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PROFILE OF ANAEMIA AND ASSOCIATED FACTORS IN NON-HAEMATOLOGICAL MALIGNANCIES: A CROSS-SECTIONAL STUDY

P. Saravanakumar[1], R.Anantha Narayani[2], S.Priyadharshini[3]

[1,2,3] *Assistant Professor, Department of Pathology Government Stanley Medical College and Hospital Chennai, Tamil Nadu, India*

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Corresponding Author:
Dr. P. Saravanakumar,
Assistant Professor, Department of Pathology Government Stanley Medical College and Hospital Chennai, Tamil Nadu, India.
Email: drsaravanakumar123@gmail.com

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ABSTRACT

Background: Anaemia is among the most common and debilitating comorbidities in patients with non-haematological malignancies, arising through multifactorial mechanisms including anemia of chronic disease, iron deficiency, bone marrow suppression, and nutritional deficiencies. Despite its high prevalence and significant impact on quality of life, anaemia in solid tumour patients remains underdiagnosed and undertreated, particularly in developing countries. Understanding the profile and associated factors of cancer-related anaemia is essential for timely intervention and improved patient outcomes. Objective of this study is to study the prevalence, severity, morphological type, and iron profile of anaemia, and to identify its association with type of non-haematological malignancy in patients presenting at a tertiary care institution in South India.

Materials and Methods: A cross-sectional study was conducted at a tertiary care teaching hospital for a period of two years. Sixty-five patients with confirmed non-haematological malignancies, not on chemotherapy or radiotherapy, were enrolled. Haematological parameters including haemoglobin (Hb), RBC count, MCV, MCH, MCHC, and RDW were measured by automated haematology analyser. Peripheral blood smear was examined after Leishman staining. Serum iron, total iron-binding capacity (TIBC), and serum ferritin were estimated. Chi-square analysis was performed; $p<0.05$ was taken as significant.

Results: All 65 study participants (mean age 61.22 ± 13.14 years; 54% male) were anaemic. Moderate anaemia (Hb 8–9.9 g/dL) was the most prevalent (41.54%), followed by mild (33.85%) and severe anaemia (24.62%). Peripheral smear revealed normocytic normochromic pattern in 75.38% of cases. Gastrointestinal and lung malignancies showed the highest rates of severe anaemia. Iron reserve was largely preserved; serum ferritin was elevated (>150 ng/mL) in 52.31% of cases. MCV (p=0.001), MCH (p=0.010), RBC count (p=0.010), RDW (p=0.010), and serum iron (p=0.009) showed statistically significant associations with type of malignancy.

Conclusion: Moderate anaemia is the predominant form in non-haematological malignancies in South India, with predominantly normocytic normochromic morphology consistent with anaemia of chronic disease. Gastrointestinal malignancies carry the highest burden of severe anaemia. Routine screening with RBC indices, peripheral smear, and iron studies is recommended in all cancer patients to enable early diagnosis and appropriate management of anaemia.

Keywords: Non-haematological malignancy; Cancer-related anaemia; Anaemia of chronic disease; Iron deficiency; Peripheral smear; Haematological parameters; India

INTRODUCTION

Cancer represents one of the foremost global health challenges of the twenty-first century. The World Health Organization has projected a 70–75% rise in global cancer incidence over the next 25 years, placing an escalating burden on healthcare systems worldwide.[2]. Alongside the primary disease, cancer patients are confronted with a spectrum of comorbidities that compound morbidity and impair treatment efficacy. Among these, anaemia occupies a position of singular clinical importance: it is one of the most prevalent and impactful complications in the oncological setting, affecting up to 70% of patients over the course of their illness.[11].

Cancer-related anaemia (CRA) is a multifactorial condition arising through several distinct but often overlapping pathways. These include impaired erythropoiesis driven by pro-inflammatory cytokines (particularly IL-6, TNF-alpha, and interferon-gamma), iron sequestration mediated by hepcidin upregulation, reduced erythropoietin synthesis, nutritional deficiencies (iron, folate, vitamin B12), direct bone marrow invasion by metastatic disease, haemolysis, and chronic blood loss from intraluminal tumours.[3,21,23]. The resulting anaemia shares haematological characteristics with anaemia of chronic inflammation—typically normocytic normochromic morphology with preserved iron stores, low serum iron, elevated ferritin, and disproportionately low erythropoietin levels relative to the degree of anaemia.[41,48].

The clinical consequences of CRA are substantial. Symptomatic anaemia—manifesting as fatigue, dyspnoea, cognitive impairment, and diminished functional capacity—adversely affects quality of life (QoL) and compromises tolerance to chemotherapy and radiotherapy [49,66]. Moreover, tumour hypoxia resulting from anaemia promotes genomic instability, angiogenesis, and resistance to anti-tumour therapy, thereby worsening disease prognosis.[67]. Anaemia has been identified as an independent predictor of mortality in several cancer types, with a 65% overall increase in mortality risk in anaemic cancer patients compared to non-anaemic counterparts.[73].

Despite this burden, anaemia in non-haematological malignancies is frequently underestimated and inadequately treated, particularly in developing countries where pre-existing nutritional anaemia, late-stage presentation, and limited healthcare access compound the problem.[57,58]. Studies from India consistently demonstrate a higher prevalence and greater severity of CRA compared to Western cohorts.[62,63,64]. Data from South Indian tertiary care institutions specifically characterising anaemia profiles across different solid tumour types remain limited, creating a gap in the evidence base that informs clinical management guidelines.

The present study was undertaken to systematically characterise the profile of anaemia—encompassing prevalence, severity, morphological type, erythrocyte indices, and iron studies—in patients with non-haematological malignancies attending a tertiary care institution in South India, and to determine significant associations between anaemia parameters and tumour type.

Objective is to study the profile of anaemia and associated haematological and iron-profile parameters in patients with non-haematological malignancies. Secondary objectives: To determine the prevalence and severity of anaemia across different tumour types; to characterise peripheral blood smear morphology; to evaluate serum iron, TIBC, and ferritin; and to identify statistically significant associations between haematological parameters and tumour type.

MATERIALS AND METHODS

This was a cross-sectional, observational study conducted at the Department of Pathology in a tertiary care teaching hospital for a period of two years. The study was approved by the Institutional Human Ethics Committee (IHEC), and written informed consent was obtained from all participants prior to enrolment.

Sample size was calculated using the formula $4pq/d^2$, where p = 74% (prevalence of anaemia in non-haematological malignancies from Gupta et al. [20]), q = 26%, and d = 15% of p = 11.1. This yielded a minimum sample size of approximately 63; 65 cases were recruited using purposive sampling to account for potential attrition.

All patients (both sexes, all age groups) with histopathologically or clinico-radiologically confirmed non-haematological malignancies were eligible for inclusion. Patients were excluded if they were currently receiving chemotherapy or radiotherapy; had significant comorbidities affecting haematopoiesis (severe cardiac, renal, or hepatic disease); or declined to provide informed consent. Cases of haematological malignancies (leukaemia, lymphoma, myeloma) were excluded to maintain homogeneity of the study population.

Venous blood samples were collected from each participant under aseptic conditions. Complete blood count parameters—haemoglobin (Hb), RBC count, haematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), and red cell distribution width (RDW)—were measured using an automated haematology analyser. Peripheral blood smears were prepared, Leishman-stained, and examined under light microscopy for morphological classification (normocytic normochromic, microcytic hypochromic, or macrocytic normochromic). Serum iron (normal range 55–160 µg/dL in men; 40–155 µg/dL in women), total iron-binding capacity (TIBC), and serum ferritin (normal 30–500 ng/mL) were estimated using standard biochemical methods.

Anaemia was defined and graded according to WHO criteria: mild (Hb 9.0–10.9 g/dL in women; or Hb 10–12 g/dL for the study's operational threshold), moderate (Hb 7.0–8.9 g/dL, study threshold 8–9.9 g/dL), and severe (Hb <7.0 g/dL; study threshold <8 g/dL). All 65 recruited patients were anaemic, confirming the null hypothesis should be rejected.[5,6]. Data were entered in Microsoft Excel 2016 and analysed using IBM SPSS Statistics version 20.0 (trial). Descriptive statistics including frequency, percentage, mean, and standard deviation were computed. Associations between categorical haematological parameters and tumour type were assessed using Pearson's chi-square test. ANOVA was used for continuous variables across age groups. Statistical significance was set at $p<0.05$.

RESULTS

A total of 65 patients were enrolled. Males constituted 53.8% (n=35) and females 46.2% (n=30). Age ranged from 15 to 85 years with a mean age of 61.22 ± 13.14 years. The 50–60 and 60–70 year age groups each comprised 32.31% of cases (n=21 each), making the sixth and seventh decades of life the most commonly affected. Among females, breast cancer was the most frequent malignancy (n=12, 18.46%), followed by thyroid (n=5, 7.69%) and cervical carcinoma (n=4, 6.15%). Among males, laryngeal and prostatic cancers each accounted for 14.29% (n=5 each), followed by lung, stomach, and bladder cancers (11.43% each). The full demographic profile is presented in [Table 1].

Table 1: Demographic profile and malignancy site distribution (N=65)

Characteristic	Frequency (n=65)	Percentage (%)
Gender: Male	35	53.8
Gender: Female	30	46.2
Age: <40 years	7	10.8
Age: 40–50 years	4	6.2
Age: 50–60 years	21	32.3
Age: 60–70 years	21	32.3
Age: 70–80 years	11	16.9
Age: >80 years	1	1.5
Most common in females: Breast	12	18.5
Most common in females: Thyroid	5	7.7
Most common in females: Cervix	4	6.2
Most common in males: Prostate	5	14.3
Most common in males: Larynx	5	14.3
Most common in males: Lung/Bladder/Stomach	4 each	11.4 each

All 65 patients were anaemic. Moderate anaemia (Hb 8–9.9 g/dL) was the most prevalent, found in 27 patients (41.54%), followed by mild anaemia (Hb 10–12 g/dL) in 22 patients (33.85%), and severe anaemia (Hb <8 g/dL) in 16 patients (24.62%). The overall mean haemoglobin was 9.08 ± 1.6 g/dL. Peripheral blood smear examination revealed normocytic normochromic morphology in 49 cases (75.38%), consistent with anaemia of chronic disease. Microcytic hypochromic morphology was found in 15 cases (23.08%), reflecting iron deficiency aetiology in a significant minority. One case (1.54%) showed macrocytic normochromic morphology. The haematological parameters [Table 2] showed that mean RBC count was 3.13 ± 0.8 × 10^6/µL, mean MCV 86.5 ± 0.71 fL, and mean MCHC 34.5 ± 2.12 g/dL.

Table 2: Anaemia severity, morphological type, and haematological parameters (N=65)

Anemia Parameter	Frequency (n=65)	Percentage (%)
Mild anemia (Hb 10–12 g/dL)	22	33.85
Moderate anemia (Hb 8–9.9 g/dL)	27	41.54
Severe anemia (Hb < 8 g/dL)	16	24.62
Mean Hb (g/dL) ± SD	9.08 ± 1.6	—
Mean RBC count (×10^6/µL) ± SD	3.13 ± 0.8	—
Mean MCV (fL) ± SD	86.5 ± 0.71	—
Mean MCHC (g/dL) ± SD	34.5 ± 2.12	—
Normocytic normochromic (peripheral smear)	49	75.38
Microcytic hypochromic (peripheral smear)	15	23.08
Macrocytic normochromic (peripheral smear)	1	1.54

The distribution of anaemia severity varied meaningfully across tumour categories [Table 3]. Gastrointestinal malignancies (n=14) demonstrated the greatest burden of severe anaemia: 8 patients (57.14%) had Hb <8 g/dL, reflecting the predisposition of intraluminal GI tumours to chronic blood loss and iron malabsorption. Lung malignancies (n=7) also showed a high rate of severe anaemia: 4 cases (57.14%) had Hb <8 g/dL, likely exacerbated by advanced-stage disease and tumour hypoxia. Breast malignancies (n=12) showed a predominantly mild anaemia pattern: 7 patients (58.33%) had mild anaemia, possibly reflecting earlier diagnosis and better nutritional status at presentation. Urogenital (n=10) and thyroid malignancies (n=6) had no cases of severe anaemia,

consistent with their relatively less aggressive anaemia-inducing pathophysiology. Gynecological malignancies (n=5) showed uniformly moderate-to-mild anaemia, with one case of severe anaemia (20%). Despite these trends, Pearson's chi-square analysis showed that severity of anaemia was not statistically significantly associated with type of malignancy (χ^2=22.466, df=14, p=0.070), attributable to the limited sample size; significance at the 10% level (p<0.10) was noted.

Table 3: Distribution of anaemia severity by tumour type

Type of Malignancy	Total (n)	Mild (Hb 10–12)	Moderate (8–9.9)	Severe (<8 g/dL)
Breast	12	7 (58.3%)	4 (33.3%)	1 (8.3%)
Gastrointestinal	14	2 (14.3%)	4 (28.6%)	8 (57.1%)
Gynecological	5	2 (40.0%)	2 (40.0%)	1 (20.0%)
Head & Neck	9	3 (33.3%)	4 (44.4%)	2 (22.2%)
Lung	7	1 (14.3%)	2 (28.6%)	4 (57.1%)
Urogenital	10	4 (40.0%)	6 (60.0%)	0 (0.0%)
Thyroid	6	2 (33.3%)	4 (66.7%)	0 (0.0%)
Malignant Melanoma	2	1 (50.0%)	1 (50.0%)	0 (0.0%)

Iron profile data by tumour type are summarised in [Table 4]. Serum iron was within the reference range (50–150 µg/dL) in 47 patients (72.31%); only 8 patients (12.31%) had depleted serum iron (<50 µg/dL), and 10 patients (15.38%) had elevated iron (>150 µg/dL). Serum ferritin was elevated (>150 ng/mL) in 34 patients (52.31%), while 31 patients (47.69%) had values in the 15–150 ng/mL range; no patient had ferritin <15 ng/mL. TIBC was reduced (<250 µg/dL) in 35 patients (53.85%), consistent with the suppressed transferrin synthesis characteristic of anaemia of chronic disease. Gynecological malignancies showed the lowest mean serum iron (45.19 ± 9.49 µg/dL) and highest mean TIBC (328.6 ± 36.63 µg/dL), indicating true iron deficiency in this group—corroborated by 100% microcytic hypochromic peripheral smears. Head and neck malignancies showed the highest mean ferritin (248.56 ± 60.55 ng/mL). MCV (χ^2=36.169, df=14, p=0.001), MCH (χ^2=32.810, df=7, p=0.010), RBC count (χ^2=26.652, df=7, p=0.010), RDW (χ^2=31.773, df=7, p=0.010), and serum iron (χ^2=18.540, df=7, p=0.009) all showed statistically significant associations with tumour type.

Table 4: Iron profile and erythrocyte indices by tumour type (Mean ± SD)

Malignancy Type	Mean Serum Iron (µg/dL)	Mean TIBC (µg/dL)	Mean Ferritin (ng/mL)	Predominant Smear
Breast (n=12)	86.9 ± 15.1	253.6 ± 43.8	139.8 ± 33.7	Normocytic
Gastrointestinal (n=14)	112.3 ± 50.7	238.5 ± 70.8	201.7 ± 101.2	Normocytic/Microcytic
Gynecological (n=5)	45.2 ± 9.5	328.6 ± 36.6	65.4 ± 16.9	Microcytic
Head & Neck (n=9)	144.4 ± 30.4	185.6 ± 32.2	248.6 ± 60.6	Normocytic
Lung (n=7)	119.9 ± 20.7	204.0 ± 43.5	225.0 ± 83.0	Normocytic
Urogenital (n=10)	106.4 ± 51.4	228.3 ± 74.6	184.2 ± 120.8	Mixed
Thyroid (n=6)	94.0 ± 28.5	261.5 ± 45.3	134.7 ± 67.2	Normocytic

Age-stratified analysis revealed significant variation in haematological parameters across age groups (ANOVA, p<0.05). Mean haemoglobin was highest in the <40-year age group (10.45 g/dL) and lowest in the 60–70-year group (8.25 g/dL). Mean MCV was lowest in the 50–60-year group (67.70 fL), likely corresponding to the high prevalence of GI and gynaecological malignancies in this group, which are associated with iron deficiency. Mean RDW was highest in the 60–70-year group (17.85%), indicating greater anisocytosis—a marker of nutritional deficiency and mixed aetiology anaemia in this age group. Mean serum iron was lowest in the 50–60-year group (45.47 µg/dL) and mean ferritin was lowest in the same group (72.20 ng/mL), suggesting relative iron depletion in middle-aged cancer patients despite ongoing inflammatory state.

DISCUSSION

This cross-sectional study provides a systematic characterisation of the anaemia profile in 65 patients with non-haematological malignancies at a South Indian tertiary care institution. The finding that all 65 recruited patients were anaemic underscores the pervasive nature of cancer-related anaemia (CRA) in this clinical setting and is consistent with Indian data showing higher CRA prevalence compared to Western cohorts.

The predominance of cancer cases in the 50–70-year age range (64.6% of cases) in our study aligns with established epidemiological data from the National Cancer Institute's SEER database, which documents an incidence of 2,261 per 100,000 in patients ≥65 years versus 207 per 100,000 in younger individuals.[17] Singh et al. similarly noted peak malignancy incidence in the fifth decade,[13] and Sharma et al. documented the highest case burden in patients above 50 years.[16] The trend toward increasing malignancy in younger age groups, noted in the background data of this study, is attributed to changing dietary habits, sedentary lifestyle, and environmental exposures in urban Indian populations. In females, breast cancer was the dominant malignancy (18.46%), consistent with breast cancer's status as the most common female

malignancy in India. In males, laryngeal and prostatic cancers were most prevalent, reflecting the demographic and lifestyle profile (notably high tobacco use) of the study region in South India.

The universal anaemia prevalence (100%) in our series reflects the selection of a treatment-naive, symptomatic hospital-based population. This is higher than the 40% reported at enrolment in the large European Cancer Anaemia Survey (ECAS) and the 35% documented in the Australian Cancer Anaemia Survey,[11,19] but is broadly consistent with Indian data. Sharma et al. documented anaemia in 60% of cancer patients,[16] while Kanuri et al. reported 64% prevalence,[18] and the study by Gupta et al. which informed our sample size calculation reported 74%.[20] The proportionately higher prevalence in the present study likely reflects pre-existing nutritional anaemia in the Indian population, compounding the tumour-associated insult, as well as the referral pattern of a tertiary care hospital where patients with symptomatic or advanced disease predominate.

The distribution of anaemia severity in the present study—with moderate anaemia (41.54%) as the most common category—differs from Western surveys where mild anaemia dominates (Table 5). The ECAS reported mild anaemia in 41.9% and the Polish Cancer Anemia Survey (POLCAS) in 82.1% of cases, with severe anaemia rates of 8.9% and 1.7% respectively.[11,20] In contrast, 24.62% of our patients had severe anaemia. This gradient is explained by the higher background prevalence of nutritional anaemia in India, delayed presentation to tertiary care, and limited early detection infrastructure in the Indian healthcare context.

Table 5: Comparison of anaemia severity distribution with published studies

Study	Mild (%)	Moderate (%)	Severe (%)	None (%)
European Cancer Anemia Survey (ECAS).[11]	41.9	49.2	8.9	—
Australian Cancer Anemia Survey.[19]	78.0	22.0	—	—
Polish Cancer Anemia Survey (POLCAS).[20]	82.1	16.2	1.7	—
Sharma et al.[16]	—	—	12.4 (<8g%)	87.6
Kanuri et al.[18]	64% overall anemia prevalence	—	—	36%
Present Study	33.85	41.54	24.62	0*

* All 65 enrolled patients were anaemic; 0% had no anaemia on enrolment.

The predominance of normocytic normochromic anaemia (75.38%) on peripheral smear is a hallmark of anaemia of chronic disease (ACD), in which iron utilisation is impaired by inflammation-driven hepcidin upregulation, rather than iron stores being depleted. Inflammatory cytokines—particularly IL-6, TNF-alpha, and interferon-gamma produced by tumour-activated immune cells—drive hepcidin synthesis, sequester iron in macrophages and hepatocytes, and suppress erythropoietin production, collectively producing this characteristic normochromic pattern.[21,23,24] The high serum ferritin (>150 ng/mL in 52.31% of cases) and reduced TIBC in the majority of patients further support this pathogenesis, as ferritin rises as an acute-phase reactant during chronic inflammation even when erythropoiesis is iron-restricted.

The 23.08% prevalence of microcytic hypochromic anaemia in our study indicates that a clinically significant subset of patients had iron deficiency as a contributor to or primary cause of their anaemia. This was most pronounced in gynecological malignancies (100% microcytic hypochromic), GI malignancies (35.71%), and urogenital malignancies (50%)—all tumour types associated with chronic blood loss. The lowest mean serum iron (45.19 µg/dL) and highest TIBC (328.6 µg/dL) in gynecological malignancy cases confirm true iron deficiency rather than functional iron deficiency in this group, consistent with the haemorrhagic tendency of cervical and uterine tumours. Ludwig et al. demonstrated that iron deficiency affects up to 63.2% of pancreatic and 51.9% of colorectal cancer patients,[14] and Aapro et al. documented iron deficiency in 32–60% of cancer patients across tumour types,[15] underscoring the frequency of this contributing factor.

Gastrointestinal malignancies showed the most severe anaemia in our series, with 57.14% of patients having Hb <8 g/dL. The mechanisms are multifactorial: intraluminal tumour bleeding, impaired iron absorption due to mucosal involvement of the duodenum and jejunum, post-gastrectomy iron malabsorption, and advanced disease stage at presentation all contribute. Head and neck cancers showed the highest mean ferritin (248.56 ng/mL) and predominantly normocytic morphology, consistent with the systemic inflammatory state generated by these tumours; severe anaemia was present in 22.2% of cases, reflecting nutritional compromise from dysphagia in advanced disease.

Lung malignancies demonstrated a strikingly high rate of severe anaemia (57.14%), despite relatively preserved mean serum iron. This pattern is consistent with ACD in the context of advanced-stage disease, combined with the known association between lung cancer and microangiopathic haemolytic anaemia in mucinous subtypes. Breast malignancies showed predominantly mild anaemia (58.33%), potentially reflecting earlier detection, better nutritional status, and the lower tendency for haemorrhagic complications in this tumour type. This is in accord with the ECAS data, where breast cancer patients had lower anaemia severity than GI or lung cancer patients.[11]. Urogenital cancers (prostate, bladder, kidney) presented with entirely moderate-to-mild anaemia and no severe cases, likely reflecting the diagnostic trajectory of these malignancies through symptoms of lower urinary tract obstruction (notably

benign prostatic hypertrophy) which facilitates earlier detection.

The interpretation of serum ferritin in cancer patients requires caution: as an acute-phase reactant, ferritin can be normal or elevated despite underlying iron deficiency in the presence of ongoing inflammation, a state termed functional iron deficiency (FID). In the present study, the absence of any patients with ferritin <15 ng/mL and the elevated ferritin in 52.31% of cases must be contextualised against the concurrent reduced TIBC (<250 µg/dL in 53.85%), which reflects suppressed transferrin synthesis in ACD rather than iron repletion. The combination of elevated ferritin with low TIBC and low serum iron is diagnostic of ACD, while a disproportionately low TIBC with normal/elevated ferritin but very low serum iron indicates FID. Both patterns are aetiologically important because they respond differently to treatment: ACD may benefit from erythropoiesis-stimulating agents (ESAs) combined with intravenous iron, whereas true iron deficiency responds to iron supplementation alone.[15] The recognition of this distinction carries direct implications for individualised anaemia management in cancer patients.

The statistically significant associations of MCV (p=0.001), MCH (p=0.010), RBC count (p=0.010), RDW (p=0.010), and serum iron (p=0.009) with tumour type confirm that the nature of red cell abnormalities is meaningfully influenced by the underlying cancer biology and its mechanisms of iron derangement. The non-significant association of Hb severity with tumour type (p=0.070) at the conventional 5% threshold—which became significant at 10%—is attributable to the limited sample size and highlights the need for larger, adequately powered prospective studies. These findings are consistent with those from the ECAS, where types of anaemia were associated with different tumour categories, and with the observation by Schwartz et al. that the incidence and severity of CRA depend substantially on tumour type, disease extent, and patient characteristics.

CONCLUSION

This study demonstrates that anaemia is universal in patients with non-haematological malignancies presenting at a South Indian tertiary care institution. Moderate anaemia is the predominant severity grade, and normocytic normochromic morphology—consistent with anaemia of chronic disease—is the most common peripheral smear finding. The substantially higher prevalence of severe anaemia compared to Western oncology surveys reflects the compounding effect of pre-existing nutritional anaemia, late-stage presentation, and limited early detection in the Indian healthcare setting.

Gastrointestinal and lung malignancies carry the greatest burden of severe anaemia, while breast and urogenital cancers predominantly present with mild anaemia. Iron studies reveal that the functional iron deficiency characteristic of ACD is the dominant pattern, with preserved or elevated ferritin and reduced TIBC, though a meaningful subset—particularly gynecological and GI malignancy patients—have superimposed true iron deficiency. Erythrocyte indices (MCV, MCH, RBC count, RDW) and serum iron levels are significantly associated with tumour type, indicating that morphological subclassification of anaemia guides aetiology-specific management.

The findings strongly support the recommendation that all cancer patients should undergo baseline screening with complete RBC indices, peripheral blood smear examination, and iron studies (serum iron, TIBC, ferritin) at the time of diagnosis. Early identification and treatment of anaemia—whether through intravenous iron supplementation, erythropoiesis-stimulating agents, or blood transfusion based on anaemia grade and aetiology—can significantly improve quality of life, enhance tolerance to definitive cancer therapy, and potentially improve survival outcomes. Larger multicentre prospective studies are needed to validate these associations and to define optimal anaemia management algorithms for Indian cancer patients.

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