



**AL ZAHRAWI UNIVERSITY**  
**COLLGE OF PHARMACY**  
**Graduation Project**

**Evaluation of the Treatment of Leukemic Patients in Central and  
Southern Iraq**

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## Abstract

### Introduction:

Leukemia is a heterogeneous group of hematological malignancies characterized by the uncontrolled proliferation of abnormal white blood cells in the bone marrow and peripheral blood. It comprises four major subtypes: acute lymphoblastic leukemia (ALL), acute myeloid leukemia (AML), chronic lymphocytic leukemia (CLL), and chronic myeloid leukemia (CML), each differing in pathophysiology, prognosis, and therapeutic approach. In Iraq, leukemia represents a growing public health concern, with increasing incidence across diverse age groups.

### Materials and Methods:

A retrospective cross-sectional study was conducted from September 2025 to April 2026, involving 250 leukemia patients from central and southern Iraq. Diagnoses were established by specialist physicians according to World Health Organization (WHO) criteria. Data were collected using a structured form comprising 29 variables across four domains: sociodemographic characteristics, disease and treatment variables, chemotherapy regimens and supportive therapies, and patient follow-up with treatment response based on pre- and post-treatment laboratory findings.

### Results:

Among the 250 patients, males predominated (64%), and the largest proportion were aged over 50 years (37.6%), with most residing in urban areas (71.6%). Acute myeloid leukemia (AML) was the most prevalent subtype (52.8%). Cytarabine (40.0%) and anthracyclines (37.2%) were the most frequently used first-line chemotherapeutic agents. Immunophenotyping using flow cytometry markers (CD19, CD33, CD13, CD4, and HLA-DR) revealed significant associations across leukemia subtypes, with CD19 showing the highest statistical significance ( $p < 0.001$ ). A statistically significant reduction in white blood cell (WBC) counts was observed following treatment, indicating therapeutic effectiveness. Additionally, ondansetron was widely utilized in patients receiving highly emetogenic regimens, particularly cytarabine- and anthracycline-based therapies, demonstrating its role in managing chemotherapy-induced nausea and vomiting.

### Conclusion:

Leukemia management in central and southern Iraq generally aligns with international standards, particularly regarding chemotherapy protocols and immunophenotypic diagnostics. However, challenges remain, including variability in treatment duration, incomplete hematological recovery in some patients, and disparities in healthcare access between urban and rural populations. These limitations reflect constraints in healthcare infrastructure, particularly in advanced diagnostics and supportive care services, which may influence treatment consistency and overall outcomes.

### Aim:

To evaluate medication patterns, therapeutic efficacy, and the use of diagnostic and laboratory monitoring in the management of leukemia patients in Iraq.

**Key words:** leukemia, ALL, AML, CLL, CML, chemotherapy, Anthracyclines.

## 1. Background

Leukemia is a heterogeneous group of hematological malignancies characterized by the uncontrolled proliferation of abnormal white blood cells in the bone marrow and peripheral blood (1). It includes several major subtypes—acute lymphoblastic leukemia (ALL), acute myeloid leukemia (AML), chronic lymphocytic leukemia (CLL), and chronic myeloid leukemia (CML)—each with distinct biological behavior, prognosis, and treatment strategies (2). Globally, leukemia accounts for a significant proportion of cancer-related morbidity and mortality, particularly in low- and middle-income countries where healthcare systems face substantial challenges in diagnosis and management (3).

The etiology of leukemia is multifactorial, involving genetic susceptibility and environmental exposures. Inherited conditions such as Down syndrome, Klinefelter syndrome, Ataxia telangiectasia, and Bloom syndrome increase leukemia risk due to chromosomal instability and impaired DNA repair. Environmental factors, including viral infections (Epstein-Barr virus, Human T-lymphotropic virus type 1), ionizing radiation, benzene exposure, cigarette smoking, and prior chemotherapy, also contribute to disease development (4). Clinical presentation is often nonspecific, with symptoms including fever, fatigue, weight loss, bone pain, bruising, and bleeding. Definitive diagnosis requires bone marrow biopsy, which informs treatment decisions ranging from chemotherapy to allogeneic stem cell transplantation. Prognosis is highly dependent on leukemia subtype (5). Recent therapeutic advances, including tyrosine kinase inhibitors, monoclonal antibodies, and hematopoietic stem cell transplantation, have significantly improved survival rates in high-income settings where comprehensive diagnostics and advanced therapies are accessible (6,7).

In Iraq, leukemia poses a significant public health challenge, with rising incidence across all age groups. The healthcare system, particularly in central and southern regions, faces strain due to years of conflict, economic challenges, and uneven distribution of medical resources (8). While oncology services have expanded in urban centers such as Baghdad, Najaf, and Karbala, access to specialized care remains limited in rural and peripheral areas, leading to delays in diagnosis and treatment initiation that adversely affect patient outcomes (9).

**Objective:** This study aims to evaluate the types of medications, their efficacy, and the utilization of diagnostic and laboratory follow-up tests in the management of leukemia patients in Iraq.

## **2. Materials and Methods:**

### **2.1. Patients and method**

A retrospective cross-sectional study was conducted between September 2025 and April 2026, enrolling 250 leukemia patients from central and southern Iraq, including Babylon, Karbala, Najaf, Al-Qadisiyah, and Al-Muthanna. Diagnosis was established by specialist physicians according to World Health Organization (WHO) criteria. All patients were evaluated comprehensively with documented clinical data and follow-up. Data were collected using a structured form comprising 30 variables organized into four sections. The first section included sociodemographic characteristics (age, sex, and residence). The second section covered disease- and treatment-related variables, including leukemia subtype, number of treatment cycles, and relevant diagnostic tests. The third section included details of chemotherapy regimens, adjuvant therapies, and premedication. The fourth section assessed patient follow-up, outcome, and treatment response.

based on pre- and post-treatment laboratory parameters, including mean corpuscular volume (MCV), platelet count (PLT), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW-CV), lymphocyte count (LYM), platelet large cell ratio (P-LCR), hemoglobin (Hb), and white blood cell count (WBC).

Collected data were entered into Microsoft Excel and subsequently analyzed using IBM SPSS Statistics. Statistical analysis was performed with a 95% confidence level and a 5% margin of error. The required sample size was determined using an online sample size calculator to ensure adequate statistical power.

## **2.2 Statistical analysis:**

Quantitative data were expressed as the median (interquartile range), and qualitative data were expressed as absolute frequencies (number) and relative frequencies (percentage). We used the Chi-square test to compare percentages of categorical variables. Baseline data versus follow-up data was compared by a Wilcoxon Signed Ranks test. We used the Mann-Whitney test to compare two groups of non-normally distributed variables after testing for normality with the Kolmogorov-Smirnov test. All tests were two-sided.  $p$ -value  $< 0.05$  was considered statistically significant (S), and  $p$ -value  $\geq 0.05$  was considered statistically insignificant (NS).

## **3. Results**

In this study, there were a total of 250 patients with leukemia disease distributed regarding their general characteristics.

### **Descriptive Analysis:**

Figure 1,2,3,4 illustrates the baseline demographic and clinical characteristics of the 250 patients in the study cohort. The four panels detail the percentage distribution across gender (majority male at 64%) figure 1, age groups

(predominantly >50 years at 37.6%) figure 2, residence (primarily urban at 71.6%) figure 3, and the primary leukemia diagnosis (with Acute Myeloid Leukemia [AML] being the most prevalent at 52.8%) figure 4.

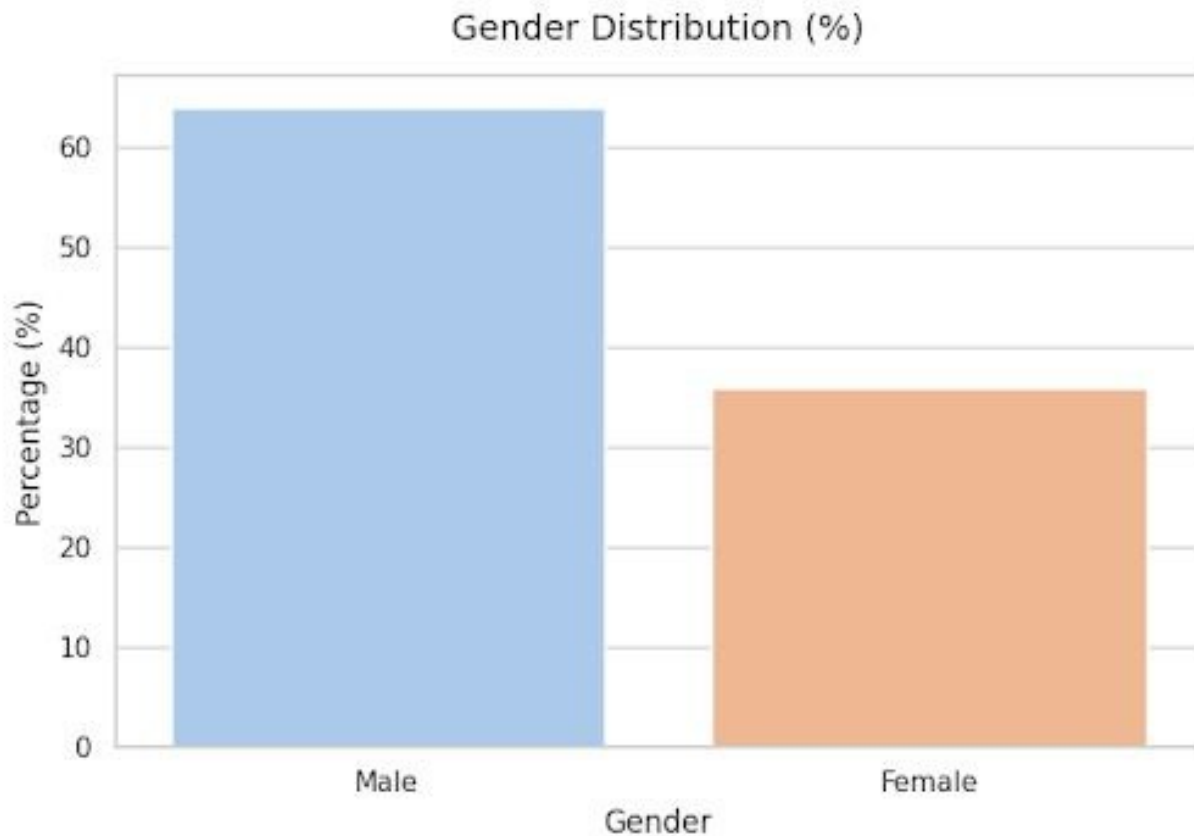


Figure1: The percentage distribution across gender of the Leukemia Patient Cohort (N=250).

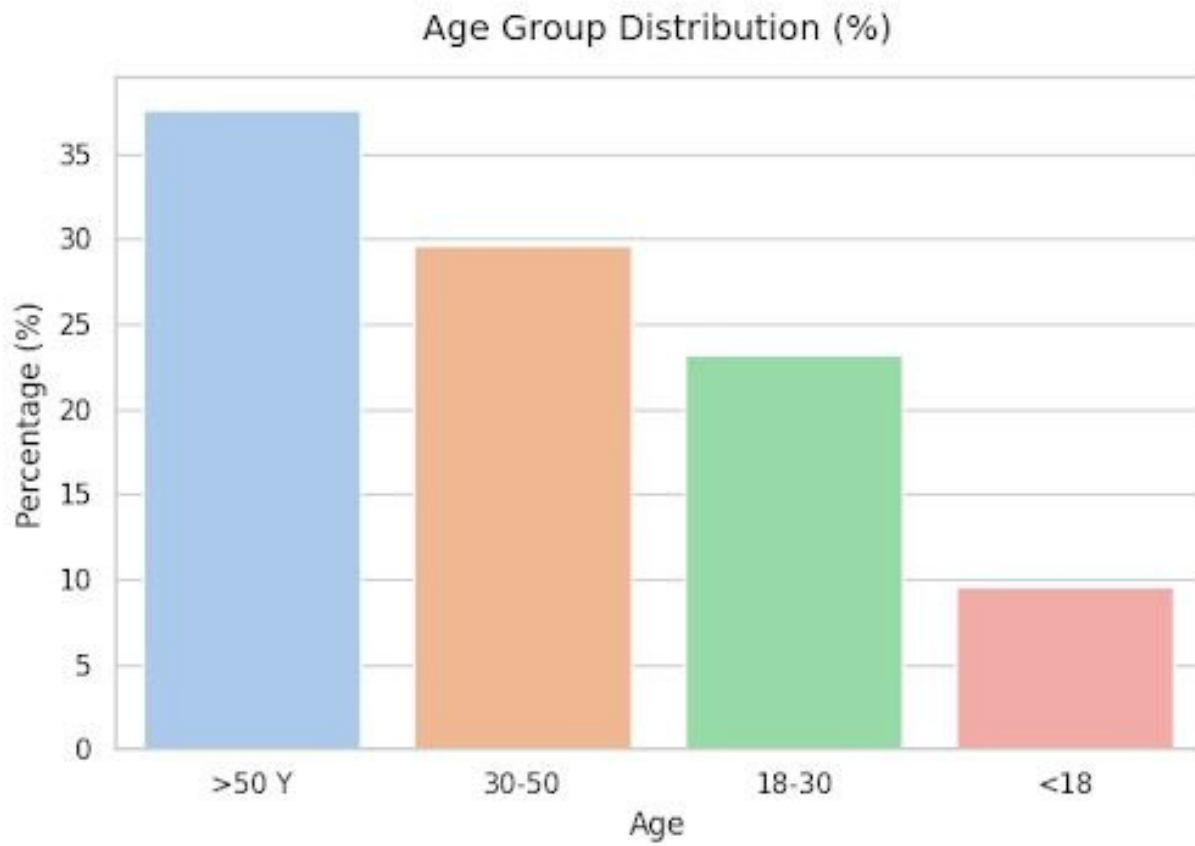


Figure2: The percentage distribution across age groups of the Leukemia Patient Cohort (N=250).

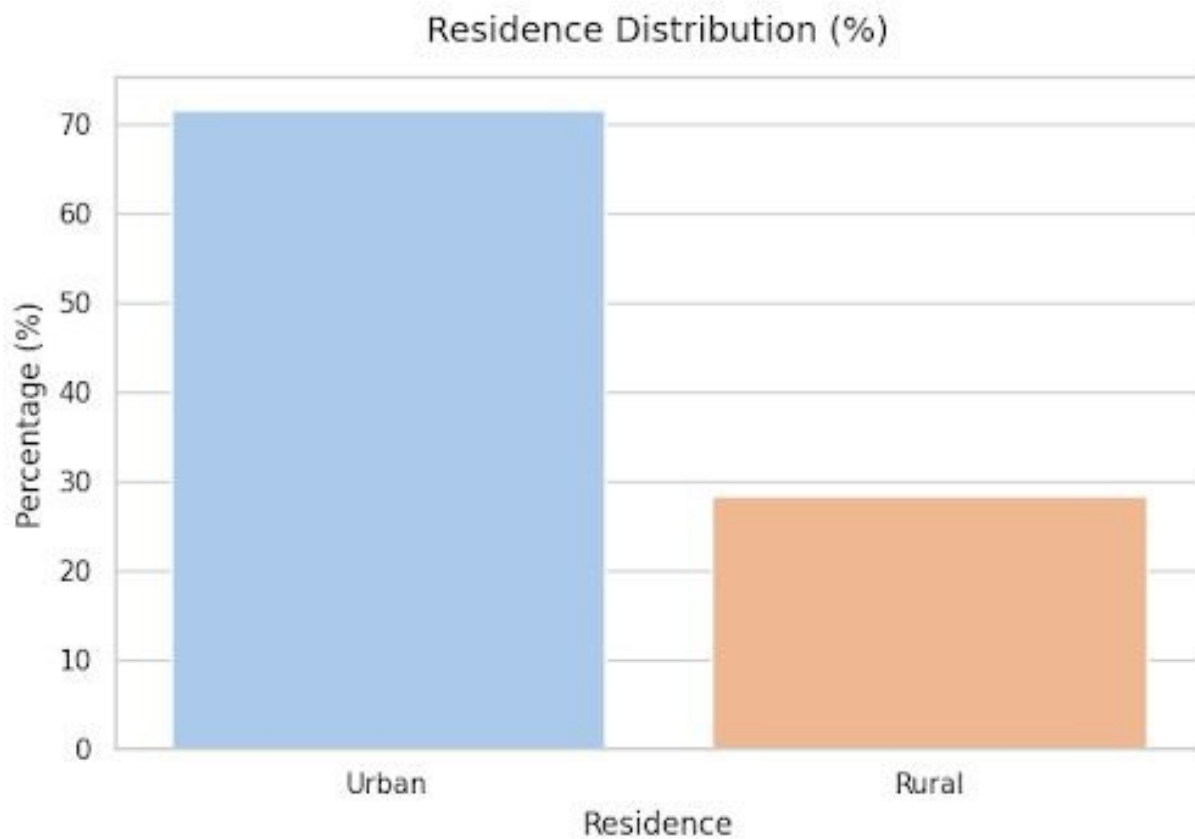


Figure3: The percentage distribution across residence of the Leukemia Patient Cohort (N=250).

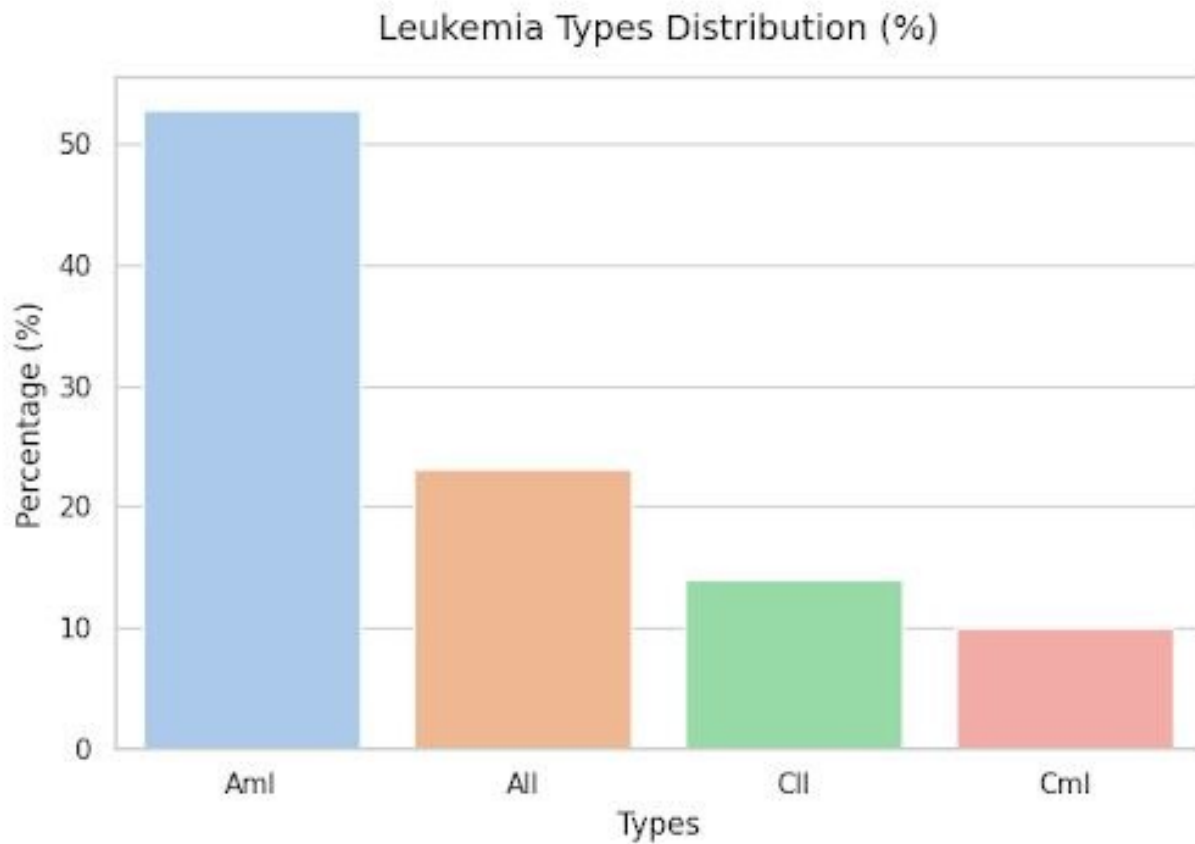


Figure4: The percentage distribution across the primary leukemia diagnosis of the Leukemia Patient Cohort (N=250). Where Acute Lymphocytic Leukemia (ALL), Acute Myeloid Leukemia (AML), Chronic Lymphocytic Leukemia (CLL), Chronic Myeloid Leukemia (CML).

Figure 5 illustrates the distribution of chemotherapeutic agents and adjuvant therapies administered across the patient cohort (N=250). The data indicate that Cytarabine (Cytosar) and Anthracyclines (Doxorubicin, Daunorubicin, Idarubicin) are the most frequently utilized first-line treatments, administered to 40.0% and 37.2% of the patients, respectively.

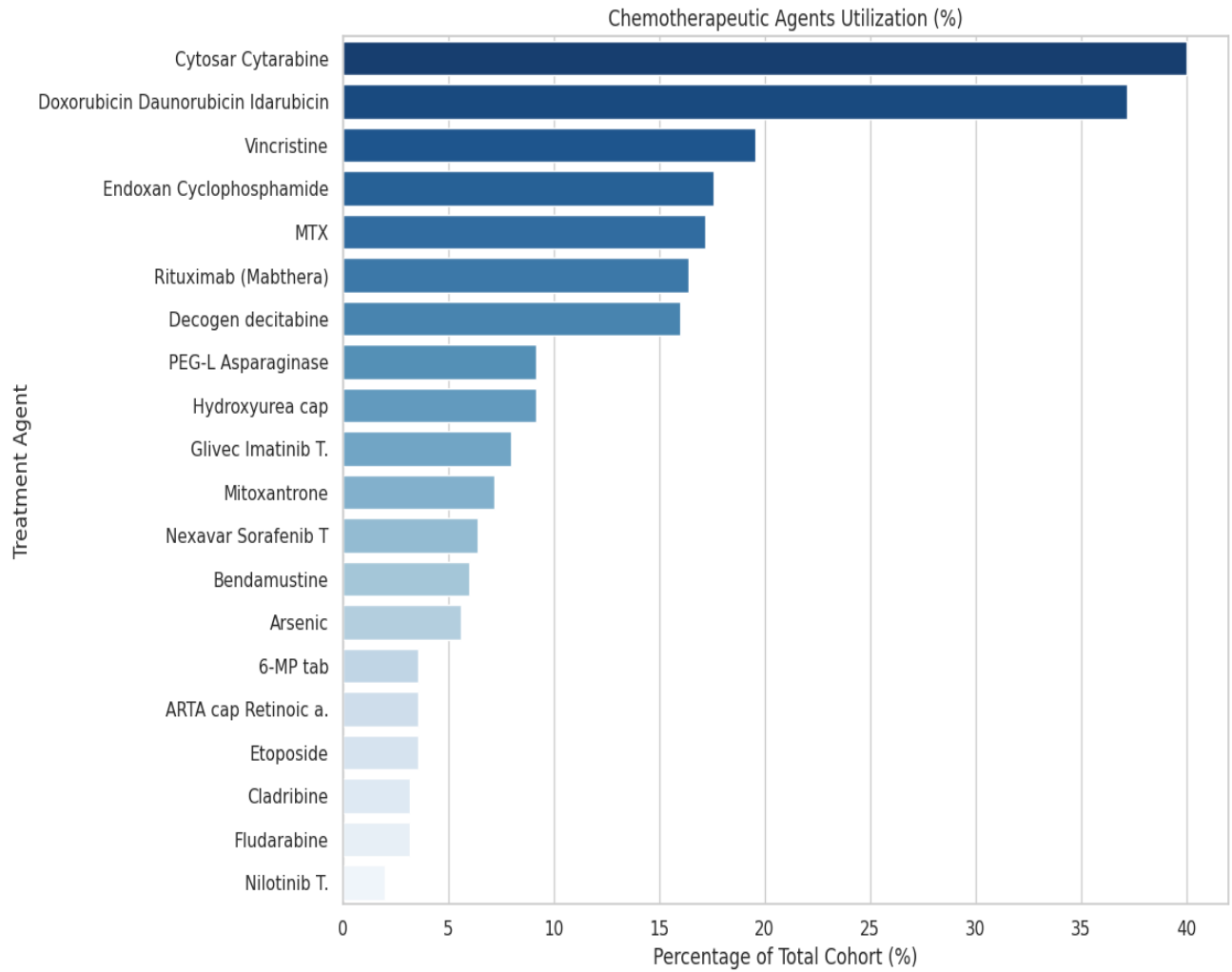


Figure 5: Prevalence of Chemotherapeutic Agents in the Study Cohort

Table 1: Distribution of Chemotherapy Protocols by Leukemia Subtype

Treatment Protocol	AML (n=132)	ALL (n=58)	CLL (n=35)	CML (n=25)	p-value
Cytarabine (Cytosar)	50.0% (66)	53.4% (31)	2.9% (1)	8.0% (2)	< 0.001
Anthracyclines	41.7% (55)	62.1% (36)	2.9% (1)	4.0% (1)	< 0.001
Vincristine	3.8% (5)	69.0% (40)	8.6% (3)	4.0% (1)	< 0.001
Cyclophosphamide	4.5% (6)	51.7% (30)	20.0% (7)	4.0% (1)	< 0.001
MTX (Methotrexate)	6.8% (9)	55.2% (32)	0.0% (0)	8.0% (2)	< 0.001

Figure 6 depicts the frequency distribution of the total number of treatment cycles administered per patient. The distribution is heavily right-skewed, indicating that although the median number of cycles is 5.0, a subset of patients required significantly longer therapeutic regimens (ranging up to 120 cycles). This positive skew elevates the cohort's mean to 11.57 cycles, highlighting variability in treatment duration due to individual patient response, disease severity, and maintenance therapy requirements.

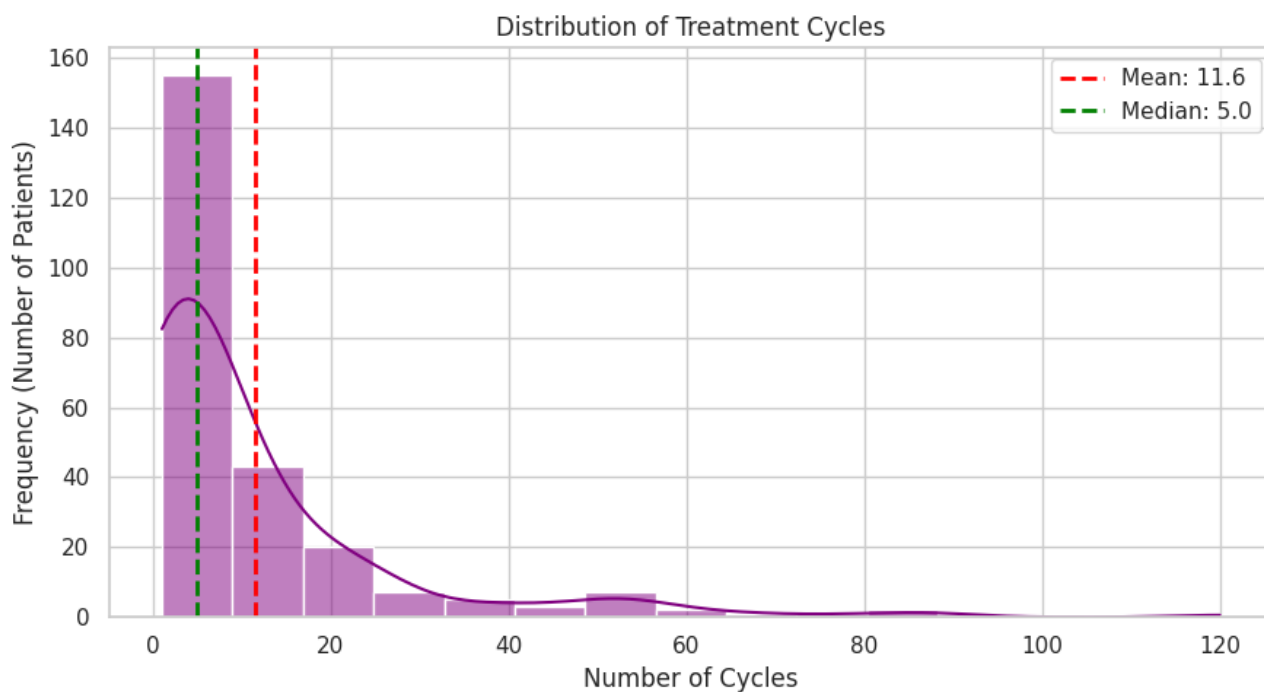


Figure 6: Distribution and Central Tendency of Administered Treatment Cycles

**Inferential Analysis (Hypothesis Testing):**

Using Chi-Square analysis, we evaluated the flow cytometry markers—specifically CD19, CD33, CD13, CD4, and HLA-DR—across our AML, ALL, CLL, and CML patients. CD19, which showed the most statistically significant result, with a p-value < 0.001. As we know, CD19 is a hallmark pan-B-cell marker, making it highly specific for delineating lymphoid lineage malignancies, particularly for differentiating our ALL and CLL cases from myeloid malignancies.

Similarly, highly significant associations for CD33 and CD13, both with p-values well below the 0.05 threshold. This perfectly reflects clinical expectations, as these

are classic myeloid antigens that are highly expressed in our AML patient population.

We also observed a statistically significant variance with CD4 across the subtypes. However, it is worth noting that HLA-DR did not reach statistical significance in this cohort analysis ( $p=0.57$ ). This suggests that, within this particular sample size, HLA-DR positivity was not reliably discriminative of the four specific disease groups on its own.

Table 2: Antibody Significance in Leukemia Typing

Antibody Marker	Clinical Significance (p-value)	Statistically Significant? ( $p < 0.05$ )
CD19	< 0.001	Yes (Highly Significant)
CD33	< 0.001	Yes (Highly Significant)
CD13	0.0003	Yes
CD4	0.0258	Yes
HLA-DR	0.5709	No

The most striking finding here is the white blood cell count (WBC). Post-treatment, we observed a large, statistically significant decrease in WBCs. This directly reflects the profound myelosuppressive efficacy of the induction and consolidation chemotherapies used in this cohort. Interestingly, when looking at the cohort as a whole, platelets and hemoglobin did not show a statistically significant directional shift in this specific follow-up window.

Table 3: Shifts in Hematological Parameters Post-Chemotherapy

Hematological Parameter	Clinical Significance (p-value)	Significant Shift Post-Treatment?
WBC (White Blood Cells)	< 0.001	Yes (Massive Downward Shift)
PLT (Platelets)	0.4277	No
HB (Hemoglobin)	1.2000	No

We analyzed the administration of Zofran against highly emetogenic drugs, specifically the Anthracyclines and Cytarabine. The statistics here are exceptionally clear. There is a highly significant correlation ( $p < 0.001$ ) between the use of these heavy chemotherapy agents and the concurrent use of Zofran.

Table 4: Correlation Between Highly Emetogenic Chemotherapy and Antiemetic Use

Drug Administration Comparison	Clinical Significance (p-value)	Statistically Significant?
Anthracyclines vs. Zofran Use	< 0.001	Yes
Cytarabine vs. Zofran Use	< 0.001	Yes

**Patient Outcome Distribution:**

Almost half of the patients (48.4%) showed an "Improved" outcome after treatment. A little over a quarter (26.8%) experienced a "Worsening" of their condition. A complete "Cure" was achieved in 16.0% of the cases. Fatal outcomes ("Die") accounted for 8.8% of the patient population as show in table 5,6,7,8.

Table5: Patients outcome distribution

Outcome	Frequency (N)	Percentage (%)
Improved	121	48.4%
Worsening	67	26.8%
Cure	40	16.0%
Die	22	8.8%

Treatment outcomes differed markedly among leukemia subtypes. **AML** showed the best overall response, with the highest numbers of cures (22) and improvements (62). **ALL** also demonstrated a favorable response, with 18 cures and low mortality (4 deaths). In contrast, **CML** showed no recorded cures but a high rate of improvement (18/25, ~72%), indicating effective disease control rather than curative outcomes. **CLL** had the poorest outcomes, with no cures, higher rates of worsening (13), and relatively greater mortality (6) compared to CML. Overall, acute leukemias exhibited greater curative potential, whereas chronic leukemias were associated primarily with disease control, particularly in CML, and poorer outcomes in CLL. As show in table 6.

Table 6: Cross-tabulations analyzing how patient outcomes differ by Leukemia Type

Leukemia Type	Cure	Improved	Worsening	Die	Total
AML (Acute Myeloid)	22	62	37	11	132
ALL (Acute Lymphoblastic)	18	25	11	4	58
CML (Chronic Myeloid)	-	18	6	1	25
CLL (Chronic Lymphocytic)	-	16	13	6	35
Total	40	121	67	22	250

Patient outcomes by gender showed slight variations in distribution. Males (n = 160) had higher absolute counts across all categories, with improvement most common (77), followed by worsening (42), cure (27), and death (14). Females (n = 90) demonstrated a comparable pattern, with improvement (44) predominating, followed by worsening (25), cure (13), and death (8). Proportionally, no meaningful gender differences were observed, indicating that gender was not a significant determinant of treatment outcome in this cohort.

Table 7: Cross-tabulations analyzing how patient outcomes differ by Gender

Gender	Cure	Improved	Worsening	Die	Total
Male	27	77	42	14	160
Female	13	44	25	8	90
Total	40	121	67	22	250

Patient outcomes varied significantly across age groups. Younger patients (<18 years) showed the most favorable outcomes, with higher proportions of cure (7/24) and lower mortality (1/24). In contrast, older patients (>50 years) exhibited poorer outcomes, with increased rates of worsening (30/94) and death (11/94), despite having the highest number of improvements (43). Intermediate age groups (18–30 and 30–50 years) demonstrated moderate outcomes between these extremes.

Table 8: Cross-tabulations analyzing how patient outcomes differ by Age groups

Age Group	Cure	Improved	Worsening	Die	Total
< 18 years	7	10	6	1	24
18 - 30 years	11	32	10	5	58
30 - 50 years	12	36	21	5	74
> 50 years	10	43	30	11	94
Total	40	121	67	22	250

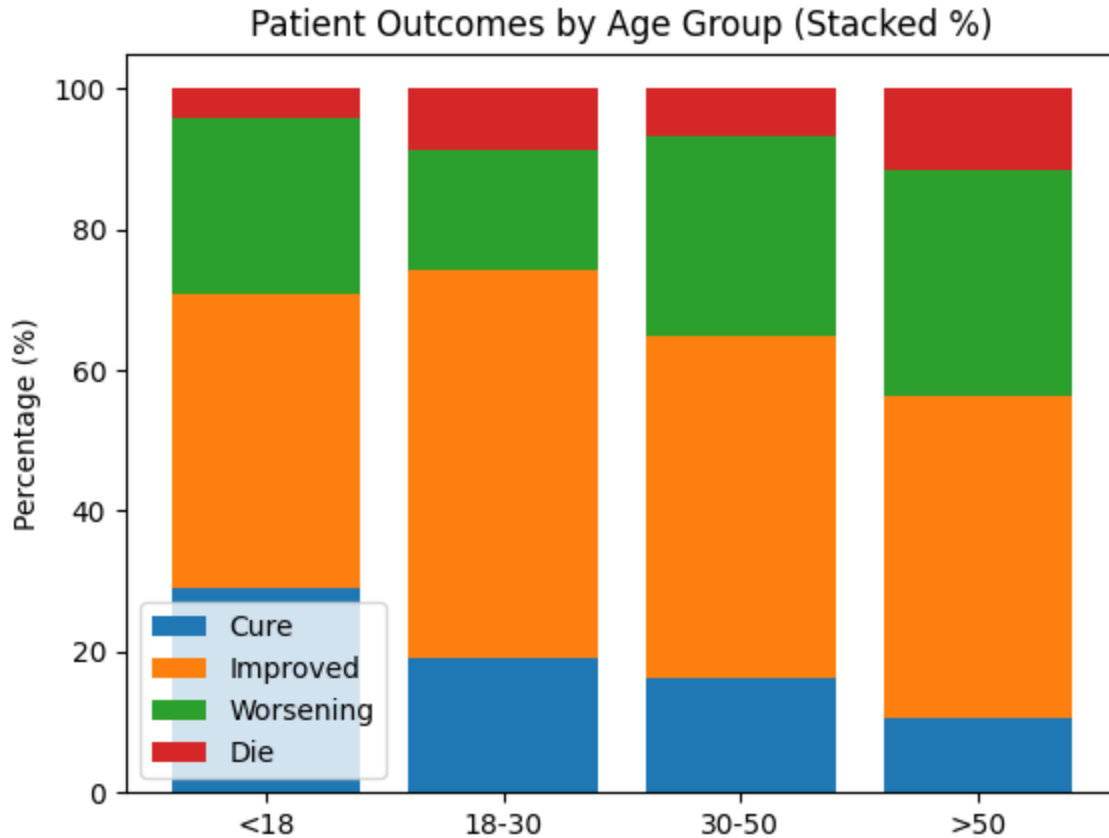


Figure 7: Patient outcomes by Age groups

#### 4. Discussion

The findings of the present study are largely consistent with international evidence regarding the epidemiology, treatment patterns, and clinical outcomes of leukemia, while also highlighting disparities typical of low- and middle-income healthcare settings.

The demographic profile of the study population showed a predominance of male patients (64%) and individuals aged over 50 years (37.6%), which is consistent with global epidemiological trends especially in Iran and Jordan, the similarity with them might be due to shared genetic backgrounds in the Middle East or

exposure to similar environmental pollutants from oil industries and regional conflicts (10). International studies report that acute myeloid leukemia (AML) is the most common leukemia subtype in adults and is more frequent in older populations, with a slight male predominance, supporting the observed predominance of AML (52.8%) in this cohort that may be due to the fact that men in Iraq are more likely to work in industrial or outdoor environments where they are exposed to chemical pollutants or radiation. Additionally, biological factors such as the protective effect of estrogen in females are often cited as a reason for lower incidence in women (11,12). It also aligns with studies from neighboring countries like Iran and Jordan, which consistently show higher incidence rates in males (13). The higher proportion of urban residents (71.6%) likely reflects improved access to diagnostic and treatment facilities in cities, while rural populations may be underrepresented due to barriers in healthcare access.

Chemotherapy remains the cornerstone of leukemia treatment in this study, with Cytarabine and anthracyclines being the most frequently used agents. This aligns closely with international standards, particularly the widely accepted “3+7” induction regimen for AML, achieving complete remission rates of approximately 50–70% in developed settings (14). The statistically significant association between chemotherapy protocols and leukemia subtypes ( $p < 0.001$ ) confirms appropriate treatment selection based on disease classification. Similarly, the use of vincristine, cyclophosphamide, and methotrexate in acute lymphoblastic leukemia (ALL) reflects adherence to established global protocols. These findings indicate that, despite resource limitations, clinical practice in the studied regions generally follows evidence-based guidelines. The difference is that clinics in neighboring countries like Turkey and Jordan have increasingly started integrating Targeted Therapy and Immunotherapy alongside standard chemotherapy to improve remission rates (15).

However, differences become apparent when comparing outcomes and healthcare delivery between developed and developing regions. Studies from high-income countries demonstrate improved survival rates due to advanced supportive care and access to novel therapies, variability in treatment cycles and response observed in this study suggests less consistent outcomes. For example, long-term studies of cytarabine-based regimens have reported complete remission rates approaching 90% and long-term survival exceeding 70% in specific subtypes under optimal conditions (16). In contrast, studies from developing countries, such as Iran and Egypt, report lower remission rates ( $\approx 58\text{--}63\%$ ) and shorter median survival (11–13 months), largely due to limited resources and delayed treatment (17). The distribution of treatment cycles was markedly right-skewed, with a median of 5 cycles and a mean of 11.57 cycles, indicating heterogeneity in disease severity, treatment response, and the need for prolonged therapy, particularly in chronic leukemias. Such variability is also reported internationally but tends to be better managed in resource-rich settings through individualized treatment strategies and continuous monitoring. In developed healthcare systems, treatment duration is influenced by disease subtype, patient fitness, and response to therapy, with some patients requiring prolonged maintenance therapy. Similarly, international data highlight that older patients or those ineligible for intensive chemotherapy have significantly poorer outcomes and shorter survival, emphasizing the role of individualized treatment strategies (18).

Flow cytometry findings in this study are strongly supported by international evidence. The highly significant association of CD19 with lymphoid leukemias and CD33/CD13 with myeloid leukemias reflects their established diagnostic roles in leukemia classification (19). These markers are widely used globally to guide diagnosis and treatment decisions. In contrast, the lack of statistical significance

for HLA-DR suggests limited discriminative value in this cohort, which is consistent with international observations that its utility is context-dependent.

With respect to treatment response revealed a significant reduction in white blood cell (WBC) count following chemotherapy ( $p < 0.001$ ) in this study is consistent with the expected myelosuppressive effect of induction therapy reported internationally (20). However, the absence of significant changes in hemoglobin and platelet levels contrasts with findings from high-resource settings, where supportive measures such as transfusions and growth factor support often facilitate faster hematologic recovery. This discrepancy likely reflects limitations in supportive care services and resource availability within the studied regions.

Supportive care practices, particularly the use of antiemetics, demonstrated strong adherence to clinical guidelines (21). The highly significant association between the use of emetogenic chemotherapy agents (anthracyclines and Cytarabine) and ondansetron administration ( $p < 0.001$ ) indicates appropriate management of chemotherapy-induced nausea and vomiting. This aligns with international recommendations and highlights an area of strength in patient care.

Outcomes varied notably by leukemia subtype. Acute leukemias (AML and ALL) showed higher cure rates, reflecting the effectiveness of intensive, potentially curative treatment strategies. In contrast, chronic leukemias (CML and CLL) were characterized mainly by disease control rather than cure. CML patients demonstrated high improvement rates with minimal mortality, consistent with the impact of targeted therapies, whereas CLL showed relatively higher progression and mortality, suggesting a less favorable prognosis in this cohort.

Gender did not significantly influence outcomes, as males and females exhibited similar distributions across all outcome categories, indicating that sex is not a major prognostic factor in this population.

Age was strongly associated with prognosis. Younger patients had better outcomes, including higher improvement and lower mortality rates, while patients older than 50 years showed increased disease progression and the highest death rates. This trend likely reflects reduced treatment tolerance, comorbidities, and adverse disease biology in older individuals and this agrees with well-established evidence.

Overall, these findings reinforce established trends in leukemia outcomes: treatment response is most favorable in younger patients and in acute disease, chronic leukemias tend toward control rather than cure, gender has little independent effect, and advanced age is associated with worse prognosis.

Despite these positive aspects, several systemic challenges remain evident. The concentration of patients in urban areas underscores disparities in healthcare access, with rural populations facing delayed diagnosis and limited treatment availability. Resource constraints, including drug shortages, limited diagnostic capabilities, and insufficient supportive care infrastructure, likely contribute to variability in treatment outcomes. These findings are consistent with studies from other low- and middle-income countries, where reduced survival rates and treatment inconsistencies are commonly reported due to similar limitations.

## **5. Conclusion**

Leukemia management in central and southern Iraq generally follows international standards, with subtype-specific chemotherapy regimens and key immunophenotypic markers guiding treatment. Nonetheless, variability in therapy duration, limited hematological improvement, and urban–rural disparities highlight systemic constraints in healthcare infrastructure and supportive services. While therapeutic approaches align with global practices, outcomes are suboptimal due to

resource limitations rather than clinical decision-making. In conclusion, improving leukemia outcomes in central and southern Iraq will depend on a coordinated strategy emphasizing strengthened infrastructure, reliable drug supply, expanded diagnostic and therapeutic access, and enhanced supportive care to ensure equitable, high-quality, standardized treatment.

## **6.Recommendation**

Based on the findings of this study, several recommendations can be proposed to improve the management and outcomes of leukemia patients in central and southern Iraq:

### **1. Strengthening Healthcare Infrastructure:**

Expand and equip oncology and hematology centers in underserved and rural areas to reduce disparities in access to diagnosis and treatment.

### **2. Ensuring Continuous Drug Availability:**

Improve supply chain systems to ensure consistent availability of essential chemotherapeutic agents and supportive medications.

### **3. Enhancing Diagnostic Capacity:**

Increase access to advanced diagnostic tools, including molecular and cytogenetic testing, to enable accurate classification and personalized treatment.

### **4. Improving Supportive Care Services:**

Develop supportive care systems, including blood transfusion services, infection control, and intensive care facilities, to enhance treatment outcomes and patient survival.

### **5. Training and Workforce Development:**

Invest in training programs for oncologists, hematologists, and specialized nursing staff to improve the quality of care and adoption of advanced therapies.

**6. Establishing National Treatment Guidelines:**

Implement standardized national protocols aligned with international guidelines to ensure uniformity in leukemia management across all regions.

**7. Enhancing Patient Follow-Up Systems:**

Develop structured follow-up programs and electronic health records to monitor treatment response and long-term outcomes effectively.

**8. Promoting Early Detection and Awareness:**

Increase public awareness and screening initiatives to facilitate early diagnosis and timely intervention.

**9. Encouraging Research and Data Collection:**

Support national cancer registries and clinical research to generate local evidence and guide policy-making.

**6. Conflict of interest:** There is no conflict of interest in this research.

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