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Six-Year Evolution of Cancer Case-Mix and Demographic Profiles at a Tertiary Oncology Center in Iraq: A Registry -Based Study (2021–2026).

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Abstract

Background: Cancer represents a substantial public health challenge in Iraq, where reliable longitudinal institutional data are important for understanding oncology service demands and the changing composition of registered cancer cases. Although population-based cancer statistics provide estimates of disease burden, comparatively less attention has been given to evaluating temporal changes in cancer case-mix and demographic characteristics within individual tertiary oncology institutions,

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particularly while accounting for registry quality and the magnitude of statistical associations. **Objective:** To evaluate the stability of the observed temporal associations and to examine the six-year changes in cancer diagnostic case-mix, age distribution and sex composition of oncology records at a tertiary cancer center in Iraq over the period 2021-2026**. Methods:** This was a retrospective analytical study based on registries of six annual electronic datasets for the years 2021-2026. Of the 14,294 non-empty registry records, 13,806 records were eligible based on the primary eligibility criteria of a recognizable ICD-10 malignant neoplasm code and recorded sex. Descriptive statistics were used to describe annual distributions of diagnostics and demographics. Calendar year and composition by cancer site or sex were evaluated using Pearson's chi-square tests. The Kruskal–Wallis test was used to assess differences in age distributions and Cramer's V was used to assess the strength of the association. Binomial logistic regression models were used to analyze the annual changes in the relative representation of 12 major cancer sites. Multiple comparisons were controlled using the Benjamin-Hochberg false discovery rate (FDR) procedure. Sensitivity analyzes limited the observation window to 2021–2025. **Results:** Eligible registry records numbered 2,131, 2,343, 2,192, 2,296, 2,719, and 2,125 from 2021 through 2026, respectively. Breast cancer (C50) was the most frequently recorded malignancy (3,315; 24.0%), followed by lung cancer (C34; 1,269; 9.2%), bladder cancer (C67; 714; 5.2%), prostate cancer (C61; 710; 5.1%), and malignant brain neoplasms (C71; 654; 4.7%). Cancer-site composition differed significantly across calendar years (χ^2=89.20, df=60, p=0.0086), although the association was small (Cramer's V=0.036). Sex composition remained stable (χ^2=1.88, df=5, p=0.865). There was a significant difference in the distributions of age (Kruskal–Wallis H=21.83, p=0.00057) with a descriptive increase in the median age from 55 to 57 years. The unadjusted temporal regression showed a decreasing relative representation of breast cancer (OR=0.966, 95% CI: 0.944–0.988) and an increasing relative representation of malignant brain neoplasms (OR=1.068, 95% CI: 1.019–1.119), both with an FDR-adjusted q of 0.038. However, both associations were not significant after multiple testing correction when excluding 2026. **Conclusion:** The registry had a stable overall sex composition, with small temporal changes in the composition of cancer diagnostics and age distribution. In the full six-year analysis, statistically significant temporal associations were observed for selected cancer sites, but these were not robust to restriction of the observation period. The results emphasize the necessity of interpreting trends in

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hospital-based oncology in terms of effect sizes, sensitivity analyzes, and explicit consideration of registry completeness, repeated registration and reporting-year inconsistencies.

Keywords: Cancer registry, Oncology, Cancer case-mix, Iraq; Demographic trends, Temporal analysis, ICD-10, Retrospective study, Statistical association.

Introduction

Cancer remains one of the major public health challenges of the 21st century, imposing a massive burden on health systems, economies and societies worldwide. While the mortality rates have plateaued or decreased in high-income nations due to advances in early detection and targeted treatments, the burden on low and middle-income countries (LMICs) was exponentially increasing. Limited access to comprehensive oncology care, demographic shifts, aging populations and lifestyle transitions are contributing factors to this disparity [1]. The epidemiological landscape in the Middle East and especially in Iraq has changed considerably over the last few decades. Cancer rates in Iraq have been climbing steadily. This trend was often compounded by environmental hazards in specific regions, strains on health care infrastructure in the aftermath of conflict and exposures from heavy industrialization, oil extraction and petrochemical activities, especially in the southern and central governorates. National health reports and estimates from the International Agency for Research on Cancer (IARC) indicate that the Iraqi population was disproportionately burdened by malignancies including hematologic malignancies, gastrointestinal cancers and breast cancer that often present with advanced stages and younger median ages compared to those of Western populations [1]. Cancer remains one of the biggest obstacles to increasing life expectancy in the 21st century. The epidemiological transition, characterized by the adoption of Westernized lifestyles and aging populations globally, has led to a significant increase in the incidence of cancer [2]. High-income countries have effective preventive strategies and advanced early detection programs, whereas low- and middle-income countries (LMICs) bear a disproportionate and rapidly increasing burden of [2]. The Middle East and North Africa (MENA) region [3] was expected to double its cancer rates in the next two decades, which will likely place considerable pressure on their fragile healthcare infrastructures and specialized treatment facilities. The closest English-language

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equivalent was a 12-year retrospective analysis by the Rizgary Oncology Center in Erbil . It covers the years 2014 to 2025 and was explicitly divided into two 6-year periods (2014–2019 and 2020–2025). It was a preprint (medRxiv, August 2026) and not peer-reviewed [4]. 11,704 patients with histopathologically confirmed solid tumors [4]. Males make up 43.6% of the population, while females make up 56.4% [5]. Breast cancer accounts for more than 25% of all cases, followed by lung cancer, colorectal cancer, prostate cancer and bladder cancer [4].

Tertiary oncology centers are useful for understanding the evolution of cases they see, as they receive referrals from a wide catchment area and deal with a wide spectrum of malignancies, and cancer remains a major cause of morbidity and mortality worldwide [6]. However, caution study exercised in interpreting the case mix of retrospective registry data from these centers in view of the institution's own catchment area and records, which are influenced by local referral patterns, diagnostic capacity and recording practices [7]. However, these patterns cannot be attributed to changes in disease burden alone, as annual totals in single-center series are influenced by changes in referral volume, pathology archiving, and completeness of confirmed malignant diagnoses [8]. Thus, the present analysis treats the registry ’s annual totals as an administrative measure of caseload, not an exact proxy for incidence. It also places the registry data in context with national and regional registry data wherever possible, such as the Bangladeshi hospital-based series demonstrating how institutional case mix reflects local diagnostic and referral structures [9]. which means that the present cohort needs to be considered within the framework of these regional patterns and not as an isolated entity. Similar hospital-based series from Pakistan and Nigeria have also demonstrated a predominance of older adult age groups of patients. The referrals for radiotherapy are often higher for female patients than male patients, which supports the notion that the institutional case mix was driven as much by local referral and diagnostic structures as it was by the underlying disease burden [10]. The present study therefore evaluates the institution's six-year caseload for age and sex distribution. The observed patterns can then be understood in terms of these referral and diagnostic effects, rather than solely to changes in population risk. The patients who are first included in the registry are defined by referral thresholds, access to diagnosis and the completeness of pathology records [11]. The descriptive age and sex distribution shown here study taken as a pointer to the patients that have made it to this tertiary center given the female

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preponderance and median age of about 50 years that have been reported in similar multi-institution cohorts in northeast Nigeria [12]. Thus, this descriptive profile situates the present cohort within the framework of a larger pattern in which gastrointestinal, genitourinary and gynecologic malignancies constitute a large proportion of cases treated, and in which the age at presentation differs markedly by cancer type [13]. In the present cohort, almost half of the treated cases were cervical cancer, and the age bands with the highest share of patients were 46–55 and 56–65 years. This distribution was in accordance with the predominance of female patients and the concentration of the disease among middle-aged women as reported in regional radiotherapy series [14]. The predominance of cervical cancer in the current cohort was consistent with the reported treatment burden in Northern Nigerian radiotherapy services where cervical cancer accounted for half of the reviewed cases and female patients constituted the large majority of referrals [15]. This distribution was consistent with the data. Taken together, these findings suggest that the proportion of females in treated cancers was driven by the people who are referred and diagnosed at tertiary centers rather than the underlying epidemiology. It was therefore important to take into account the current age and sex distribution when considering institutional referral pathways. Future registry -based studies at this center would thus benefit from linking referral source, diagnostic pathway and pathology completeness to each recorded case, to distinguish true shifts in the underlying age and sex distribution of cancer from shifts in annual caseload [16]. Additionally, this linkage would allow for direct comparison of the age and sex profile with regional registry benchmarks, such as the reported female predominance and mid-life concentration of gynecological malignancies in northeastern Nigeria [17]. This linkage would also help to determine whether the substantial increase in annual totals was due to real changes in incidence or merely increased referral volume and improved archiving of confirmed malignant diagnoses, a distinction that single-center registries have rarely been able to make [18]. In future registry -based work in this setting, the age and sex distribution of treated cancers could be compared with regional patterns of who presents for radiotherapy and related services, which would also benefit from linking each recorded case to its referral source and diagnostic pathway[19].The estimates that would come from differentiating these influences would be more effective in leading the institution’s planning for the changing demographic needs of its patients [7]. Routine monitoring of data completeness, validity, comparability and

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timeliness would further strengthen the interpretation of these longitudinal patterns and support reliable comparisons across registry settings [20].

It has also looked at how patterns of cancer change over time, with national analyzes showing changes in the numbers of cases registered by age, sex and geographical area [21]. Registry-based data indicate that caution is warranted in the interpretation of changes in caseload at a single tertiary center, which could reflect changes in referral volume and archiving practice, rather than changes in incidence at the population level [22]. To consider the six-year trends in age and sex distribution as real changes in the cancer burden, consistent case definitions, complete pathology archiving and linkage of referral records would be required [23]. These methodological safeguards allowed the separation of the six-year trend of age and sex profiles at this center from changes in referral practice and provided a sound basis for future service planning [24]. In addition, it would enable the institution to record the age and sex distribution of its caseload each year, an important measure of the effectiveness of decentralized treatment services in reaching their target populations [25]. Such year-on-year reporting may reflect improved archiving of confirmed malignant diagnoses, as well as real changes in the age and sex structure of treated cancers, which may account for the apparent increases in caseload. Regular checks of completeness, validity and comparability of the registries [20] would be needed to consistently interpret such comparisons. The hospital case counts alone are not sufficient to calculate incidence in the population without a well-defined geographic catchment area and the corresponding age- and sex-specific population denominators [26] to generate rates for comparison with regional and national benchmarks. The rates are reliably determined only when case ascertainment is complete and timely, as demonstrated in similar registry studies [27]. The completeness rates are very different between registries.

In this respect, the example of the Saudi Arabian registry analysis shows how methodological choices such as calculation of trends based on the number of cases instead of age-standardized rates, when the standardization procedure changes, can ensure comparability between reporting periods [28]. Such a degree of methodological transparency was also important for the present cohort, as the reported age and sex distributions can only be meaningfully compared with other registries if the parameters, case definitions, and reporting windows are explicitly described [29]. Without such explicit reporting conventions, the true variation in cancer burden may be easily

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misinterpreted as differences in age and sex distribution between centers, especially if pathology records are incomplete and diagnostic verification varies between sites [30]. Therefore, a strong comparison of age and sex profiles across the six-year period requires a clear description of the number of confirmed malignant diagnoses archived each year against the number lost due to incomplete records [31]. Similar registry evaluations have shown that the accuracy of such comparisons depends on uniform quality indicators, e.g. timeliness, validity and completeness of the underlying record [32]. In addition, approaches to completeness assessment vary widely between registries [33]. Hence, a standardized set of quality indicators needs to be consistently applied across reporting years to compare the age and sex trends at this center with population-based registries in the region [34]. In addition to the completeness and accuracy indicators that are currently used by other regional registries, the annual caseload of the center can be reported within this standardized framework. Studies have shown that there can be a large variation in the quality of demographic data and case ascertainment among sites [35]. The combination of these measures would improve the effectiveness of the demographic profile in assessing the changing service needs of the center and would also make the interpretation of it proportional to the quality and coverage of the underlying records. This proportional interpretation also requires [32]. Readers can look at the age and sex distribution for each year, the definition of its catchment area, the source of the determinant, and estimates of completeness [36] to assess the extent to which the observed shifts are due to changes in the risk profile of the population rather than service patterns. The age and sex profile of the center also could be compared to published registry standards because these conventions were uniformly reported over a six-year period. These require reporting of rates by site, age and sex, and of specific indices of diagnostic validity and the proportion of cases which have been microscopically verified [37]. Changes in age and sex distribution over 6 years may reflect real changes in the number of cancer cases or simply changes in the thorough and consistent reporting of confirmed diagnoses each year [38][39].

1.1. Research gap

Existing national and international cancer statistics provide valuable information on cancer burden in Iraq. Nevertheless, national cancer incidence estimates do not necessarily describe how the diagnostic and demographic composition of patients attending an individual tertiary oncology center changes over time. This study was

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designed specifically to fill the research gap of the need for an integrated institutional analysis that integrates the composition of cancer sites, demographic variation, association strength, site-specific temporal regression, and sensitivity to reporting period selection. The study also addresses an important methodological question, namely whether the statistically significant differences in registry composition are robust when a potentially incomplete reporting year was excluded. This gap was defined as a need for a particular analytical approach, not a claim that there is no previous cancer studies conducted at the Iraqi hospitals.

1.2. Scientific novelty

The scientific contribution of this investigation was composed of four complementary parts. It evaluates six consecutive years of oncology registry data in one analytic model for the first time. Secondly, it estimates the temporal evolution of the composition of cancer sites with Cramer's V, which distinguishes the strength of association from statistical significance. Third, it performs site-specific temporal regression with false discovery rate correction to reduce the risk of over-interpreting multiple exploratory comparisons. Fourth, it compares the full six-year dataset with a limited observation period of 2021–2025 to evaluate the robustness of temporal associations. The study therefore adds a methodological and institutional perspective to the evaluation of longitudinal cancer registries.

1.3. Study objectives

The primary objective was to evaluate the change in the relative distribution of major cancer diagnostic groups in the registered oncology records from 2021 to 2026. Secondary outcomes: To describe the annual age- and sex-specific distributions; to describe the most frequently registered types of malignant neoplasms; to measure the strength of relationships between calendar year and the categories of diagnoses; to study time trends by anatomic site; and to assess the sensitivity of these associations to inclusion of the 2026 dataset.

1.4. Research hypotheses

H1: The diagnostic case-mix of cancer varies substantially between calendar years.
H2: The age distributions vary quite a bit from calendar year to calendar year.
H3: Sex composition of the population varies widely between calendar years.

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H4: After correction for multiple comparisons, statistically significant temporal associations are observed in the relative representation of selected cancer sites.

2. Materials and Methods

2.1. Study design and setting

A retrospective, observational, analytical study was done using six annual electronic oncology registry datasets from 2021 to 2026.The source records were collected from a tertiary oncology center in Iraq. The purpose of the study was to describe the demographic characteristics and diagnostic composition of the institution, and not to estimate the incidence of cancer in the general population.

2.2. Data source and study population

The original datasets consisted of six Excel workbooks containing annual oncology registry records. Removed completely blank rows and identified 14,294 source records. The initial primary analytical cohort included records that were identifiable as male or female and contained a recognizable ICD-10 malignant neoplasm code starting with the letter C. Thirteen thousand eight hundred six records met the criteria.

2.3. Unit of analysis

The unit of analysis was the individual registry record. It was not possible to determine whether all records belonged to unique patients as there was no reliable way of identifying unique patients and no data to separate first-time registration from subsequent clinical encounters. No record was removed based on similar demographic characteristics or patient names alone. Thus, the investigation describes the composition and timing of the oncology registry records, not the number of confirmed unique cancer patients or new cancer cases. The statistical analysis of the data was considered limited by the potential correlation of records from the same individual.

2.4. Eligibility criteria

For the main analysis, records were eligible if they were extracted from one of the six annual datasets, had a recognizable ICD-10 malignant neoplasm code, and had an identifiable sex designation. In the primary complete-case analysis, we excluded records without identifiable malignant neoplasm codes or sex data. Age analyzes were

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restricted to records with interpretable numeric ages within the predefined plausible range of 0–110 years.

2.5. Study variables

The primary explanatory variable was the calendar year. The primary outcome was the cancer diagnosis category, determined using the three-character ICD-10 malignant neoplasm code recorded. Separate analyzes were performed for the 12 most common cancer codes recorded. The remaining malignant neoplasm codes were combined into a “Other C codes” category for the purpose of overall case-mix comparison. Demographic characteristics were evaluated: age, sex. Smoking status, comorbidities, metastatic status, geographical residence and socioeconomic variables were not included as principal study outcomes as these variables are reserved for separate investigations conducted using the same registry.

2.6. Data preparation and validation

Annual datasets were harmonized to ensure consistency of analytical variable names and formats. Standardized, recognizable ICD-10 codes were established as three-character C categories. Harmonization of grouping of sex values into male and female values. Age was converted to numeric format and invalid values were treated as missing. The annual workbook was the source-year indicator due to the differences in workbook years and the dates recorded. The quality control of the data included checking for possible duplicate names, missing data and inconsistencies in the dates of registration. Caution needs to be exercised in interpreting the time completeness of the 2026 dataset as the dates included in the dataset were beyond the analysis date of 22 October 2026.

2.7. Statistical analysis

Categorical variables were summarized by frequency and percent. Age was summarized using means and medians. The changes in composition of cancer diagnoses over time were evaluated by Pearson’s chi-square test. The strength of the association was measured using Cramér’s V:

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$$V = \sqrt{\frac{\chi^2}{N \times \min(r-1, c-1)}}$$

where (N) was the number of observations and (r) and (c) are the dimensions of the contingency table. Sex composition was compared between years using Pearson's chi-square test. Differences in age distributions were examined using the Kruskal–Wallis H test. Separate binomial logistic regression models for site-specific temporal analysis were used to analyze the 12 most commonly recorded cancer categories. The dependent variable was the presence of the specific diagnosis compared with all other eligible malignant neoplasm records for each cancer category. Calendar year was included as a continuous predictor. In particular the model was defined as:

where (pt) represents the proportion of eligible records belonging to the selected cancer category in year (t).

Annual odds ratios were calculated as:

$$OR = e^{\beta_1}$$

$$95\%\,CI = e^{\beta_1 \pm 1.96\,SE(\beta_1)}$$

- 95% Confidence Interval (level of confidence)
- Exponent (e)
- Regression coefficient (β_1)
- 1.96 (for 95% CI)
- Standard error of the regression coefficient ($SE(\beta_1)$)

The false discovery rate was controlled over the 12 site-specific tests using the Benjamini–Hochberg procedure. A sensitivity analysis was carried out by limiting the observation period to 2021–2025.All regression estimates reported are unadjusted, because the models fit used annual aggregated counts of diagnoses. No adjustment for age and sex was made at the multivariable record level in this analysis. The statistical significance of the primary tests was assessed using two-sided p-values of less than 0.05. For the site-specific family of comparisons, we used FDR-adjusted q-value < 0.05.

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2.8. Ethical considerations

The study involved a retrospective analysis of data routinely recorded in cancer patient registries. Publication was approved by the Research Ethics Committee at the College of Medicine, University of Kufa, in 2026. The study was conducted in accordance with the ethical principles set forth in the Declaration of Helsinki. Informed consent was obtained from all participants—where applicable—and the confidentiality of their data was maintained throughout the study.

3. Results

3.1. Registry volume and analytical eligibility

The six annual datasets contained 14294 nonempty registry records. Of these 13,806 (96.6 %) met the primary eligibility criteria.

Table 1. Annual distribution and eligibility of oncology registry records.

Year	Source records	Eligible records	Eligibility (%).
2021	2,175	2,131	98.0
2022	2,365	2,343	99.1
2023	2,214	2,192	99.0
2024	2,357	2,296	97.4
2025	2,824	2,719	96.3
2026	2,359	2,125	90.1
Total	14,294	13,806	96.6

The highest number of eligible records was for 2025 and the lowest number was for 2026.The share of eligible cases was smaller in 2026 than in earlier years, possibly because of differences in the completeness of the data or in the way it was recorded. These findings reflect registry volume and analytic eligibility, not changes in cancer incidence.

3.2. Overall distribution of major cancer diagnoses

The most commonly reported malignancy was breast cancer (C50) with 3,315 cases (24.0%). Lung cancer (C34) ranked second, followed by bladder cancer (C67), prostate cancer (C61) and malignant neoplasms of the brain (C71).

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Table 2. Twelve most frequently recorded malignant neoplasm categories, 2021–2026

Cancer category	Cancer category ICD-10 Records Percentage (%)		
Breast	C50	3,315	24.0
Lung	C34	1,269	9.2
Bladder	C67	714	5.2
Prostate	C61	710	5.1
Brain	C71	654	4.7
Colon	C18	536	3.9
Non-Hodgkin lymphoma	C85	500	3.6
Pancreas	C25	421	3.0
Rectum	C20	366	2.7
Stomach	C16	365	2.6
Ovary	C56	357	2.6
Hodgkin lymphoma	C81	345	2.5

Denominator for percentages was 13,806 eligible records. Percentages are rounded to one decimal place. The categories are based on the ICD-10 codes that have been registered. Percentage of eligible records, 2021–2026

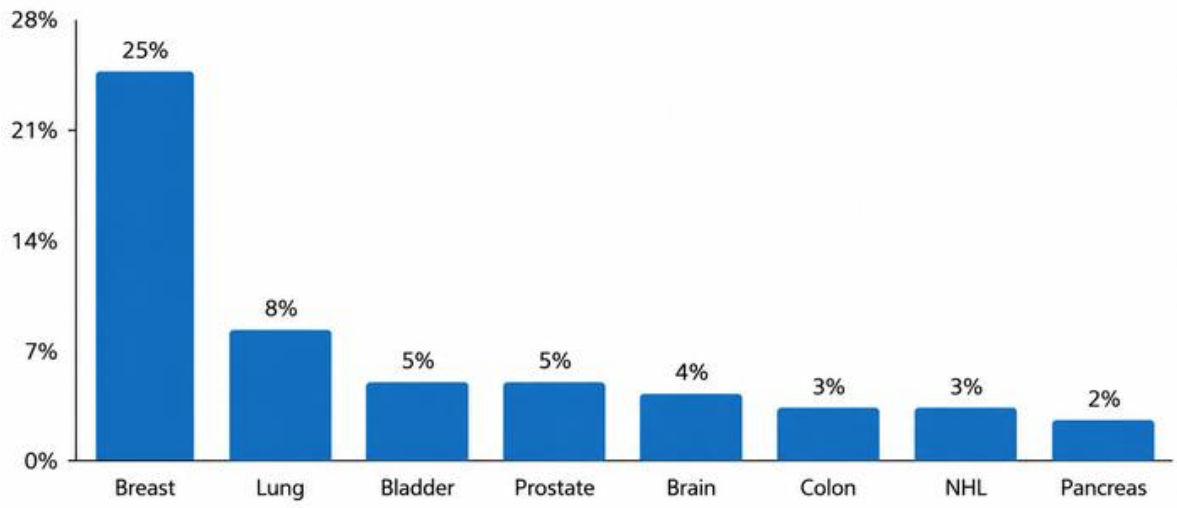

Figure 1. Relative distribution of the eight most frequently recorded malignant neoplasm categories.

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3.3. Temporal variation in diagnostic case-mix

The distribution of the 12 most frequently recorded cancer categories and all remaining malignant neoplasm codes differed significantly across the six calendar years.

$$\chi^2(60) = 89.20, \quad p = 0.0086$$

However, the corresponding effect size was small:

$$Cramér's\ V = 0.036$$

Table 3. Annual distribution of selected major cancer diagnoses.

Year	Breast C50	Lung C34	Bladder C67	Prostate C61	Brain C71	Breast C50
2021	543	178	129	135	98	543
2022	584	230	107	116	96	584
2023	542	188	124	104	88	542
2024	542	213	92	116	107	542
2025	631	255	152	135	135	631
2026	473	204	110	104	128	473

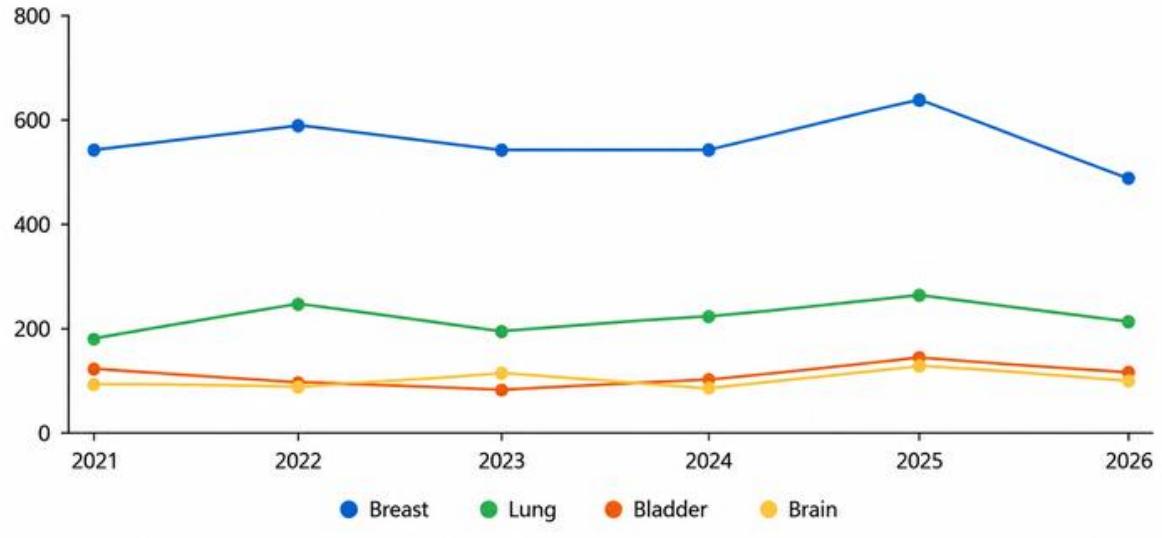

Figure 2. Annual counts of four major cancer categories.

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Note that these are record counts, not incidence rates (unstandardized). In 2021, breast cancer accounted for about 25.5% of eligible records and in 2025 it was 23.2%. During the same years, lung cancer was present in approximately 8.4% and 9.4% of eligible records. These observations reveal the difference between changes in the absolute number of registered cases and changes in their relative contribution to the institutional case-mix.

3.4. Sex composition

The eligible registry population was predominantly female records during the study period.

Table 4. Annual distribution of registered sex.

Year	Female, n (%)	Male, n (%)
2021	1,182 (55.5)	949 (44.5)
2022	1,336 (57.0)	1,007 (43.0)
2023	1,222 (55.7)	970 (44.3)
2024	1,278 (55.7)	1,018 (44.3)
2025	1,512 (55.6)	1,207 (44.4)

Pearson's chi-square test demonstrated no statistically significant association between calendar year and sex composition: $\chi^2(5) = 1.88, \quad p = 0.865$

Sex distribution was relatively stable across the 6 years with females ranging from 55.2% to 57.0%. So, the assumption of large temporal differences in the overall sex composition was not confirmed.

3.5. Age distribution

Valid age information was available for 13,796 eligible records.

Table 5. Annual age characteristics.

Year	Valid age records	Mean age
2021	2,129	52.7
2022	2,342	53.7
2023	2,189	54.4

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2024	2,294	54.4
2025	2,719	54.7
2026	2,123	55.3

The Kruskal–Wallis test identified statistically significant differences in age distributions across the study years: $H(5) = 21.83, \quad p = 0.00057$

The mean age increased descriptively from 52.7 years in 2021 to 55.3 years in 2026, while median age increased from 55 to 57 years.

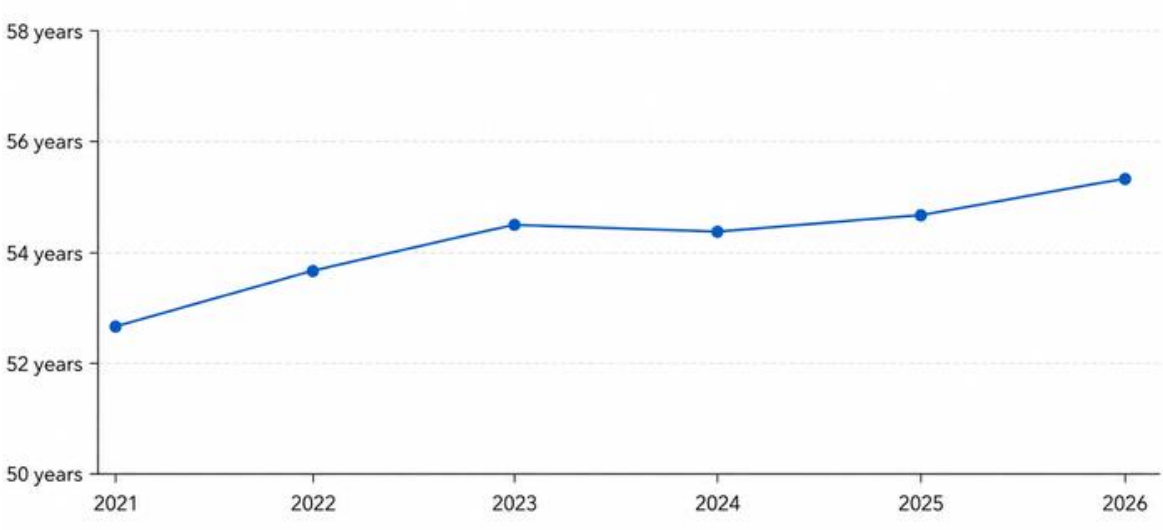

Figure 3. Mean age by registry year. The graph describes annual means and does not establish an independently tested linear trend.

The Kruskal–Wallis result was significant in that it suggests differences in the annual age distributions but does not establish a monotonic temporal increase or specific pairwise differences.

3.6. Site-specific temporal regression

Separate unadjusted binomial logistic regression models were fitted for the 12 most frequently recorded cancer categories.

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Table 6. Annual associations in the relative representation of major cancer sites, 2021–2026.

ICD-10	OR per year (95% CI)	p-value	FDR q-value
C50	0.966 (0.944–0.988)	0.0032	0.0380
C34	1.019 (0.984–1.054)	0.2950	0.5159
C67	0.986 (0.943–1.031)	0.5362	0.6435
C61	0.962 (0.920–1.006)	0.0907	0.3594
C71	1.068 (1.019–1.119)	0.0063	0.0380
C18	1.037 (0.985–1.092)	0.1680	0.4033
C85	1.022 (0.970–1.078)	0.4131	0.6197

OR = unadjusted odds ratio per one-year increase; CI = confidence interval; FDR = false discovery rate.

The models look at the percentage of cancer diagnoses within eligible records, not the general incidence of cancer in the general population. Two categories had statistically significant temporal associations after FDR correction. The relative representation of breast cancer decreased in the fitted model (OR=0.966, 95% CI: 0.944–0.988; q=0.038), which corresponds to an approximately 3.4% decrease in odds per additional calendar year. The odds of having malignant brain neoplasms increased (OR=1.068, 95% CI: 1.019–1.119; q=0.038), corresponding to an approximately 6.8% increase in odds per calendar year. However, none of the other categories examined remained significantly associated after correction for multiple testing. These associations reflect changes in the relative mix of eligible registry records and should not be taken to reflect changes in population-level cancer risk.

3.7. Sensitivity analysis excluding 2026

A sensitivity analysis was performed with the observation period 2021–2025 to account for potential incomplete reporting and discrepancies in dates in the 2026 dataset.

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Table 7. Selected temporal associations after exclusion of 2026.

Cancer site	OR per year (95% CI)	p-value	FDR q-value
Breast (C50)	0.969 (0.940–0.998)	0.0341	0.3518
Lung (C34)	1.017 (0.974–1.063)	0.4428	0.6215
Brain (C71)	1.034 (0.973–1.100)	0.2834	0.5669
Prostate (C61)	0.952 (0.899–1.007)	0.0879	0.3518

Although the association with breast cancer was statistically significant before correction, neither breast cancer nor malignant brain neoplasms were significant after correction for FDR. In the limited analysis (2021–2025), none of the time-related associations remained statistically significant after multiple-testing correction across the full set of 12 site-specific comparisons. The time-dependent associations that were site-specific in the six-year analysis were dependent on the observation period.

3.8. Registry data-quality findings

During the preliminary data audit, there were differences found between registered registration dates and annual workbook labels, possible repeated patient names, incomplete sex recording and missing diagnostic information. The percentage of records that met the primary analytical eligibility criteria decreased from 98.0% in 2021 to 90.1% in 2026.The 2026 workbook also included records from previous calendar years and dates beyond October 22, 2026. These results highlight the need to be careful in interpreting the 2026 results and raise questions about the comparability of data from the annual registries.

4. Discussion

4.1. Principal findings

The six-year retrospective registry study showed large differences in age distribution, relatively stable sex composition and statistically significant but small differences in cancer diagnostic case mix. Breast cancer was the most common malignancy recorded followed by lung cancer, bladder cancer, prostate cancer and malignant brain neoplasms. There was a statistically significant association between diagnostic composition and calendar year, but the effect size was very small, implying

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that there was limited temporal variation in the overall distribution of cancer diagnoses. The complete six-year analysis showed changes in the relative representation of breast cancer and malignant brain neoplasms by site-specific temporal regression. However, these associations were not statistically significant after correction for multiple testing when the analysis was restricted to 2021–2025, indicating that inclusion of 2026 data was sensitive. The results indicate a general consistency in the institutional oncology case mix.

4.2. Cancer case-mix and comparison with global evidence

In the current study, breast cancer was the most commonly recorded malignancy, accounting for 24.0% of eligible oncology registry records. The next most commonly recorded malignancies were lung cancer (9.2%), bladder cancer (5.2%), prostate cancer (5.1%) and malignant brain neoplasms (4.7%). The distribution reflects the dominance of breast cancer in the study institution and shows the presence of many other major malignancies contributing to its clinical workload. The predominance of breast cancer was consistent with national cancer statistics from Iraq. The Iraqi Cancer Registry Annual Report 2022 identified breast cancer as the most frequently diagnosed cancer nationally, accounting for 21.2% of registered cancer cases. Lung and colorectal cancers were also among the most frequently recorded malignancies [40]. Similarly, the World Health Organization's Iraq cancer profile reported breast cancer as the leading cancer by incidence in 2018, representing 20.3% of cases, followed by lung cancer (8.4%) and bladder cancer (5.7%), [4]These findings suggest broad similarities between the diagnostic profile observed in the present institutional registry and the patterns reported in national Iraqi cancer statistics. At the global level, the findings also share some similarities with international cancer statistics, although the ranking of cancer sites differs. According to the Global Cancer Observatory estimates for 2022, lung cancer was the most frequently diagnosed cancer worldwide, followed by female breast cancer, colorectal cancer, prostate cancer, and stomach cancer. Breast cancer was the most frequently diagnosed malignancy among women globally [40]. The high proportion of breast cancer in the present study was therefore consistent with its substantial contribution to the global cancer burden, while its first-place ranking in this institutional registry differs from the worldwide ranking across both sexes.

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According to GLOBOCAN 2022, lung cancer was the most commonly diagnosed cancer worldwide, followed by female breast, colorectal, prostate and stomach cancers. But the current study demonstrated that the most common diagnosis in eligible records at the study center was breast cancer. This difference was not necessarily a contradiction, but could be due to differences in the type of registry data studied, the populations included, referral patterns and case ascertainment [41]. Consideration must also be given to the comparability of the current institutional findings with national and international cancer statistics, considering that the criteria and methods of case ascertainment may differ. The proportions reported in this study represent the distribution of eligible records at a single tertiary oncology center and should not be interpreted as population-based incidence proportions or rates [42].

4.3. Magnitude of temporal case-mix variation

Despite the statistically significant association between calendar year and diagnostic composition, the observed Cramér's V of 0.036 indicates a very small association. This finding was particularly relevant when analyzing large administrative data sets. “Statistical significance alone was not necessarily an indication that the make-up of the oncology population has changed to such an extent that it has caused significant clinical or operational repercussions. Thus, the findings of the present study suggest that the institutional distribution of major cancer diagnoses remained relatively stable, despite the presence of detectable annual variations. This observation might be relevant for service planning as the continuing demand for management of common malignancies may justify continuation of established oncology services. However, the case-mix of the registry alone was not sufficient to estimate the workload of treatment, staffing needs or resource use. There was little variation in the distribution of cancer diagnoses, although it varied a lot across the 6 years of the study (2021–2026). The overall comparison revealed a statistically significant difference in the diagnostic composition between the years, but the effect size was limited (Cramér’s V = 0.036). This finding indicates that the total case mix was relatively stable, with year-to-year variations in the relative distribution of reported cancer types being noticeable. Statistical significance should therefore not be read as evidence for large changes in the institutional cancer profile. Sex composition did not show significant temporal difference, which further supported the stability of the overall case mix ($\chi 2(5) = 1.88$, $p = 0.865$). Conversely, age distributions differed widely across the study period

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(Kruskal–Wallis H (5) = 21.83, p = 0.00057). Descriptively, the mean age increased from 52.7 years in 2021 to 55.3 years in 2026. The difference observed does not prove a particular underlying demographic or epidemiologic mechanism, though this pattern may suggest a shift toward older patients in the later years of the study. Site-specific temporal analyzes demonstrated decreased relative representation of breast cancer records (odds ratio per year = 0.966, 95% CI: 0.944–0.988; p = 0.0032; false discovery rate-adjusted q = 0.038) and increased representation of malignant brain neoplasms (odds ratio per year = 1.068, 95% CI: 1.019–1.119; p = 0.0063; q = 0.038). These associations remained statistically significant after correction of the false discovery rate in the primary analysis. But the sensitivity analysis limited to the years 2021-2025 showed no association remaining after correction. The variation seen could be due to a combination of factors (eg, change in referral patterns, service utilization, diagnostic practices, and comprehensiveness of annual data capture). The final year of the study may have been affected by the lower proportion of eligible individuals in 2026 and the potential incompleteness of records from that year. In addition, the lack of reliable unique patient identifiers prevents the ability to confirm that all records are associated with unique individuals. The results taken together suggest that the institutional cancer case mix showed a statistically detectable temporal variation, but of smaller magnitude. Age distributions and the proportional representation of selected cancer sites changed over time, whereas the sex composition was stable. These results relate to changes in the mix of institutional cases captured. They should not be taken as evidence of changes in population-level cancer incidence or risk. The observed Cramér's V was 0.036, indicating a very small association, despite the statistically significant association between calendar year and diagnostic composition. This was an important distinction, because the p-value tells you something about the evidence against the null-hypothesis, whereas an effect-size measure was useful for describing the scale of the observed association [43].

4.4. Temporal associations for breast cancer and malignant brain neoplasms

In the six-year temporal regression, a statistically significant decrease in relative representation of breast cancer and increase in relative representation of malignant brain neoplasms were observed. There are many reasons to be cautious in interpreting these results. The results describe relative proportions of diagnostic observations rather than absolute incidence of disease. Second, the estimated odds ratios were not adjusted for

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age, sex or any other potential explanatory factors. Third, observations may include multiple registrations for individual patients. Fourth, the 2026 dataset might have affected the estimated temporal associations. Of particular interest was the evidence obtained by the sensitivity analysis.

4.5. Stability of sex composition

Slightly more than half of the eligible observations in the six-year period were female records. The overall distribution by sex was stable, as no statistically significant association was found between sex composition and calendar year. Breast cancer's strong contribution to the registry may be partly explained by the relatively high percentage of female records. But this was only a descriptive statement and does not give a formal breakdown of sex composition by diagnostic category. The results should not be interpreted as evidence of a higher incidence of cancer among females in the general population, since the study does not establish unique incident cases and does not have population denominators.

4.6. Variation in age distribution

The Kruskal-Wallis test indicated that the age distributions for the six calendar years were significantly different. The median age increased from 55 to 57 years and the mean age increased from 52.7 to 55.3 years, which may suggest the gradual shift to older registered oncology cases. The impact of aging on the global cancer burden has been extensively reported [44]. However, the institutional age pattern may also reflect changes in registration practices, diagnostic mix, availability of treatment or referral patterns. The latter results cannot determine an independent linear trend of aging in the present analytic framework because there is no multivariable adjustment or pairwise post-hoc testing.

4.7. Importance of sensitivity analysis

This study makes an important contribution to methodology in showing that the period of observation can change statistically significant temporal associations. The limited analysis for 2021–2025 reduced the evidence for the associations found for breast cancer and malignant brain neoplasms. This highlights the significance of not relying on the results of a single analytical specification in longitudinal registry studies.

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4.8. Registry quality and implications for cancer surveillance

The study identified several data quality issues that are relevant to longitudinal cancer surveillance. The analytical cohort may not be fully representative due to incomplete demographic data and missing diagnostic codes. Multiple registrations can affect the yearly totals and also break the assumption of independent observations. Differences between years of workbook entry and registration dates may lead to temporal misclassification. These problems suggest the need for standardized electronic registration systems, unique patient identifiers, and uniform quality-assurance procedures. Systematic data validation, consistent case definitions and reliable diagnostic classification are highlighted in international guidelines for cancer registration [45]. Data-quality findings from this study emphasize the importance of evaluating completeness, comparability, validity, and timeliness when interpreting cancer registry data. The completeness of annual reporting, the classification of dates, and the absence of information can vary, affecting the comparability of observations over time. Standardizing definitions in annual reporting, strengthening the data validation processes, and using reliable patient identifiers may improve the quality and interpretability of future longitudinal analyzes [46]. The enhancement of these components would improve the capacity of tertiary oncology centers in Iraq to provide valuable information for institutional planning and broader cancer surveillance.

4.9. Implications for oncology service planning

Breast and lung cancers are common and demonstrate a continuing need for services related to these cancers within institutions. Relatively stable overall case-mix may help maintain continuity of core oncology service delivery. The observed differences in age distribution may also be relevant for supportive care, treatment assessment and multidisciplinary management.

4.10. Study strengths

The investigation employed a large number of oncological records and six consecutive annual registry datasets. It includes descriptive epidemiological data analysis, formal hypothesis testing, effect size estimation, site-specific temporal regression, multiple testing correction, and sensitivity analysis. Findings were not inflated because of the distinct separation of registry records and individual patients.

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The study also discusses the longitudinal findings regarding the data quality assessment.

4.11. Study limitations

This inquiry has numerous constraints. First, the single-center design limits the generalizability of the findings to other oncology institutions or the Iraqi population as a whole. Secondly, the unit of analysis was the registry record, not the unique patient, and repeated registrations could not be identified reliably. Third, the within-patient correlation potential could affect statistical significance and standard errors. Fourth, selection bias can arise due to the absence of diagnostic or demographic information. Fifth, differences between the recording dates and the workbook years may affect annual comparisons. Sixth, the 2026 dataset included records dated in the future relative to the analysis date, and it was unclear how to classify these records temporally or in terms of reporting completeness. Seventh, site-specific regression models were not adjusted for age and sex, which limits the interpretation of causal or independent-association relationships. Eighth, cancer incidence or age-standardized rates could not be estimated in the study due to the lack of population denominators. Finally, the observational design does not enable us to make causal conclusions about the causes of observed changes in institutional diagnostic composition. There were no reliable unique identifiers for patients, which made it impossible to distinguish between the records of different individuals and repeated registrations with certainty. Thus, the results are descriptive of eligible registry records and not a verified count of unique patients. The single-center design and absence of population denominators also limit the generalizability of the study and preclude calculation of population-based cancer incidence rates [41].

5. Conclusions

This six-year retrospective analysis of oncology registry records from a tertiary cancer center in Iraq demonstrated modest temporal variation in cancer diagnostic case-mix and significant differences in age distributions, alongside relatively stable sex composition. Breast cancer remained the most frequently recorded malignancy, followed by lung cancer and other common solid tumors. Although the overall diagnostic composition differed significantly across years, the small effect size suggests limited structural change in the institutional case-mix. In the detailed six-year analysis,

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the exploratory temporal regression revealed statistically significant associations between malignant brain neoplasms and breast cancer. But the results were no longer significant after correction for multiple testing when the observation time was limited to 2021–2025.Thus, there was not strong evidence from the results for sustained temporal changes specific to a particular site. The study demonstrates the potential utility of longitudinal hospital registry analysis to understand the composition of oncology services, but also emphasizes the importance of registry quality, proper statistical interpretation and sensitivity analyzes. Standardized registration procedures and reliable patient identification would improve the validity of future longitudinal cancer studies in Iraq.

6. Recommendations

1. Develop standardized procedures for cancer registries. Develop and implement standardized electronic recording systems, ICD-10 coding conventions and annual reporting definitions for oncology institutions.

2. Improve patient identification. Develop patient identifiers that are reliable and unique and that can distinguish between new diagnoses and repeat registrations and follow-up encounters.

3. Improve monitoring of data quality. Do regular assessments to find any potential duplicate records, inconsistent dates, invalid values, and missing information.

4. Longitudinal case-mix monitoring must be implemented. Review institutional patterns of oncology based on both absolute numbers and relative proportions of diagnoses.

5. Add sensitivity analyzes and effect sizes. Future registry studies should report the robustness and magnitude of statistical associations rather than relying on p-values.

6. Look for demographic differences. More record-level analyzes study performed to determine if age-related changes are still present when sex and cancer diagnostic composition are considered.

7. Scale up multi-center research. To compare institutional patterns between several oncology centers in Iraq to assess the consistency of the observed distribution of diagnosis and demographic.

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8. Strengthen the link with cancer surveillance systems. Where possible, link validated population-based cancer registration systems to hospital-based records to support more reliable epidemiologic evaluations.

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