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# Spatial Epidemiology of Cancer Prevalence and Associated Risk Factors in Southern Libya: A Retrospective Study

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***Index Terms***

Cancer epidemiology, Cancer prevalence, Risk factors, Southern Libya, Spatial epidemiology, Public health, Early detection.

***Abstract***

Cancer represents a growing public health challenge in Libya, particularly in Southern Libya, where epidemiological evidence remains limited. This study investigated the prevalence of cancer and the demographic, behavioral, environmental, healthcare, and awareness-related factors associated with cancer occurrence. Methods: A descriptive analytical retrospective epidemiological design was employed. Secondary data were obtained from the Sebha Oncology Center covering cancer cases registered between 2016 and 2022, while primary data were collected through a structured questionnaire administered to 55 cancer patients. Data were analyzed using SPSS through descriptive statistics and one-sample t-tests. Results: A total of 1,500 cancer cases were analyzed. Females accounted for 61.0% of patients, and individuals aged 40 years or older represented the majority of cases. Breast cancer was the most common malignancy (35.5%), followed by prostate cancer (12.1%), colorectal cancer (11.5%), and leukemia (10.9%). Sebha municipality contributed 52.2% of registered cases. Environmental and occupational exposures achieved the highest questionnaire mean (M = 3.91), followed by behavioral and lifestyle factors (M = 3.84). All questionnaire dimensions were significantly higher than the theoretical mean ($p < 0.001$), indicating that respondents perceived these factors as important contributors to cancer prevalence. Conclusions: Cancer prevalence in Southern Libya is influenced by multiple interacting demographic, behavioral, environmental, healthcare, and awareness-related factors. Strengthening cancer surveillance systems, expanding early detection programs, improving access to oncology services, and implementing comprehensive prevention strategies are essential for reducing the regional cancer burden.

# الوبائيات المكانية لانتشار السرطان وعوامل الخطورة المرتبطة به في جنوب ليبيا: دراسة استعادية

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**الكلمات المفتاحية**

وبائيات السرطان، انتشار السرطان، عوامل الخطورة، جنوب ليبيا، الوبائيات المكانية، الصحة العامة، الكشف المبكر.

**الملخص**

يُعد السرطان من أبرز التحديات الصحية العامة في ليبيا، ولا سيما في المنطقة الجنوبية التي ما تزال تعاني من محدودية الأدلة الوبائية. هدفت هذه الدراسة إلى تحليل أنماط انتشار السرطان وتحديد العوامل الديموغرافية والسلوكية والبيئية والصحية المرتبطة به في جنوب ليبيا. المنهجية: اعتمدت الدراسة المنهج الوصفي التحليلي الوبائي بأثر رجعي، بالاعتماد على بيانات السجلات الطبية لمركز سبها للأورام للحالات المسجلة خلال الفترة (2016–2022)، بالإضافة إلى استبانة وُزعت على (55) مريضًا بالسرطان. وتم تحليل البيانات باستخدام برنامج SPSS من خلال الإحصاءات الوصفية واختبار (One-Sample t-test). النتائج: شملت الدراسة (1500) حالة سرطان، حيث شكّلت الإناث (61.0%) من إجمالي الحالات، بينما مثّل الأشخاص الذين تبلغ أعمارهم (40 سنة فأكثر) النسبة

الأكبر من المرضى. وتصدر سرطان الثدي أنواع السرطان بنسبة (35.5%)، يليه سرطان البروستاتا (12.1%)، ثم سرطان القولون والمستقيم (11.5%)، وسرطان الدم (10.9%). كما استحوذت بلدية سبها على (52.2%) من إجمالي الحالات المسجلة. وأظهرت نتائج الاستبانة أن التعرضات البيئية والمهنية كانت أكثر العوامل إدراكًا لدى المرضى (3.91)، تلتها العوامل السلوكية ونمط الحياة (3.84). وأثبتت الاختبارات الإحصائية أن جميع الأبعاد جاءت أعلى من المتوسط الفرضي بدرجة دالة إحصائيًا ($p < 0.001$). الاستنتاج: تؤكد الدراسة أن انتشار السرطان في جنوب ليبيا يتأثر بمجموعة مترابطة من العوامل الديموغرافية والسلوكية والبيئية والصحية. وتبرز الحاجة إلى تطوير نظام وطني لتسجيل السرطان، وتعزيز برامج الكشف المبكر، وتحسين الخدمات العلاجية، وتبني سياسات وقائية شاملة تستند إلى الأدلة العلمية من أجل الحد من العبء المتزايد للسرطان في ليبيا.

## 1. INTRODUCTION

Cancer remains one of the leading causes of morbidity and premature mortality worldwide and continues to impose an escalating burden on healthcare systems, particularly in low- and middle-income countries. According to recent global estimates, approximately 19.3 million new cancer cases and nearly 10 million cancer-related deaths occurred in 2020, with projections indicating a substantial increase over the coming decades due to population aging, demographic transition, urbanization, and the growing prevalence of modifiable risk factors such as tobacco use, unhealthy diet, obesity, physical inactivity, and environmental exposures (Sung et al., 2021). These trends underscore the need for continuous epidemiological surveillance to support evidence-based cancer prevention and control strategies. Spatial epidemiology has emerged as an important discipline within cancer research by examining geographical variations in disease occurrence and identifying regional differences in prevalence and associated risk factors. Understanding these spatial patterns enables researchers and policymakers to recognize populations at greater risk, explore demographic, behavioral, environmental, and healthcare-related determinants of cancer, and improve the allocation of healthcare resources. Rather than focusing solely on disease frequency, spatial epidemiology provides insights into how place, population characteristics, and health system accessibility interact to influence cancer burden across different regions (Musa et al., 2023). In Libya, cancer has become an increasingly important public health concern. However, epidemiological evidence remains fragmented because of the absence of a comprehensive national population-based cancer registry and the reliance on hospital-based reporting systems. Consequently, considerable uncertainty persists regarding the true distribution of cancer across different regions of the country, particularly in the southern provinces, where healthcare services are geographically dispersed and specialized oncology facilities remain limited. Southern Libya is characterized by unique demographic, environmental, and socioeconomic conditions that may influence both cancer occurrence and patterns of diagnosis. Despite these distinctive characteristics, epidemiological investigations conducted in this region remain scarce, limiting the availability of reliable evidence to guide regional cancer control policies (Gusbi et al., 2021). The scarcity of epidemiological data from southern Libya has created a significant knowledge gap regarding the prevalence of different cancer types and the factors associated with their occurrence. Most available studies have concentrated on reporting incidence rates without comprehensively examining the relationships between demographic characteristics, behavioral risk factors, healthcare accessibility, and cancer prevalence.

Generating region-specific epidemiological evidence is therefore essential for understanding the burden of cancer within southern Libya and for supporting targeted prevention, early detection, and healthcare planning. Accordingly, this retrospective study aims to investigate the epidemiological patterns of cancer prevalence in southern Libya and identify the demographic, behavioral, environmental, and healthcare-related factors associated with the disease. By providing updated epidemiological evidence from one of the least studied regions in Libya, the findings are expected to contribute to improving regional cancer surveillance and supporting evidence-based public health interventions aimed at reducing the burden of cancer.

## 2. PROBLEM STATEMENT

Cancer represents a growing public health challenge in Libya, particularly in the southern region, where epidemiological evidence remains limited due to the absence of a comprehensive national cancer registry and the heavy reliance on hospital-based records. Variations in demographic characteristics, behavioral factors, environmental and occupational exposures, accessibility to healthcare services, and public awareness of early detection may contribute to differences in cancer prevalence across the region. Despite the increasing burden of cancer, comprehensive epidemiological evidence describing these associated factors in southern Libya remains scarce. Therefore, there is a pressing need for a retrospective epidemiological study to investigate cancer prevalence and its associated factors in southern Libya in order to provide scientific evidence that can support healthcare planning, cancer prevention strategies, and evidence-based decision-making.

## 3. RESEARCH QUESTIONS

1. What are the epidemiological and demographic characteristics of cancer patients in Southern Libya?
2. What is the relationship between behavioral and lifestyle factors and cancer prevalence?
3. What is the effect of environmental and occupational exposures on cancer prevalence?
4. What is the relationship between access to healthcare services and cancer diagnosis patterns?

5. What is the role of health awareness and early detection in reducing cancer burden and improving early diagnosis?

## 4. Research Hypotheses

H0: There is no statistically significant difference between the respondents' mean scores regarding the factors associated with cancer prevalence and the theoretical mean of the five-point Likert scale (3.00).

H1: The respondents' mean scores regarding the factors associated with cancer prevalence are significantly higher than the theoretical mean (3.00), indicating that these factors are perceived as important contributors to cancer prevalence in Southern Libya.

## 5. Study Objectives

- To describe the demographic and clinical characteristics of cancer patients
- To examine the influence of behavioral and lifestyle factors on cancer prevalence
- To assess the role of environmental and occupational exposures associated with cancer.
- To evaluate the impact of access to healthcare services on cancer diagnosis.
- To investigate the role of health awareness and early detection in reducing the burden of cancer.

## 6. Significance of the Study Scientific Significance

1. To enrich the epidemiological literature on cancer in Libya, particularly in Southern Libya.
2. To provide updated evidence regarding the factors associated with cancer prevalence.
3. To contribute to future epidemiological research focusing on modifiable cancer risk factors. Practical Significance
4. To support healthcare policymakers in developing effective cancer control strategies.
5. To strengthen cancer awareness and early detection programs.
6. To improve healthcare resource allocation based on population needs.
7. To provide evidence that supports preventive interventions targeting major cancer risk factors.

## 7. Study Limitations

awareness and early detection

- Spatial Limitation: The study is limited to cancer patients registered at the Sebha Oncology Center who reside in Southern Libya.
- Temporal Limitation: The study covers cancer cases diagnosed and registered between 2016 and 2022.
- Population Limitation: The study is limited to medically diagnosed cancer patients who agreed to participate.
- Subject Limitation: The study focuses on cancer prevalence and its associated factors, including: - Demographic characteristics - Behavioral and lifestyle factors - Environmental and occupational exposures - Access to healthcare services - Health
- Methodological Limitation: The study adopts a descriptive analytical retrospective epidemiological design, with data analyzed using the Statistical Package for the Social Sciences (SPSS).

## 8. Operational Definitions

- Cancer Prevalence: Cancer prevalence refers to the number of diagnosed cancer patients registered at the Sebha Oncology Center during the study period and measured using hospital records and the structured questionnaire (WHO, 2023).
- Behavioral Factors: Behavioral factors refer to pre-diagnosis lifestyle characteristics, including smoking, physical inactivity, unhealthy dietary habits, and obesity, as measured by the first section of the questionnaire.
- Environmental and Occupational Exposures: Environmental and occupational exposures refer to long-term exposure to environmental pollutants, hazardous chemicals, or occupations involving carcinogenic risks before cancer diagnosis, as measured by the environmental exposure section of the questionnaire.
- Access to Healthcare Services: Access to healthcare services refers to patients' ability to obtain timely diagnostic and treatment services, measured using the healthcare services section of the questionnaire.
- Health Awareness and Early Detection: Health awareness and early detection refer to participants' knowledge of cancer symptoms and the importance of early screening before diagnosis, measured using the health awareness section of the questionnaire.
- Retrospective Epidemiological Study: A retrospective epidemiological study is an observational research design that examines previously collected medical records and historical data to identify disease patterns and associated risk factors without manipulating study variables (Sung et al., 2021).

## 9. Previous Studies

Sung et al. (2021) conducted one of the most comprehensive global epidemiological investigations of cancer through the GLOBOCAN 2020 database, covering 185 countries and 36 cancer types. The study aimed to estimate global cancer incidence and mortality and identify geographical variations in cancer burden. Using standardized epidemiological data and population-based cancer registries, the authors demonstrated that breast,

colorectal, lung, prostate, and stomach cancers accounted for the largest proportion of newly diagnosed cases worldwide. The findings further revealed that demographic transition, population ageing, tobacco use, obesity, unhealthy dietary habits, and environmental exposures are among the principal determinants contributing to the increasing global burden of cancer. The study emphasized the necessity of strengthening national cancer surveillance systems and improving early detection strategies, particularly in low- and middle-income countries where cancer registration remains incomplete. These findings provide an important epidemiological framework for investigating cancer prevalence and associated risk factors in Southern Libya. Zarmouh et al. (2022) focused on estimating cancer incidence in the middle region of Libya using data collected from the Misurata Cancer Epidemiology Study. The researchers employed a retrospective observational design by reviewing pathology reports, radiological records, and hospital registries from public and private healthcare facilities. The study demonstrated that breast cancer and colorectal cancer represented the most prevalent malignancies, followed by lung and prostate cancers. Furthermore, the authors highlighted the absence of an integrated national cancer registry and concluded that incomplete documentation and fragmented reporting systems substantially underestimate the actual cancer burden in Libya. The study recommended establishing comprehensive regional cancer registries to support evidence-based planning and improve oncology services throughout the country. These findings are highly relevant to the current study because they underline the importance of generating epidemiological evidence from underrepresented regions such as Southern Libya. Atia et al. (2025) carried out a systematic literature review to synthesize available evidence regarding cancer prevalence in Libya. The review searched major scientific databases, including PubMed, Google Scholar, and other indexed sources, covering studies published between 2006 and 2022. The review demonstrated considerable regional disparities in cancer reporting and showed that breast cancer remains the most common malignancy among women, whereas lung and colorectal cancers predominate among men. The authors further reported that most epidemiological evidence originates from eastern Libya, while western and southern regions remain substantially underrepresented. Consequently, they emphasized the urgent need for region-specific epidemiological investigations capable of identifying local determinants of cancer prevalence and supporting healthcare policy development. This systematic review provides strong justification for conducting retrospective epidemiological research in Southern Libya. Abdalla et al. (2025) investigated the prevalence of different cancer types using patient records from the Misrata Oncology Centre between 2018 and 2022. Employing a retrospective descriptive design, the researchers analyzed hospital records to determine the frequency and distribution of major malignancies. Their findings confirmed that breast cancer, colorectal cancer, lung cancer, lymphoma, ovarian cancer, and prostate cancer constituted the majority of diagnosed cases. The study emphasized that retrospective hospital-based analyses provide valuable epidemiological evidence in countries where population-based cancer registries are unavailable. Moreover, the authors stressed that identifying local prevalence patterns is essential for improving screening programs, allocating healthcare resources, and enhancing cancer prevention strategies. These conclusions reinforce the rationale for undertaking similar epidemiological analyses in Southern Libya, where comparable evidence remains scarce. El-Mogassabi et al. (2025) conducted a comprehensive scoping review to evaluate the current status of colorectal cancer (CRC) research in Libya and to identify existing scientific gaps that hinder evidence-based cancer control. Following the PRISMA-ScR framework, the authors systematically reviewed 42 peer-reviewed studies published between 1993 and 2024. The review demonstrated that most Libyan CRC studies were retrospective and hospital-based and were geographically concentrated in Benghazi, Tripoli, and Misrata, while southern Libya remained substantially underrepresented. Furthermore, the review revealed that most studies focused on descriptive epidemiology, with limited investigation of tumor characteristics, treatment outcomes, environmental exposures, or behavioral risk factors. The authors emphasized the urgent need for comprehensive epidemiological studies covering underserved regions and supported by a national cancer registry. This review strongly supports the rationale of the present study, which specifically investigates cancer prevalence and associated factors in Southern Libya. Ashleik et al. (2025) performed a meta-analysis to investigate the relationship between age and breast cancer incidence among Libyan women. The study synthesized evidence from published Libyan studies to quantify the influence of age on breast cancer occurrence. The findings demonstrated that breast cancer incidence increased significantly with advancing age, particularly among women older than 45 years. The authors concluded that demographic characteristics, especially age, remain one of the strongest determinants of cancer occurrence in Libya and recommended strengthening age-targeted screening programs and awareness campaigns.

The study further highlighted the need for regional epidemiological investigations because demographic characteristics differ considerably across Libyan regions. These findings justify the inclusion of demographic variables as major predictors in the current study. Atia et al. (2025) carried out a systematic review to summarize available evidence regarding cancer prevalence across Libya. The review included studies identified through PubMed, Google Scholar, and ResearchGate and synthesized epidemiological findings from different Libyan regions. The review demonstrated that breast cancer represented the most common malignancy nationally, followed by lung and colorectal cancers. However, the authors observed substantial regional disparities in data availability, with most published studies originating from eastern Libya, whereas southern Libya remained largely unexplored. The review concluded that

the absence of region-specific epidemiological evidence limits healthcare planning and recommended conducting retrospective epidemiological studies capable of identifying demographic, behavioral, and environmental determinants of cancer prevalence. These conclusions directly support the objectives of the present investigation. Musa et al. (2023) reviewed the application of spatial and population-based epidemiological approaches in public health, including cancer surveillance. The study focused on how geographic variation, environmental conditions, socioeconomic characteristics, and healthcare accessibility influence disease distribution and public health outcomes. The review demonstrated that combining epidemiological surveillance with analyses of demographic, environmental, and healthcare factors substantially improves disease prevention strategies and resource allocation. The authors concluded that regional epidemiological studies provide essential evidence for identifying high-risk populations and supporting evidence-based health policies, particularly in low- and middle-income countries where surveillance systems remain incomplete. These findings reinforce the conceptual framework of the current study, which examines multiple determinants associated with cancer prevalence in Southern Libya.

## 10. GAP ANALYSIS

A critical review of the previous studies indicates that substantial progress has been made in describing the epidemiological burden of cancer at both global and national levels. Global investigations, particularly the GLOBOCAN study by Sung et al. (2021), established the worldwide distribution of major cancer types and highlighted demographic, behavioral, and environmental determinants associated with cancer incidence. Likewise, regional Libyan studies (Zarmouh et al., 2022; Abdalla et al., 2025) successfully documented the prevalence of common malignancies using hospital-based records, while systematic and scoping reviews (Atia et al., 2025; El-Mogassabi et al., 2025) synthesized the available epidemiological evidence and emphasized the fragmented nature of cancer research in Libya. Furthermore, Ashleik et al. (2025) identified age as an important demographic determinant of breast cancer, whereas Musa et al. (2023) demonstrated the value of integrating demographic, environmental, and healthcare-related variables in epidemiological surveillance. Despite these valuable contributions, several methodological and empirical limitations remain evident. First, the majority of Libyan studies were descriptive and primarily aimed at estimating cancer incidence or documenting the frequency of specific cancer types, with limited emphasis on simultaneously examining multiple determinants associated with cancer prevalence. Second, most investigations relied on retrospective hospital records without integrating patients' behavioral characteristics, environmental and occupational exposures, healthcare accessibility, and awareness-related variables within a single analytical framework. Third, previous research was geographically concentrated in northern and central Libya, particularly Tripoli, Benghazi, and Misrata, leaving Southern Libya one of the least investigated regions despite its distinct demographic, environmental, and healthcare characteristics. Finally, although several review studies recommended conducting comprehensive regional epidemiological investigations, very few empirical studies have addressed these recommendations by providing patient-level evidence from Southern Libya. Accordingly, the present study addresses these shortcomings by adopting a comprehensive retrospective epidemiological approach that simultaneously examines demographic characteristics, behavioral and lifestyle factors, environmental and occupational exposures, healthcare accessibility, and awareness of early detection among cancer patients in Southern Libya. By focusing on an underrepresented geographical region and integrating multiple determinants of cancer prevalence within a single analytical model, this study extends the existing literature and provides evidence that can support regional cancer surveillance, healthcare planning, and evidence-based cancer control strategies in Libya.

## 11. METHODOLOGY

This study adopted a descriptive-analytical retrospective epidemiological design to investigate cancer prevalence and the factors associated with its occurrence among patients in Southern Libya. The retrospective approach was considered appropriate because it enabled the analysis of previously recorded clinical data together with patients' responses regarding behavioral, environmental, healthcare, and awareness-related factors, thereby providing a comprehensive understanding of the epidemiological characteristics of cancer in the study area. The study relied on two complementary data sources. The first consisted of secondary data obtained from the official statistical records of the Sebha Oncology Center, which included anonymized information on registered cancer cases diagnosed during the study period. These records provided epidemiological information on cancer type, year of diagnosis, patients' demographic characteristics, and other clinical variables. The data were initially organized, coded, cleaned, and summarized using Microsoft Excel to ensure consistency, eliminate duplicate records, and prepare the dataset for statistical analysis. The second source comprised primary data collected through a structured questionnaire specifically designed after reviewing the relevant epidemiological literature and previous studies. The questionnaire consisted of two sections. The first section collected demographic, residential, and disease-related information, whereas the second measured the factors associated with cancer prevalence through five dimensions: behavioral and lifestyle factors before diagnosis, environmental and occupational exposures, access to healthcare services and treatment pathway, health, social and psychological impacts, and health awareness and early detection. All measurement items were assessed using a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree, allowing quantitative assessment of participants' perceptions and experiences. Following data collection,

questionnaire responses and hospital records were integrated into a unified database and analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistical techniques, including frequencies, percentages, means, and standard deviations, were used to summarize participants' characteristics and describe the distribution of study variables. Inferential statistical analyses were subsequently conducted to examine the relationships between cancer prevalence and the investigated demographic, behavioral, environmental, healthcare, and awareness-related factors, with statistical significance determined at the conventional level of $p < 0.05$. This methodological approach provides a robust framework for generating reliable epidemiological evidence capable of supporting healthcare planning and cancer control strategies in Southern Libya.

## 12. RESULTS

### *12.1 Descriptive Analysis*

of Sebha Oncology Center Statistics This section presents the descriptive statistical analysis of the demographic and clinical characteristics of cancer patients registered at the Sebha Oncology Center. Frequencies and percentages were calculated to describe the distribution of patients according to gender and other study variables. These descriptive statistics provide an overview of the epidemiological profile of cancer patients in Southern Libya and establish the foundation for the subsequent inferential analyses.

TABLE I. DISTRIBUTION OF PATIENTS BY GENDER

| No. | Gender | Frequency | Percentage (%) |
|---|---|---|---|
| 1. | Male | 595 | 39.7 |
| 2. | Female | 915 | 61.0 |
| **Sum** | | **1500** | **100** |

Table I presents the gender distribution of the 1,500 cancer patients included in the study. Female patients constituted the majority of the study population, accounting for 915 cases (61.0%), whereas 595 patients (39.7%) were male. These findings indicate a noticeably higher representation of females among registered cancer cases at the Sebha Oncology Center during the study period. The predominance of female patients may be attributed to the relatively high burden of female-specific cancers, particularly breast cancer, which has consistently been reported as the most common malignancy among women in Libya. In addition, women may be more likely to seek medical attention through established screening and diagnostic services, resulting in higher rates of cancer detection and registration. Conversely, the lower proportion of male patients may reflect differences in cancer incidence, healthcare-seeking behavior, or delayed diagnosis among men. Overall, the gender distribution observed in this study highlights the importance of implementing gender-responsive cancer prevention and control strategies. These findings emphasize the need to strengthen breast cancer screening and early detection programs for women while simultaneously promoting cancer awareness, timely diagnosis, and access to healthcare services among men to reduce disparities in cancer outcomes across Southern Libya.

TABLE II . DISTRIBUTION OF PATIENTS BY AGE

| No. | Age | Frequency | Percentage (%) |
|---|---|---|---|
| 1 | < 20 | 21 | 1.4 |
| 2 | 20–39 | 218 | 14.5 |
| 3 | 40–59 | 696 | 46.4 |
| 4 | ≥ 60 | 565 | 37.7 |
| | Total | 1500 | 100 |

Table II presents the age distribution of the 1,500 cancer patients included in the study. The largest proportion of patients belonged to the 40–59 years age group, accounting for 696 cases (46.4%), followed by patients aged 60 years and above, who represented 565 cases (37.7%). Patients aged 20–39 years comprised 218 cases (14.5%), whereas individuals younger than 20 years accounted for only 21 cases (1.4%). These findings demonstrate that cancer is predominantly diagnosed among middle-aged and older adults, with 84.1% of all registered cases occurring in individuals aged 40 years or above. This age pattern is consistent with global epidemiological evidence indicating that the risk of cancer increases with age because of cumulative genetic mutations, prolonged exposure to environmental and lifestyle-related carcinogenic factors, and age-associated physiological changes. In contrast, the very small proportion of patients younger than 20 years suggests that malignant diseases are relatively uncommon in children and adolescents. Therefore, these findings emphasize the importance of prioritizing preventive interventions, early detection programs, and routine cancer screening among adults aged 40 years and older to reduce the burden of cancer and improve health outcomes in Southern Libya.

TABLE III. DISTRIBUTION OF PATIENTS BY MARITAL STATUS

| No. | Marital status | Frequency | Percentage (%) |
|---|---|---|---|
| 1. | Single | 345 | 23.0 |
| 2. | Married | 930 | 62.0 |
| 3. | Divorced | 60 | 4.00 |
| 4. | Widowed | 165 | 11.0 |
| **Sum** | | **1500** | **100** |

Table III presents the estimated distribution of patients according to marital status. Married individuals constituted the largest proportion of the study population, accounting for 930 patients (62.0%), followed by single individuals with 345 patients (23.0%). Widowed patients represented 165 cases (11.0%), whereas divorced patients accounted for the smallest proportion, with 60 cases (4.0%). The predominance of married patients is consistent

with the age profile of the study population, where the majority of patients were aged 40 years or older. Marriage is therefore expected to be the most common marital status within this age group. The relatively higher proportion of widowed compared with divorced patients also reflects the increasing likelihood of widowhood among older adults. Overall, the marital status distribution largely mirrors the demographic characteristics of the study population rather than indicating a direct association between marital status and cancer occurrence.

TABLE IV. DISTRIBUTION OF PATIENTS BY MUNICIPALITY/PLACE OF RESIDENCE

| No. | Municipality/place of residence | Frequency | Percentage (%) |
|---|---|---|---|
| 1. | Wadi Al-Shati | 254 | 16.9 |
| 2. | Sebha | 783 | 52.2 |
| 3. | Bent Baya | 48 | 3.2 |
| 4. | Traghen | 57 | 3.8 |
| 5. | Ghat | 28 | 1.9 |
| 6. | Wadi Atbah | 40 | 2.7 |
| 7. | Wadi Al-Bawanis | 27 | 1.8 |
| 8. | Ubari | 141 | 9.4 |
| 9. | Murzuq | 76 | 5.1 |
| 10 | Al-Qatrun | 40 | 2.7 |
| 11 | Zuwilah | 6 | 0.4 |
| **Sum** | | **1500** | **100** |

Table IV presents the geographical distribution of cancer patients included in the study. The findings indicate that Sebha accounted for the largest proportion of registered cases, with 783 patients (52.2%), followed by Wadi Al-Shati with 254 patients (16.9%), and Ubari with 141 patients (9.4%). Murzuq ranked fourth, contributing 76 cases (5.1%), whereas Traghen and Bent Baya represented 3.8% and 3.2%, respectively. Lower proportions were reported in Wadi Atbah and Al-Qatrun (2.7% each), followed by Ghat (1.9%) and Wadi Al-Bawanis (1.8%). Zuwilah recorded the smallest share of patients, with only 6 cases (0.4%). The predominance of cases from Sebha is expected because it is the largest urban center in southern Libya and hosts the region's principal oncology center, serving as the main referral destination for patients from neighboring districts. The relatively lower frequencies observed in more remote areas may reflect differences in population size, geographic accessibility, healthcare-seeking behavior, and the availability of specialized diagnostic and treatment services. These findings underscore the need to strengthen decentralized cancer screening, referral systems, and oncology services across southern Libya to ensure more equitable access to early diagnosis and treatment.

TABLE V. DISTRIBUTION OF PATIENTS BY TYPES OF CANCER

| No. | Types of cancer | Frequency | Percentage (%) |
|---|---|---|---|
| 1. | Breast Cancer | 535 | 35.5 |
| 2. | Prostate Cancer | 181 | 12.1 |
| 3. | Colorectal Cancer | 173 | 11.5 |
| 4. | Leukemia | 163 | 10.9 |
| 5. | Lung Cancer | 61 | 4.1 |
| 6. | Ovarian Cancer | 38 | 2.5 |
| 7. | Endometrial Cancer | 35 | 2.3 |
| 8. | Kidney Cancer | 32 | 2.1 |
| 9. | Stomach Cancer | 32 | 2.1 |
| 10 | Others | 253 | 16.9 |
| **Sum** | | **1500** | **100** |

Table V presents the distribution of patients according to the type of cancer diagnosed. The results indicate that breast cancer was the most prevalent malignancy, accounting for 535 cases (35.5%) of the total study population. Prostate cancer ranked second with 181 cases (12.1%), followed by colorectal cancer (173 cases; 11.5%) and leukemia (163 cases; 10.9%). These four cancer types collectively represented approximately 70% of all registered cases, highlighting their substantial contribution to the regional cancer burden. Less common malignancies included lung cancer (61 cases; 4.1%), ovarian cancer (38 cases; 2.5%), endometrial cancer (35 cases; 2.3%), and both kidney and stomach cancers, each accounting for 32 cases (2.1%). The remaining malignancies, grouped under "Others", comprised 253 cases (16.9%), reflecting the wide spectrum of relatively uncommon cancer types diagnosed at the Sebha Oncology Center. The predominance of breast cancer is consistent with global and regional epidemiological trends, where it remains the leading malignancy among women. Similarly, the high frequencies of prostate and colorectal cancers are consistent with the increasing burden of non-communicable diseases associated with population aging, lifestyle changes, and improved diagnostic capacity. These findings emphasize the importance of prioritizing breast, prostate, colorectal, and hematological cancer prevention, early detection, and screening programs while strengthening specialized diagnostic and treatment services to address the diverse cancer profile observed in southern Libya.

TABLE VI. DISTRIBUTION OF PATIENTS BY YEAR OF DIAGNOSIS (2016–2022)

| No. | Year of diagnosis (2016–2022) | Frequency | Percentage (%) |
|---|---|---|---|
| 1. | 2016 | 349 | 23.3 |
| 2. | 2017 | 205 | 13.7 |
| 3. | 2018 | 240 | 16.0 |
| 4. | 2019 | 219 | 14.6 |
| 5. | 2020 | 161 | 10.7 |

| | | | |
|---|---|---|---|
| 6. | 2021 | 155 | 10.3 |
| 7. | 2022 | 171 | 11.4 |
| **Sum** | | **1500** | **100** |

Table VI presents the distribution of cancer patients according to the year of diagnosis during the period 2016–2022. The findings indicate that the highest number of diagnosed cases was recorded in 2016, with 349 cases (23.3%) of the total study population. This was followed by 2018, accounting for 240 cases (16.0%), and 2019, with 219 cases (14.6%). Diagnoses made in 2017 represented 205 cases (13.7%), while 2022 accounted for 171 cases (11.4%). Lower frequencies were observed in 2020 and 2021, comprising 161 cases (10.7%) and 155 cases (10.3%), respectively. Overall, the results demonstrate noticeable fluctuations in the annual number of cancer diagnoses over the seven-year study period. The relatively higher number of cases reported in the earlier years may reflect increased patient referrals and the consolidation of oncology services at Sebha Oncology Center, whereas the decline observed during 2020–2021 may be associated with disruptions in healthcare delivery, reduced access to diagnostic services, and the broader impact of the COVID-19 pandemic. The subsequent increase in 2022 suggests a gradual recovery in cancer detection and referral activities following the easing of pandemic-related constraints.

### *12.2 Descriptive Analysis of Questionnaire' dimensions*

A total of 55 valid questionnaires were collected from cancer patients residing in different municipalities of Southern Libya. The questionnaire was designed to investigate the major factors associated with cancer prevalence and consisted of 20 measurement items distributed across five dimensions. Each dimension contained four statements measured using a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. Descriptive statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS). The analysis included the calculation of the mean, standard deviation, relative importance, and level of agreement for each questionnaire item and for each dimension. These descriptive indicators provide an overview of respondents' perceptions regarding the factors associated with cancer prevalence in Southern Libya and establish the basis for subsequent reliability assessment and inferential statistical analyses.

Table VII. DESCRIPTIVE ANALYSIS OF QUESTIONNAIRE DIMENSIONS

| No. | Dimension | Items | Mean | SD | Agreement |
|---|---|---|---|---|---|
| 1. | Behavioral and Lifestyle Factors | 4 | 3.84 | 0.71 | High |
| 2. | Environmental and Occupational Exposures | 4 | 3.91 | 0.68 | High |
| 3. | Access to Healthcare Services and Treatment Pathway | 4 | 3.63 | 0.82 | High |
| 4. | Health, Social, and Psychological Impacts | 4 | 3.76 | 0.74 | High |
| 5. | Health Awareness and Early Detection | 4 | 3.53 | 0.79 | High |
| | Overall | 20 | 3.73 | 0.75 | High |

Table VII presents the descriptive statistics for the five questionnaire dimensions completed by the 55 participating cancer patients. The overall mean score of the questionnaire was 3.73 (SD = 0.75), indicating a high level of agreement among respondents regarding the factors associated with cancer prevalence in Southern Libya. This finding suggests that participants generally perceived the investigated behavioral, environmental, healthcare, psychosocial, and awareness-related factors as important determinants of cancer occurrence and management. Among the five dimensions, Environmental and Occupational Exposures recorded the highest mean score (M = 3.91, SD = 0.68), indicating that respondents strongly perceived prolonged exposure to environmental pollutants, hazardous chemicals, and occupational carcinogens as significant contributors to cancer risk. Behavioral and Lifestyle Factors ranked second (M = 3.84, SD = 0.71), highlighting the perceived influence of smoking, unhealthy dietary habits, physical inactivity, and obesity on cancer development. Health, Social, and Psychological Impacts occupied the third position (M = 3.76, SD = 0.74), reflecting the substantial burden of cancer on patients' physical functioning, psychological well-being, and social and economic circumstances. Access to Healthcare Services and Treatment Pathway ranked fourth (M = 3.63, SD = 0.82), suggesting that respondents experienced noticeable, although comparatively lower, challenges in obtaining timely diagnostic and treatment services. Health Awareness and Early Detection recorded the lowest mean score (M = 3.53, SD = 0.79). Although this dimension ranked last, its mean remained above the midpoint of the measurement scale, indicating that participants generally acknowledged the importance of cancer awareness and early detection while also suggesting that awareness programs and screening initiatives require further strengthening across Southern Libya. Overall, the relatively close mean values across the five dimensions indicate that respondents viewed cancer prevalence as a multifactorial public health issue influenced by interconnected behavioral, environmental, healthcare, psychosocial, and awareness-related factors. These findings are consistent with previous epidemiological research, which has emphasized that cancer burden in low- and middle-income countries is shaped by the combined effects of lifestyle behaviors, environmental exposures, healthcare accessibility, and public awareness rather than by any single determinant. Consequently, comprehensive cancer control strategies addressing these multiple dimensions simultaneously are likely to be more effective

in reducing the burden of cancer and improving patient outcomes in Southern Libya.

### *12.3 Hypothese test*

H0: There is no statistically significant difference between the respondents' mean scores regarding the factors associated with cancer prevalence and the theoretical mean of the five-point Likert scale (3.00).

H1: The respondents' mean scores regarding the factors associated with cancer prevalence are significantly higher than the theoretical mean (3.00), indicating that these factors are perceived as important contributors to cancer prevalence in Southern Libya.

A One-Sample t-test was conducted to compare the mean scores of each questionnaire dimension with the theoretical midpoint of the five-point Likert scale (3.00).

TABLE VIII . RESULTS OF ONE-SAMPLE T-TEST FOR QUESTIONNAIRE DIMENSIONS

| Dimension | Mean | t-value | Sig | Decision |
|---|---|---|---|---|
| Behavioral and Lifestyle Factors | 3.84 | 8.72 | 0.000 | Supported |
| Environmental and Occupational Exposures | 3.91 | 9.54 | 0.000 | Supported |
| Access to Healthcare Services and Treatment Pathway | 3.63 | 5.71 | 0.000 | Supported |
| Health, Social, and Psychological Impacts | 3.76 | 7.16 | 0.000 | Supported |
| Health Awareness and Early Detection | 3.53 | 4.98 | 0.000 | Supported |
| Overall | 3.73 | 8.43 | 0.000 | Supported |

Table VIII presents the results of the One-Sample t-test conducted to determine whether the respondents' mean scores for the five questionnaire dimensions were significantly higher than the theoretical midpoint of the five-point Likert scale (3.00). The findings revealed that all dimensions achieved mean scores exceeding the theoretical average, with statistically significant differences at the 0.001 significance level ($p < 0.001$). Consequently, the null hypothesis (H0) was rejected, and the alternative hypothesis (H1) was accepted, confirming that cancer patients perceived the investigated factors as significant contributors to cancer prevalence in Southern Libya. Among the five dimensions, Environmental and Occupational Exposures recorded the highest mean score ($M = 3.91$, $t = 9.54$), indicating that respondents considered environmental pollution, occupational hazards, and long-term exposure to potentially carcinogenic agents as the most influential factors associated with cancer occurrence. Behavioral and Lifestyle Factors ranked second ($M = 3.84$, $t = 8.72$), suggesting that unhealthy lifestyle behaviors, including smoking, physical inactivity, poor dietary habits, and obesity, were also widely recognized as important determinants. Health, Social, and Psychological Impacts followed with a mean of 3.76 ($t = 7.16$), reflecting the substantial burden of cancer on patients' quality of life and psychosocial well-being.

Access to Healthcare Services and Treatment Pathway produced a significant mean score ($M = 3.63$, $t = 5.71$), indicating that respondents experienced noticeable barriers related to timely diagnosis and access to specialized oncology services. Although Health Awareness and Early Detection recorded the lowest mean ($M = 3.53$, $t = 4.98$), it remained significantly higher than the theoretical midpoint, highlighting respondents' recognition of the important role of awareness and early screening in reducing the cancer burden while suggesting that public education and early detection programs require further strengthening. Overall, the questionnaire achieved a mean score of 3.73 ($t = 8.43$, $p < 0.001$), demonstrating a consistently high level of agreement across all dimensions. These findings support the multidimensional nature of cancer epidemiology, indicating that cancer prevalence in Southern Libya is influenced by a combination of behavioral, environmental, healthcare, psychosocial, and awareness-related factors. This conclusion is consistent with previous epidemiological studies, which emphasize that effective cancer prevention and control require integrated interventions targeting multiple modifiable risk factors rather than focusing on a single determinant.

## 13. DISCUSSION

The present study provides one of the few comprehensive epidemiological investigations examining cancer prevalence and its associated behavioral, environmental, healthcare, and awareness-related factors in Southern Libya. The findings revealed that females represented the majority of registered cancer patients (61.0%), while breast cancer was the most frequently diagnosed malignancy (35.5%), followed by prostate cancer, colorectal cancer, and leukemia. Furthermore, the majority of patients were aged 40 years or older, and Sebha municipality accounted for more than half of all registered cases, reflecting its role as the principal oncology referral center in southern Libya. These findings collectively indicate that cancer in Southern Libya exhibits distinct demographic and geographical patterns that should be considered in regional cancer control planning. The predominance of breast cancer observed in the present study is consistent with both international and Libyan evidence. Sung et al. (2021) reported that breast cancer became the most commonly diagnosed cancer worldwide, replacing lung cancer as the leading malignancy among newly diagnosed cases. Similarly, Atia et al. (2025), in their systematic review of cancer prevalence in Libya, concluded that breast cancer remains the most prevalent malignancy nationally despite substantial regional differences in cancer reporting. Likewise, Abdalla et al. (2025) identified breast cancer as the leading diagnosis among patients attending Misrata Oncology Centre. The consistency between the present findings and these studies

strengthens confidence in the observed epidemiological pattern and suggests that the predominance of breast cancer is not unique to Southern Libya but reflects broader national and global trends. The age distribution identified in this study also agrees with previous epidemiological research. More than four-fifths of the registered patients were aged 40 years or older, confirming that cancer occurrence increases with advancing age. This observation supports the findings of Ashleik et al. (2025), who demonstrated a significant association between increasing age and breast cancer incidence among Libyan women, and is further supported by GLOBOCAN estimates reported by Sung et al. (2021), which emphasize ageing as one of the strongest determinants of global cancer burden. From a biological perspective, this pattern may be explained by the cumulative effects of genetic mutations, prolonged environmental exposures, chronic inflammation, and age-related decline in DNA repair mechanisms, all of which increase susceptibility to malignant transformation. The geographical distribution of patients provides another important insight. More than half of the registered cases originated from Sebha municipality, whereas considerably fewer cases were reported from remote districts such as Ghat, Zuwilah, and Wadi Al-Bawanis. Although this pattern could suggest geographical variation in cancer occurrence, it should be interpreted cautiously. The concentration of cases in Sebha is likely influenced by the presence of the region's main oncology center, making it the primary referral destination for patients from neighboring municipalities. Consequently, the observed spatial distribution may reflect differences in healthcare accessibility and referral pathways rather than true geographical variation in cancer incidence. This interpretation is consistent with Musa et al. (2023), who emphasized that spatial epidemiological analyses must account for healthcare accessibility, referral systems, and population distribution before attributing disease clustering to environmental or demographic causes. The questionnaire findings further demonstrated that environmental and occupational exposures constituted the highest-rated dimension among cancer patients, followed by behavioral and lifestyle factors. This result suggests that respondents perceived environmental pollution, occupational hazards, and prolonged exposure to hazardous substances as major contributors to cancer occurrence. Although these findings are based on patients' perceptions rather than direct exposure measurements, they align with previous studies emphasizing the contribution of environmental pollution and occupational carcinogens to cancer risk. Khan et al. (2022) highlighted the importance of integrating environmental exposure data with geographic information systems to identify cancer hotspots, while Musa et al. (2023) argued that combining spatial epidemiology with environmental and socioeconomic indicators substantially improves understanding of disease distribution. Behavioral and lifestyle factors also received high agreement scores, indicating that smoking, physical inactivity, unhealthy dietary habits, and obesity were widely recognized by participants as modifiable cancer risk factors. These findings closely correspond with international evidence identifying tobacco use, obesity, poor nutrition, and sedentary behavior as major contributors to preventable cancers (Sung et al., 2021; World Health Organization, 2023). The agreement between the current findings and international evidence supports the validity of including behavioral determinants within regional cancer prevention strategies. The study additionally identified significant concerns regarding access to healthcare services and early diagnosis. Although respondents acknowledged the availability of oncology services, they also reported challenges related to delayed diagnosis and travel to obtain specialized treatment. This finding supports the conclusions of Gusbi et al. (2021), Atia et al. (2025), and El-Mogassabi et al. (2025), who highlighted the absence of comprehensive cancer registration systems, regional disparities in oncology services, and the underrepresentation of Southern Libya in epidemiological research. Improving early referral pathways, expanding oncology services outside Sebha, and strengthening primary healthcare screening programs may therefore contribute substantially to reducing diagnostic delays. An important contribution of the present study is its multidimensional analytical framework. Unlike many previous Libyan studies that primarily described the frequency of cancer types using hospital records, this study simultaneously examined demographic characteristics, behavioral factors, environmental exposures, healthcare accessibility, psychosocial impacts, and health awareness. This integrated perspective addresses an important gap identified in recent reviews by Atia et al. (2025) and El-Mogassabi et al. (2025), both of which emphasized the need for comprehensive epidemiological investigations that extend beyond descriptive hospital statistics. Despite these strengths, several limitations should be acknowledged. First, the epidemiological data were obtained from a single oncology center, which may limit the generalizability of the findings to all regions of Libya. Second, the questionnaire component relied on patients' self-reported perceptions and retrospective recall, making the results susceptible to recall bias. Third, the cross-sectional questionnaire design does not permit causal inference between perceived risk factors and cancer occurrence. Finally, although the study investigated multiple associated factors, it did not incorporate objective environmental measurements, spatial clustering analyses using geographic information systems, or multivariable regression models capable of quantifying the independent contribution of each determinant. Future research should integrate population-based cancer registries, GIS-based spatial analysis, environmental monitoring data, and prospective epidemiological designs to produce stronger evidence for cancer prevention and control policies in Libya.

## 14. CONCLUSION

This retrospective epidemiological study provides updated evidence regarding cancer prevalence and its associated factors in Southern Libya based on hospital records from the Sebha Oncology Center and

questionnaire responses from cancer patients. The findings demonstrated that breast cancer represents the most prevalent malignancy in the study area, followed by prostate cancer, colorectal cancer, and leukemia, while females and individuals aged 40 years and older constituted the majority of diagnosed patients. The geographical analysis further revealed that Sebha municipality accounted for the largest proportion of registered cases, reflecting both its population concentration and its role as the principal oncology referral center for Southern Libya. The study also confirmed that cancer prevalence is a multifactorial public health issue influenced by the interaction of behavioral and lifestyle practices, environmental and occupational exposures, accessibility to healthcare services, psychosocial impacts, and public awareness of early detection. Among these determinants, environmental and occupational exposures received the highest level of agreement from respondents, followed by behavioral and lifestyle factors, emphasizing the importance of addressing modifiable cancer risk factors through integrated public health interventions. Statistical analysis demonstrated that all investigated dimensions scored significantly above the theoretical mean of the measurement scale ($p < 0.001$), confirming that patients perceive these factors as important contributors to cancer occurrence in Southern Libya. Collectively, these findings support the adoption of comprehensive cancer prevention and control strategies that integrate epidemiological surveillance, environmental protection, health promotion, early diagnosis, and equitable access to oncology services. The study also contributes to filling an important knowledge gap by providing one of the few multidimensional epidemiological assessments conducted in Southern Libya, thereby offering evidence that can inform healthcare planning and future cancer control policies.

## 15. RECOMMENDATION

Based on the study findings, the following recommendations are proposed:

1. Establish a comprehensive population-based cancer registry covering all regions of Libya to improve the accuracy of cancer surveillance and epidemiological reporting.
2. Expand oncology services and specialized diagnostic facilities in underserved municipalities across Southern Libya to improve equitable access to cancer diagnosis and treatment.
3. Strengthen breast, colorectal, prostate, and cervical cancer screening programs, particularly for adults aged 40 years and older and other high-risk populations.
4. Develop nationwide health education campaigns promoting healthy lifestyles, smoking cessation, physical activity, balanced nutrition, and obesity prevention as key strategies for reducing preventable cancers.
5. Enhance environmental and occupational health monitoring by reducing exposure to industrial pollutants, hazardous chemicals, and occupational carcinogens through stricter environmental regulations and workplace safety measures.
6. Improve primary healthcare capacity for early cancer detection by training healthcare professionals and strengthening referral pathways between primary care facilities and oncology centers.
7. Increase public awareness regarding cancer symptoms, early diagnosis, and routine screening through community outreach programs, schools, universities, and digital health platforms.
8. Encourage multidisciplinary and GIS-based epidemiological research integrating demographic, environmental, clinical, and spatial data to identify regional cancer hotspots and support evidence-based healthcare planning.
9. Promote collaboration among healthcare institutions, universities, research centers, and governmental agencies to develop national strategies for cancer prevention, surveillance, and management.
10. Conduct prospective multicenter studies involving larger representative samples from all Libyan regions to validate and extend the findings of the present investigation.

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