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Original Article

Epidemiology of Multiple Primary Malignancies in Pakistan: A Population-Based Study

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ABSTRACT

Background: Cancer surveillance in Pakistan remains limited by incomplete population-level registration and uneven regional reporting, making hospital-based registry analyses useful for describing diagnosed case patterns within major oncology centers. Objective: This study aimed to describe the distribution of breast cancer, lung cancer, lymphoma, and colorectal cancer by sex, age group, and region among cancer patients registered at the Institute of Nuclear Medicine and Oncology, Lahore, during 2022–2023. Methods: A retrospective cross-sectional analysis was conducted using hospital-based registry records retrieved from the Health Management Information System and related clinical documentation. Confirmed registered cases of breast cancer, lung cancer, lymphoma, and colorectal cancer were included. Variables included cancer type, sex, age group, and region of residence. Data were summarized using frequencies and percentages, with interpretation restricted to descriptive hospital-registry patterns. Results: Among 4,460 registered cases, breast cancer was the most frequent malignancy with 3,456 cases (77.49%), followed by lung cancer with 419 cases (9.39%), lymphoma with 392 cases (8.79%), and colorectal cancer with 193 cases (4.33%). Based on cancer-specific sex counts, females accounted for 3,780 cases (84.75%) and males for 680 cases (15.25%). Breast cancer was predominantly recorded among females, whereas lung cancer, lymphoma, and colorectal cancer were more frequent among males. Punjab contributed 4,410 registered cases (98.88%). Conclusion: Breast cancer represented the dominant registered malignancy in this hospital-based dataset, while lung cancer showed a marked male predominance and Punjab accounted for most recorded cases. Findings should be interpreted as hospital-registry patterns rather than national incidence estimates. Keywords: Cancer registry, Breast cancer, Lung cancer, Lymphoma, Colorectal cancer, Hospital-based registry, Pakistan, Cancer surveillance.

INTRODUCTION

Cancer remains a major contributor to morbidity and premature mortality worldwide, with its burden increasingly shifting toward low- and middle-income countries where screening coverage, diagnostic access, treatment pathways, and surveillance systems are often unevenly developed. Malignant disease arises through progressive disruption of cellular growth control, genomic stability, tissue invasion mechanisms, immune regulation, and metastatic capacity, producing heterogeneous clinical patterns across anatomical sites, age groups, sexes, and geographic populations (1–7). For health systems, this heterogeneity makes registry-based cancer surveillance essential, because reliable information on cancer

distribution is required for planning screening services, oncology infrastructure, treatment capacity, referral pathways, and prevention strategies.

In Pakistan, cancer control remains challenged by incomplete population-level cancer registration, variable access to diagnostic facilities, delayed presentation, and regional disparities in oncology care. Published evidence from Pakistan has consistently suggested that cancer patterns differ by province, sex, age group, and tumor type, with breast cancer representing a dominant malignancy among females, lung cancer remaining strongly associated with tobacco and environmental exposures, lymphoma affecting both younger and older populations, and colorectal cancer reflecting combined genetic, inflammatory, dietary, and lifestyle-related risk factors (8–13). However, available national estimates remain limited by fragmented registry coverage and variable reporting completeness, which restricts the ability to generate fully representative incidence, mortality, and survival estimates across the country.

Hospital-based cancer registry data therefore provide an important, although not population-representative, source of evidence for describing the pattern of diagnosed and treated cancer cases within major oncology centers. The Institute of Nuclear Medicine and Oncology, Lahore, functions under the Pakistan Atomic Energy Commission cancer care network and receives a large number of patients from Punjab and other regions. Analysis of its registered cancer records can help identify the distribution of common malignancies by sex, age group, and region of residence, while also highlighting the referral concentration and reporting gaps that must be considered when interpreting hospital-based registry findings.

The present study was conducted to describe the distribution of breast cancer, lung cancer, lymphoma, and colorectal cancer among confirmed cancer patients registered at the Institute of Nuclear Medicine and Oncology, Lahore, during 2022–2023. Specifically, the study aimed to examine the frequency of these malignancies according to sex, age group, and regional distribution, and to generate evidence that may support cancer surveillance strengthening, service planning, and targeted early detection strategies in Pakistan.

MATERIAL AND METHODS

This retrospective cross-sectional study was conducted using hospital-based registry data of confirmed cancer patients registered at the Institute of Nuclear Medicine and Oncology, Lahore, Pakistan, during 2022–2023. The study used records retrieved from the Health Management Information System and related hospital documentation maintained for patient registration, clinical record keeping, diagnostic confirmation, treatment planning, and administrative reporting. The hospital operates under the Pakistan Atomic Energy Commission cancer care network and serves as a major oncology referral and treatment facility, particularly for patients from Punjab and surrounding regions. Because the analysis was based on registered hospital records rather than complete population enumeration, the findings were interpreted as hospital-based cancer registry patterns and not as national population incidence estimates.

The study population included confirmed cases of breast cancer, lung cancer, lymphoma, and colorectal cancer registered during the study period. Eligible records were those of diagnosed cancer patients admitted or registered for treatment at the hospital and having available information on cancer type and core demographic variables. The extracted variables included age, sex, region of residence, family history where available, and diagnosed cancer type. Cancer diagnoses were verified from hospital sources including medical records, outpatient department records, inpatient ward records, laboratory documentation, and treatment-related files. These sources were used to confirm the recorded diagnosis and to reduce misclassification of cancer type during data extraction.

Patients were categorized by age into adolescents aged 10–19 years, adults aged 20–39 years, middle-aged adults aged 40–59 years, and older adults aged 60 years and above. Sex was recorded as male or

female according to hospital registration records. Regional distribution was classified according to the patient's recorded area of residence, including Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan, Kashmir, and Islamabad where available. Cancer type was operationally defined as the primary diagnosis recorded in the hospital registry for one of the four included malignancy categories: breast cancer, lung cancer, lymphoma, or colorectal cancer. To maintain interpretive consistency, each record was analyzed according to the documented cancer category used for registry classification.

Data were extracted from existing hospital records using a retrospective review approach. The registry and related hospital documents were reviewed for the predefined demographic and diagnostic variables, and the information was compiled into an analytic dataset for descriptive analysis. To minimize information bias, cancer type was cross-checked across available hospital documentation wherever diagnostic and clinical records were accessible. Classification bias was addressed by restricting the analysis to confirmed diagnosed cases within the four prespecified cancer categories. Because the study was descriptive and registry-based, no exposure-outcome causal model was specified, and confounding adjustment was not performed.

The final analysis included 4,460 registered cancer cases distributed across the four included malignancy groups. Categorical variables were summarized as frequencies and percentages using the relevant denominator for each analysis. Overall cancer-type distribution was calculated using the total number of included cancer cases as the denominator. Sex-wise, age-wise, and region-wise distributions were summarized using category-specific denominators where complete data were available. No inferential hypothesis testing was applied unless complete and internally consistent denominator data were available for the relevant comparison. The analysis was therefore focused on descriptive epidemiological reporting of registered hospital cases rather than estimation of population incidence, mortality, survival, or causal risk.

Data integrity was maintained by using predefined variables, consistent category definitions, and cross-verification of diagnostic information from available hospital sources. The analysis was limited to variables documented in the hospital records, and interpretation was restricted to the scope of the registry dataset. Because the study used retrospective hospital records, patient recruitment and prospective consent procedures were not applicable to the analytic design. The study was conducted as a record-based review of registered cancer cases, with findings reported in aggregate form to describe cancer distribution patterns without identifying individual patients.

RESULTS

A total of 4,460 registered cancer cases were included in the analysis. The four malignancy categories assessed were breast cancer, lung cancer, lymphoma, and colorectal cancer. Breast cancer represented the largest diagnostic category, followed by lung cancer, lymphoma, and colorectal cancer.

Table 1. Overall Distribution of Cancer Types Among Registered Cases

Cancer Type	n	%
Breast cancer	3,456	77.49
Lung cancer	419	9.39
Lymphoma	392	8.79
Colorectal cancer	193	4.33
Total	4,460	100.00

Breast cancer accounted for 3,456 of 4,460 registered cases, representing more than three-fourths of the included malignancies. Lung cancer was the second most frequent category with 419 cases, followed by lymphoma with 392 cases and colorectal cancer with 193 cases. The distribution shows a marked predominance of breast cancer within the registered hospital-based dataset.

Table 2. Sex-Wise Distribution Within Each Cancer Type

Cancer Type	Male n	Male %	Female n	Female %	Total n
Breast cancer	18	0.52	3,438	99.48	3,456
Lung cancer	339	80.91	80	19.09	419
Lymphoma	209	53.32	183	46.68	392
Colorectal cancer	114	59.07	79	40.93	193
Total	680	15.25	3,780	84.75	4,460

The sex-wise distribution differed substantially by cancer type. Breast cancer was overwhelmingly recorded among females, with 3,438 female cases and 18 male cases. Lung cancer showed a male predominance, with 339 male cases compared with 80 female cases. Lymphoma was more evenly distributed but remained slightly higher among males, while colorectal cancer also showed a higher number of male cases than female cases. Based on the cancer-specific sex counts, the overall sex distribution was 680 males and 3,780 females among the 4,460 registered cases.

Table 3. Age-Wise Distribution Where Internally Traceable From Reported Cancer-Type Counts

Age Group	Breast Cancer n	Lung Cancer n	Lymphoma n	Colorectal Cancer n	Total n
Adolescents, 10–19 years	4	1	22	4	31
Adults, 20–39 years	626	66	76	40	808
Middle-aged adults, 40–59 years	1,976	246	222	92	2,536
Older adults, ≥60 years	898	209	170	61	1,338

Among adolescents aged 10–19 years, lymphoma was the most frequently recorded malignancy, accounting for 22 of 31 cases. Among adults aged 20–39 years, breast cancer was the dominant category, with 626 of 808 cases. The same pattern was observed among middle-aged adults aged 40–59 years, where breast cancer accounted for 1,976 of 2,536 cases. In the reported older-adult category, breast cancer remained the most frequent malignancy, followed by lung cancer, lymphoma, and colorectal cancer.

Table 4. Regional Distribution of Registered Cancer Cases Where Reported

Region	n	%
Punjab	4,410	98.88
Khyber Pakhtunkhwa	21	0.47
Kashmir	16	0.36
Sindh	6	0.13
Not reconciled in reported regional totals	7	0.16
Total	4,460	100.00

Most registered cases were from Punjab, which accounted for 4,410 of 4,460 cases. Khyber Pakhtunkhwa contributed 21 cases, Kashmir contributed 16 cases, and Sindh contributed 6 cases. The reported regional counts accounted for 4,453 cases, leaving 7 cases not reconciled within the stated regional distribution. Although Balochistan and Islamabad were mentioned in the manuscript, specific numeric counts for these regions were not provided in the reported results.

Table 5. Sex-Wise Cancer Distribution in Punjab

Cancer Type	Male n	Female n	Total n
Breast cancer	18	3,408	3,426
Lung cancer	335	78	413
Lymphoma	310	70	380
Colorectal cancer	109	82	191
Total	772	3,638	4,410

In Punjab, breast cancer was the most frequently reported malignancy, with 3,426 cases, nearly all of which were recorded among females. Lung cancer was predominantly recorded among males, with 335 male cases and 78 female cases. Lymphoma and colorectal cancer were also more frequently recorded among males than females in the Punjab subset. The Punjab data accounted for nearly the entire hospital-based registry sample, indicating that the findings are strongly weighted toward cases from this province.

Among the smaller regional subsets, Khyber Pakhtunkhwa had 21 reported cases, with breast cancer representing the largest category. Sindh had 6 reported cases, including 4 breast cancer cases, 1 lung cancer case, and 1 lymphoma case

Table 6. Reported Cancer Distribution in Khyber Pakhtunkhwa, Sindh, and Kashmir

Region	Breast Cancer n	Lung Cancer n	Lymphoma n	Colorectal Cancer n	Total n
Khyber Pakhtunkhwa	13	1	6	1	21
Sindh	4	1	1	0	6
Kashmir	9	4	2	1	16

. Kashmir had 16 reported cases, with breast cancer again representing the largest category, followed by lung cancer. These regional subsets were small compared with Punjab and should therefore be interpreted descriptively rather than as stable estimates of provincial cancer burden.

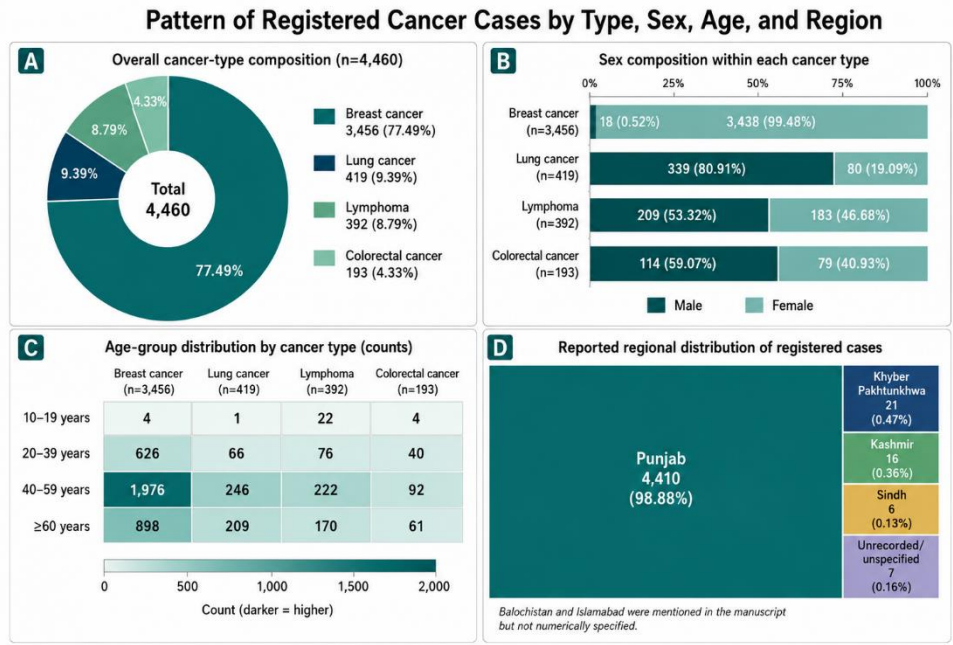

Figure 1 The figure presents a four-panel descriptive summary of registered cancer cases by cancer type, sex, age group, and region in a hospital-based registry analysis from INMOL Lahore during 2022–2023. Panel A shows the overall cancer-type composition among 4,460 registered cases. Breast cancer was the dominant malignancy, accounting for 3,456 cases (77.49%), followed by lung cancer with 419 cases (9.39%), lymphoma with 392 cases (8.79%), and colorectal cancer with 193 cases (4.33%). Panel B presents the sex distribution within each cancer type. Breast cancer was recorded predominantly among females, with 3,438 female cases (99.48%) and 18 male cases (0.52%). Lung cancer showed a marked male predominance, with 339 male cases (80.91%) and 80 female cases (19.09%). Lymphoma was more evenly distributed but remained slightly higher among males, with 209 male cases (53.32%) and 183 female cases (46.68%). Colorectal cancer was also more frequent among males, with 114 male cases (59.07%) compared with 79 female cases (40.93%). Panel C displays age-group distribution by cancer type. Breast cancer was most frequent in the 40–59 years age group, with 1,976 cases, followed by 898 cases among those aged ≥60 years and 626 cases among adults aged 20–39 years. Lymphoma contributed most prominently among adolescents aged 10–19 years, with 22 cases in that group. Lung cancer and colorectal cancer were also most frequent in the 40–59 years age group, with 246 and 92 cases, respectively. Panel D shows the reported regional distribution of registered cases. Punjab contributed the overwhelming majority, with 4,410 cases (98.88%). Smaller numbers were reported from Khyber Pakhtunkhwa 21 cases (0.47%), Kashmir 16 cases (0.36%), and Sindh 6 cases (0.13%). A further 7 cases (0.16%) were unreconciled or unspecified. Balochistan and Islamabad were mentioned in the manuscript but were not numerically specified.

Overall, the figure indicates that the dataset is heavily dominated by breast cancer cases and by patients registered from Punjab. The findings should be interpreted as hospital-based registry patterns, not national population-level incidence estimates.

DISCUSSION

This hospital-based registry analysis described the distribution of breast cancer, lung cancer, lymphoma, and colorectal cancer among 4,460 registered cancer cases at the Institute of Nuclear Medicine and Oncology, Lahore, during 2022–2023. The findings showed a marked predominance of breast cancer,

which accounted for more than three-fourths of the included cases, followed by lung cancer, lymphoma, and colorectal cancer. This pattern should be interpreted in the context of the study setting, because the data represent registered cases at a major oncology referral hospital rather than a complete population-based cancer registry. The very large contribution of Punjab to the dataset further indicates that the results primarily reflect the referral and registration profile of INMOL Lahore, with limited ability to estimate true national or provincial incidence.

The predominance of breast cancer in the present dataset is consistent with the broader pattern reported in Pakistan, where breast cancer remains a leading malignancy among women and represents a major cancer-control priority. In the present analysis, breast cancer was overwhelmingly concentrated among females, although a small number of male breast cancer cases were also recorded. This finding supports the need for strengthened breast cancer awareness, timely clinical evaluation of breast symptoms, accessible diagnostic pathways, and structured screening or early-detection strategies where feasible. However, because the present study did not include population denominators, stage at diagnosis, treatment delay, survival, or mortality data, the findings should not be interpreted as incidence rates or outcome estimates. Rather, they identify breast cancer as the dominant cancer category among registered cases in this hospital-based registry (21,25).

Lung cancer showed a clear male predominance in the registered cases, with males accounting for the majority of lung cancer records. This pattern is biologically and epidemiologically plausible in view of known associations between lung cancer and tobacco exposure, occupational hazards, air pollution, and environmental carcinogens, several of which have been reported as relevant risk factors in Pakistan. Nevertheless, the present dataset did not include smoking status, occupational exposure, environmental exposure, histological subtype, stage, or treatment outcome; therefore, the observed sex distribution should be interpreted descriptively rather than causally. Future registry studies should integrate exposure history and tumor characteristics to clarify whether the observed male predominance is explained by tobacco use, occupational exposure, delayed presentation, or referral patterns (17,18).

Lymphoma represented the third most frequent cancer category overall and showed a comparatively higher contribution among adolescents than the other included malignancies. This pattern is clinically meaningful because lymphoid malignancies often have distinct age-related distributions, with some lymphoma subtypes occurring more frequently in younger populations. However, the current registry dataset did not distinguish Hodgkin lymphoma from non-Hodgkin lymphoma, did not report histopathological subtypes, and did not include staging or treatment-response data. These missing details limit disease-specific interpretation and should be addressed in future work through subtype-level reporting, standardized diagnostic classification, and linkage of registry records with pathology and treatment databases (14).

Colorectal cancer was the least frequent of the four malignancy categories in the present study, but cases were distributed across multiple age groups. This distribution is compatible with the multifactorial nature of colorectal cancer, where genetic predisposition, inflammatory bowel disease, obesity, diet, physical inactivity, and other lifestyle-related factors may contribute to disease occurrence. The present dataset, however, did not include anatomical subsite, family history completeness, body mass index, dietary factors, colonoscopy findings, histological subtype, or tumor stage. Therefore, the study can describe the frequency of colorectal cancer among registered cases but cannot determine risk factors, screening gaps, or prognosis within this population (16,22).

The regional distribution was heavily dominated by Punjab, which accounted for nearly all reported cases. This finding should not be interpreted as evidence that Punjab has the highest true cancer incidence in Pakistan without population-adjusted denominators and complete national registry coverage. It more likely reflects a combination of hospital catchment area, geographic accessibility, referral pathways, patient preference, diagnostic availability, and registration completeness. The manuscript also mentioned Balochistan and Islamabad, but numeric counts for these regions were not

available in the reported results, and seven cases remained unreconciled within the regional totals. This reinforces the need for complete, standardized regional coding in registry datasets before reliable comparisons across provinces can be made (15).

A major strength of the study is its use of real-world hospital registry data from a major oncology center, allowing description of common cancer categories by sex, age group, and region of residence. The study also highlights the practical value of cancer registry systems for identifying service demand and guiding hospital-level planning. However, the study has important limitations. First, the hospital-based design limits generalizability to the national population. Second, the dataset appears strongly weighted toward Punjab, restricting interpretation of regional comparisons. Third, the analysis was descriptive and did not include population denominators, age-standardized rates, mortality data, stage distribution, histological subtype, treatment modality, survival, or recurrence. Fourth, several denominator inconsistencies in the manuscript require verification against the original dataset before final submission. These include the originally reported sex totals, older-adult age categories, and incomplete regional reconciliation.

Overall, the findings indicate that breast cancer formed the largest burden among the registered cases, lung cancer was predominantly recorded among males, lymphoma contributed substantially among younger patients, and colorectal cancer represented a smaller but clinically relevant category across age groups. The study supports the need to strengthen hospital-based and population-based cancer registration in Pakistan, improve completeness of demographic and clinical variables, and develop standardized reporting systems that include diagnosis, stage, histology, treatment, follow-up, and outcomes. Such improvements would allow future research to move beyond descriptive case distribution toward robust estimates of incidence, survival, mortality, and preventable cancer burden.

CONCLUSION

This retrospective hospital-based registry analysis of 4,460 cancer cases registered at INMOL Lahore during 2022–2023 showed that breast cancer was the most frequently recorded malignancy, followed by lung cancer, lymphoma, and colorectal cancer. Breast cancer was predominantly recorded among females, lung cancer showed a marked male predominance, lymphoma contributed notably among adolescents, and most registered cases were from Punjab, reflecting the hospital's catchment and referral profile. Because the data were derived from a hospital registry and not a complete population-based national registry, the findings should be interpreted as descriptive patterns of registered cases rather than national incidence, mortality, or survival estimates. Strengthening standardized cancer registration, improving completeness of regional and clinical variables, and linking registry data with diagnostic, treatment, and outcome records are essential for producing more reliable cancer surveillance evidence in Pakistan.

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