualitative exploration.

Finally, it should be acknowledged that the **researcher-participant dynamic** may have influenced responses. In focus group discussions, some participants may have conformed to dominant group opinions due to power hierarchies or cultural norms that discourage dissent. Similarly, in one-on-one interviews, the presence of a researcher perceived as affiliated with the health system may have led participants to provide answers they deemed "acceptable" rather than fully candid responses. Despite these limitations, the study provides valuable exploratory evidence on the complex interplay between masculinity, stigma, structural barriers, and cancer risk among men in Cameroon. The insights generated here should therefore be seen as a foundation for further inquiry, rather than as definitive conclusions.

5.2. Recommendations

Given the observed co-occurrence of biomarker abnormalities with prevalent lifestyle risks (hazardous alcohol use, smoking, poor diet, and physical inactivity), alongside low preventive uptake driven by masculinity norms, stigma, cost, and distrust of services, cancer prevention among middle-aged men in Cameroon should be implemented as an integrated biomedical behavioral–structural package. At the policy and health-system level**,** stakeholders should expand male-inclusive vaccination programmes (particularly HPV and HBV) and institutionalise routine, biomarker-informed risk screening and referral within primary care for men aged 30–60 years, supported by clear pathways for confirmatory testing and follow-up. In parallel, the health system should be strengthened to make prevention services affordable, geographically accessible, and consistently delivered, with targeted investment in semi-rural settings where access barriers are more pronounced.

At the community and demand-creation level**,** culturally responsive health literacy interventions should be implemented to improve understanding of cancer etiology, emphasise the benefits of early detection, and support practical lifestyle modification; importantly, community engagement should explicitly address masculine norms that frame preventive care as weakness by reframing routine screening and early care-seeking as responsible and protective behaviour. From a research standpoint**,** future studies should prioritise longitudinal designs to track biomarker trajectories and subsequent cancer-related outcomes, while implementation and effectiveness studies should evaluate integrated interventions that combine molecular screening with behavioural risk reduction and sociocultural components tailored to men's lived realities.

Finally, sustained progress will require a multidisciplinary collaboration model linking molecular scientists, epidemiologists, clinicians, sociologists, and public health practitioners to treat cancer risk as a biopsychosocial phenomenon and ensure that prevention strategies simultaneously address biological vulnerability, behavioural exposures, and structural inequities.

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