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ORIGINAL ARTICLE

Prevalence of Anemia among Patients with Solid Cancer at the Time of Diagnosis in Saudi Arabia

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ABSTRACT

Background: **Cancer represents a significant global health challenge, with elevated incidence and mortality rates, particularly in Saudi Arabia. Anemia frequently manifests as a common complication in patients diagnosed with solid tumors, often remaining undiagnosed. This study aims to evaluate the prevalence of anemia in individuals recently diagnosed with solid tumors, addressing the lack of comprehensive data on this issue.**
Methods: **A cross-sectional study was conducted using the records of 508 newly diagnosed cancer patients at King Abdulaziz Medical City (2014 - 2024). Eligible patients had confirmed histological diagnoses and no prior cancer treatment. Data included demographics, tumor types, and blood parameters (RBC, hemoglobin, hematocrit, MCV, MCH). Anemia was defined as hemoglobin < 11.5 g/dL in females and < 13.0 g/dL in males.**
Results: **Among the 508 patients analyzed, 47.9% were classified as anemic. Microcytic hypochromic anemia (MCHC) was the most prevalent subtype, observed in 25.2% of patients. Colorectal-related malignancies – including colon, rectal, and sigmoid cancers - showed the highest prevalence of MCHC anemia, suggesting chronic gastrointestinal blood loss and iron deficiency as major contributors. In contrast, breast, endometrial, and skin cancers exhibited predominantly non-anemic profiles.**
Conclusions: **Anemia was prevalent in 47.9% of newly diagnosed solid tumor patients, most commonly in colorectal cancers (colon 61%, sigmoid 58%, rectal 52%), with microcytic hypochromic anemia (25.2%) as the leading type. Excluding patients with chronic illnesses and prior treatments allowed a clearer estimate of the true burden. Early screening and management are essential to reduce treatment-induced anemia and improve patient outcomes.**
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INTRODUCTION

Cancer is a pathological disorder in which cellular elements proliferate uncontrollably and invade adjacent tissues. As the human body comprises billions of cells, cancer can arise in almost any part. Typically, cells di-

vide in response to physiological needs, replacing old or damaged ones. However, when this regulation fails, abnormal cells may grow and aggregate into tissue masses known as tumors. Tumors are either benign, which do not spread, or malignant, which can metastasize into surrounding tissues and distant organs. Malignant tumors, commonly referred to as cancer, are distinguished by their ability to invade and recur after treatment. While hematological malignancies such as leukemia usually do not form solid tumors, most other cancers do. Benign tumors may grow significantly and become dangerous depending on their location, particularly in critical areas such as the brain [1].

Globally, cancer remains a major health burden. In 2022 alone, over 20 million new cancer cases and 9.7 million cancer-related deaths were recorded. Lung cancer accounted for 12.4% of all new cases and 18.7% of all cancer deaths, followed by breast (11.6%) and colorectal cancers (9.6%) [2]. In Saudi Arabia, the Saudi Cancer Registry (SCR) reported 25,864 newly diagnosed cancer cases in 2023. Women represented a higher proportion (57%) compared to men (43%), and the median age at diagnosis was 53 years for women and 57 for men. Among Saudi females, breast cancer was the most common (3,472 cases; 32.5% of female cancers), while colorectal cancer was most common among males (2,273 cases; 12.7% of male cancers). Both cancers are significant contributors to cancer-related mortality [3]. Geographically, the highest age-standardized incidence rate (ASR) in men was in the Eastern region and in women in Riyadh, while Jazan recorded the lowest rates for both genders [4].

Several factors contribute to cancer development, including genetic predispositions, environmental exposures, and lifestyle behaviors. Smoking, diets rich in fat, and toxic chemical exposure increase cancer risk in adults. Childhood cancers are also influenced by genetic syndromes like Wiskott-Aldrich and Beckwith-Wiedemann. Moreover, viral infections such as Epstein-Barr and HIV have been associated with higher cancer risks. Environmental factors - pesticides, radiation, and certain chemicals - may also contribute. Although the exact cause of cancer remains uncertain, it is widely believed to involve a combination of these factors [5,6].

Cancer treatment varies by type, stage, and location. The three most common and widely used conventional therapies are surgery, radiotherapy, and chemotherapy. Surgery is often used to remove solid tumors at early stages [7]. Radiotherapy uses high-energy radiation to damage the DNA of cancer cells, though it can also harm healthy surrounding tissues [8]. Chemotherapy involves chemical agents that target and kill rapidly dividing cancer cells. It can be administered alone or with other treatments and is typically monitored through MRIs, CT scans, and blood tests. Despite its effectiveness, chemotherapy may damage healthy cells, resulting in severe side effects and complications [9].

One of the major limitations of conventional cancer treatments is the lack of specificity in targeting only cancer cells. Additional barriers such as dosage challenges, drug resistance, and comorbidities, especially in elderly patients, and further complicate cancer management [10,11]. Studies show that lifestyle factors - such as diet, exercise, and maintaining a healthy weight - can improve prognosis and reduce recurrence risk [12]. Moreover, cancer cells may develop resistance to chemotherapy, reducing treatment effectiveness over time [13].

Anemia is among the most frequent complications associated with both cancer and its treatments, particularly chemotherapy [14]. The National Comprehensive Cancer Network (NCCN) recommends evaluating cancer patients for anemia if hemoglobin falls below 11 g/dL or drops by 2 g/dL from baseline [15].

A study in Sudan found a 50% anemia prevalence among 471 cancer patients, with women and older adults more affected [16]. In India, anemia prevalence increased with cancer stage: 35.4% in stage I, 45.2% in stage III, and 53.6% in stage IV, with iron deficiency identified as the leading cause. The overall anemia prevalence among solid tumor patients in that study was 91% [17]. In Saudi Arabia, one study reported a 44.1% anemia rate in cancer patients, especially among those with colorectal cancer (56.8%) and female genital tract cancers (43.8%) [18]. Similarly, data from Ethiopia showed a 23% anemia prevalence among newly diagnosed solid tumor patients, with higher rates in gynecological (37.7%) and colorectal cancers (26.7%) [19]. In Thailand, anemia was present in 54.4% of patients before radiotherapy and 34.3% during radiotherapy. Patients undergoing both chemotherapy and radiotherapy had even higher anemia rates (65.2%), indicating a cumulative effect. The total anemia prevalence was 66% [20]. A European study noted anemia in 30.4% of breast cancer and 49.1% of gynecologic cancer patients, stressing the detrimental impact of anemia on quality of life and treatment response [21].

Anemia can compromise cancer treatment outcomes by reducing patients' tolerance to therapy and impairing tumor response to chemotherapy or radiotherapy. It also negatively affects quality of life and survival rates. Despite its clinical significance, anemia in cancer patients often goes underdiagnosed or undertreated, especially in regions like Asia and the Middle East. In Saudi Arabia, current data on the prevalence of anemia in newly diagnosed solid tumor patients is limited, which highlights the need for further investigation. Accordingly, this study aims to assess the prevalence of anemia among individuals diagnosed with solid tumors at the point of initial diagnosis in Saudi Arabia.

MATERIALS AND METHODS

Study design

This was a cross-sectional study at King Abdullah International Medical Research Center (KAIMRC), Ministry of National Guard, Jeddah, Saudi Arabia

Data collection and analysis

Individuals recently diagnosed with various forms of cancer - including but not limited to rectal, liver, prostate, breast, gastric, colorectal, head and neck, lung, and cancers of the female genital tract - were systematically included in this study. Patient records from King Abdulaziz Medical City in the Kingdom of Saudi Arabia were scrutinized for the period between 2014 and 2024. A cumulative total of 508 patient records were meticulously analyzed, all of which met stringent inclusion criteria such as comprehensive medical histories, histologically confirmed cancer diagnoses, representation of both genders across diverse age groups, and absence of any prior anticancer treatments. Patients were excluded if they had a documented history of hematological disorders, solid tumors or bone marrow malignancies, renal disease, pre-existing anemia, recent blood transfusions, or previous exposure to chemotherapy, radiotherapy, or surgical interventions. Data collection encompassed demographic variables (age and gender), tumor types, and complete blood count (CBC) parameters including red blood cells (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH). Anemia was defined as hemoglobin levels < 11.5 g/dL in females and < 13.0 g/dL in males [22]. Based on these thresholds, patients were categorized into anemic and non-anemic groups. MCV and MCH values were utilized to determine the morphological classification of anemia. All blood parameters were measured using the Cell-Dyn 1800 hematology analyzer from Abbott Laboratories, and rigorous quality control procedures were applied to ensure the accuracy and reliability of measurements.

Statistical analysis

Descriptive statistics were used to summarize the baseline characteristics of the study population. Continuous variables were reported as means with standard deviations (mean ± SD), while categorical variables were presented as frequencies and percentages. The distribution of continuous variables was assessed using histograms and normality tests. All analyses were performed using various R packages. Tables and figures were used to visually present the data.

RESULTS

This study presents a comprehensive hematological analysis across 25 different cancer types, with a focus on the distribution and classification of anemia in oncology patients. Using clinical datasets and statistical techniques in R, descriptive statistics were computed for key hematological parameters, including hemoglobin (HB), hematocrit, red blood cell (RBC) count, mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH). Anemia types were categorized based on red cell indices into microcytic hypochromic (MCHC), normocytic normochromic (NCNC), normocytic hypochromic (NCHC), and macrocytic patterns. Five hundred and eight cancer patients enrolled. The age range was 5 to 105, with a mean of 56.0 and a standard deviation of 16.3 years. Out of 508, 215 (42.3%) were men and 293 (57.7%) were women.

Distribution of anemia

The frequency distribution of different cancer types: Based on Figure 1, it is evident that certain cancers, such as colon, rectal, and breast, have a notably higher number of samples, likely reflecting their prevalence in the dataset or study population. Conversely, rarer cancers such as prostatic, nasal, and tongue are represented with fewer samples. Descriptive statistics of hematological parameters in different types of cancer. Values include the mean, standard deviation (SD), minimum, and maximum for hemoglobin, hematocrit, red blood cell count, mean corpuscular volume, and mean corpuscular hemoglobin (Supplemental Table S1, S2, S3).

The distribution of anemia status among the study participants showed that 47.9% (n = 243) were classified as anemic, while 52.1% (n = 265) were non-anemic. The difference, though modest, suggests a nearly balanced distribution between the two groups, with a slightly higher proportion of non-anemic individuals. This observation may reflect underlying nutritional, socioeconomic, or health-related factors influencing anemia prevalence in the study population (Figure 2).

Analysis of anemia classification among participants revealed that the majority (52.1%) were non-anemic (n = 265). Among those with anemia, the most prevalent subtype was microcytic hypochromic anemia (MCHC), accounting for 25.2% (n = 128) of the total sample. Normocytic normochromic (NCNC) and normocytic hypochromic (NCHC) anemia followed, with 14.4% and 7.5%, respectively, and other subtypes, including macrocytic normochromic (MACNC) 0.8%. These findings highlight a predominance of MCHC among anemic individuals in the study population (Figure 3).

The incidence of anemia demonstrated considerable variation among distinct types of cancer, with patients diagnosed with rectal and colon cancer displaying the highest prevalence rates (Figure 4). In particular, 61% of individuals diagnosed with colon cancer were identified as anemic (Figure 4), followed by 58% of patients with sigmoid colon cancer and 52% of those diagnosed with rectal cancer (Figure 4). This finding indicates that more than half of the individuals within these cohorts are affected by anemia, underscoring a substantial concern regarding patient management and treatment outcomes in the context of colorectal cancer (Figure 4). In contrast, breast and endometrial cancer patients demonstrated a predominantly non-anemic profile (Figure 4). These findings suggest a potential association between tumor location and hematological status, warranting further investigation into underlying mechanisms such as blood loss, nutritional deficiencies, or bone marrow involvement specific to tumor types (Figures 4). Statistical analyses (e.g., Pearson's chi-

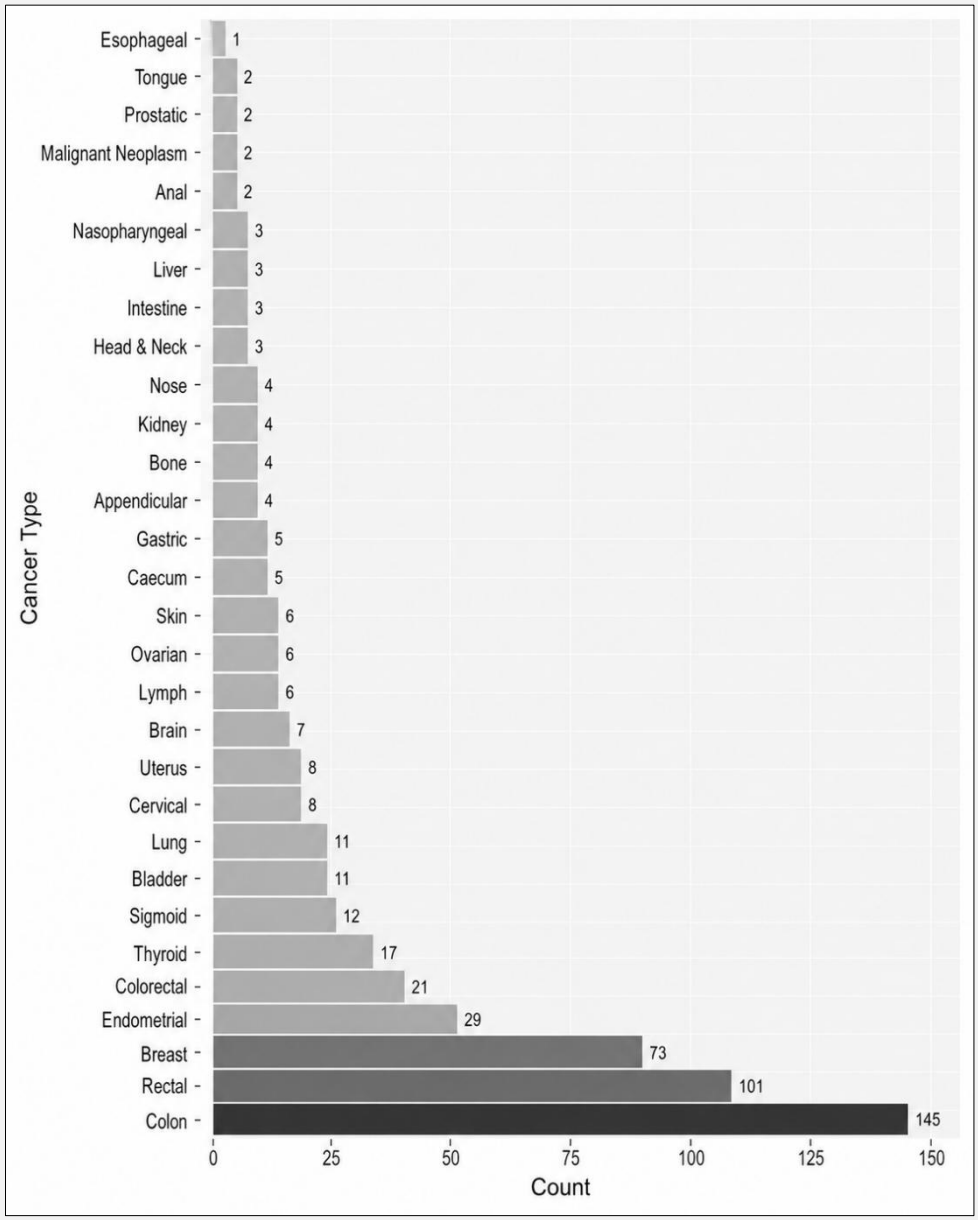

Figure 1. Distribution of sample counts across various cancer types.

squared test) indicated a significant association between anemia type and cancer type ($p < 0.001$), reinforcing that anemia phenotype is not uniformly distributed and may be influenced by the underlying malignancy. Post hoc pairwise comparisons suggest colorectal cancers are significantly more associated with microcytic hypochromic anemia (MCHC), while breast cancer shows a stronger association with a non-anemic profile (adjusted $p < 0.05$).

DISCUSSION

Anemia is common in cancer patients as a result of chemotherapy and radiation therapy, bleeding, or hemolysis. In this study, we evaluated 508 patients newly diagnosed with solid cancer who had not yet received therapy at King Abdulaziz Medical City. Our results showed that 47.9% of patients suffered from anemia. Females are higher than males. The mean age of patients was 56 years, which aligns with the mean ages reported in sev-

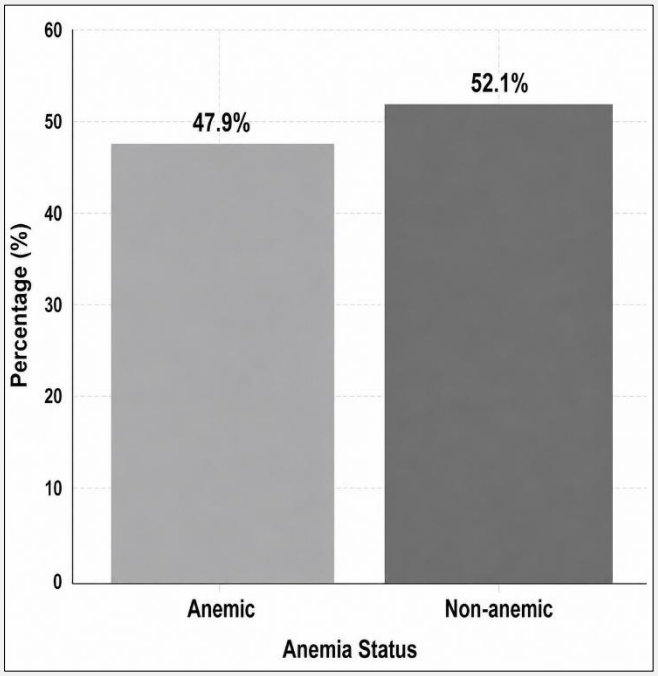

Figure 2. Distribution of anemia status among participants.

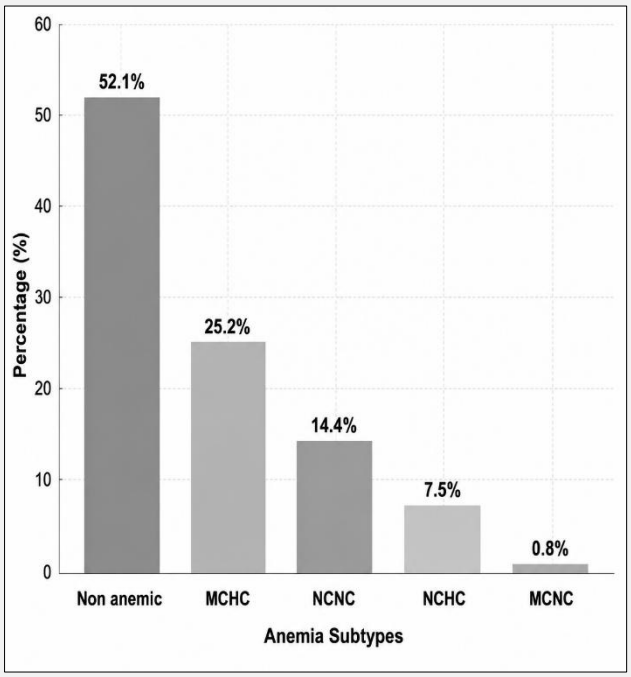

Figure 3. Distribution of anemia subtypes and non-anemic cases.

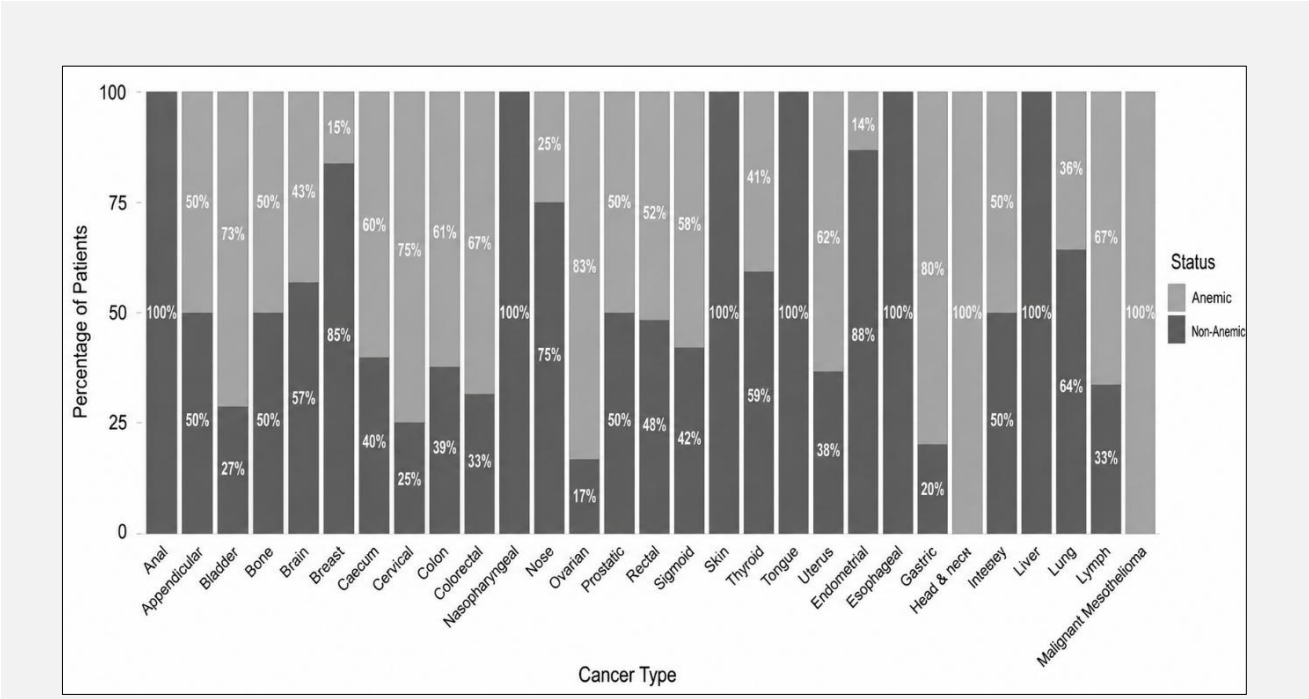

Figure 4. Distribution of anemia status by cancer type.

eral other studies. In a study by Kenar et al. [23] in Turkey, the mean age was 57 years form 310 patients. A study conducted in India [17] indicated that the average age of patients with solid tumors was 60 years. The mean age was 55 years among 471 cancer patients in Sudan [16]. These mean age similarities imply a similar age distribution throughout these studies, allowing for objective comparisons of the forms and prevalence of anemia in cancer patients across various geographic locations.

The probability of developing cancer escalates with advancing age. While cancer can afflict individuals of any age, the majority of diagnosed cases occur in individuals aged 50 and older [24].

The prevalence of anemia in the current research was 47.9%, which is relatively high in comparison to other investigations. For instance, [25] found anemia in 18.98% of 1,133 newly diagnosed cancer patients. This lower prevalence could be related to their larger cohort, which contained a wider spectrum of cancer types, potentially resulting in a lower overall anemia rate. Conversely, [23] reported an anemic prevalence of 49.7% in 310 cancer patients in Turkey, which is remarkably comparable to our data. In juxtaposition with the research conducted by Abuidris et al. [16] which encompassed a cohort of 471 cancer patients and reported an anemia prevalence of 50.3%, our investigation revealed a marginally lower prevalence of 47.9% (n = 243). While both studies indicate that approximately half of the cancer-affected population is afflicted by anemia, the slight discrepancy may be ascribed to differences in cancer types, stages at diagnosis, nutritional status, or access to healthcare services among the respective populations. Furthermore, the closely aligned percentages bolster the broader acknowledgment of anemia as a prevalent comorbidity among oncology patients.

In our investigation, the incidence of anemia was significantly high among patients with colorectal cancer, especially when evaluated by tumor subsite: colon cancer (61%), sigmoid colon cancer (58%), and rectal cancer (52%). In contrast, breast and endometrial cancer patients demonstrated a predominantly non-anemic profile. These findings suggest a potential association between tumor location and hematological status, warranting further investigation into underlying mechanisms such as blood loss, nutritional deficiencies, or bone marrow involvement specific to tumor types. The current analysis highlights the heterogeneous distribution of anemia types across various cancer types. A significant proportion of patients in most malignancy categories, particularly breast and endometrial cancers, were found to be non-anemic. This may reflect earlier-stage diagnosis, less marrow-invasive disease, or effective pre-treatment screening and support in these populations. These results are consistent with prior studies suggesting lower anemia prevalence in hormonally driven malignancies compared to gastrointestinal cancer [26,27].

Moreover, this subsite-specific classification provided more refined information about anemia patterns than

previous research that merged these subsites together as "colorectal cancer." Regardless of this discrepancy, our findings are broadly consistent with prior studies.

For instance, a research report from India found that 62% of colorectal cancer patients were anemic at diagnosis, which is consistent with our observations in colon and sigmoid colon malignancies [28]. Likewise, a study conducted in Saudi Arabia discovered a 56.8% frequency of anemia in colorectal cancer patients [18] confirming the substantial anemia burden in this group.

In contrast, other research found lower incidence rates, which could be attributed to cohort differences, classification methodologies, or population features.

For example, a Chinese study at West China Hospital found a 23.13% prevalence of anemia in colorectal cancer patients [25] but an Ethiopian study found a slightly higher frequency of 26.7% among colorectal cases [19]. Sudanese data showed an even higher rate in the combined category of colorectal/anorectal malignancies at 59.1% [16] which aligned more closely with our results. Moreover, a comparable subanalysis of gastrointestinal malignancies performed in Turkey found anemia in 54% of colon cancer patients, and 38.7% of rectal cancer patients [23]. In comparison to these findings, we found a somewhat higher anemia prevalence in colon cancer (61% vs. 54%) and a much higher rate in rectal cancer (52% vs. 38.7%). Variations in demographic characteristics and diagnostic thresholds may explain these variations. Notably, our decision to study sigmoid colon cancer independently gave significant knowledge that was typically lost in larger colorectal groupings, emphasizing the need for anatomical specificity when assessing anemia burden among gastrointestinal cancers.

Overall, while our study stands out for its granularity in subclassifying colorectal cancer types, the overall anemia prevalence we observed falls within the greater range reported in the literature. The consistently elevated rates across demographics highlight the clinical significance of early anemia detection and therapy in colorectal cancer patients.

The distribution of anemia types in our study was predominantly microcytic hypochromic anemia. Iron deficiency anemia in colorectal cancer (CRC) patients is caused mostly by chronic blood loss from tumor ulceration. This syndrome causes iron reserves to become depleted. Additionally, cancer-related inflammation promotes functional iron insufficiency via the hepcidin pathway, whereas prolonged blood loss results in absolute iron deficiency [29]. Normocytic normochromic anemia, suggestive of anemia of chronic disease (ACD), is consistent with findings in several other studies. For example, Chowdhary et al. [28] showed that the highest percentage of patients presented with microcytic hypochromic (48.2%). 38.5% exhibited the normocytic normochromic type, while the remaining were macrocytic hypochromic and dimorphic. Haideri et al. [17] found the distribution of anemia types with 89% of their anemic individuals exhibiting microcytic hypochromic anemia, a notably greater percentage than seen in our group. This variation could be linked to different underlying causes of anemia, like iron deficiency or anemia related to chronic diseases, which may vary depending on local healthcare practices or nutritional elements.

On the other hand, some studies showed that the greatest prevalence of types of anemia in their study was normocytic normochromic, followed by microcytic hypochromic. Kenar et al. [23] found that normocytic anemia was the most common type (53.3%), followed by microcytic anemia (40.9%). This pattern was similarly observed in [19], where normocytic anemia was the most prevalent.

This study highlights that anemia is a frequent comorbidity among patients newly diagnosed with solid tumors, affecting nearly half of the cohort. The prevalence was especially high in colorectal cancers, notably colon (61%), sigmoid colon (58%), and rectal cancer (52%), with microcytic hypochromic anemia being the predominant subtype. Moreover, by excluding patients with a history of chronic or acute diseases and those who had received prior transfusions or treatments, this study provides a clearer and more accurate estimate of anemia prevalence at the time of initial cancer diagnosis. Taken together, these findings emphasize the importance of early screening, accurate classification, and timely intervention to mitigate the negative impact of anemia on cancer treatment outcomes. Integrating anemia management into oncology care protocols is essential to improve patients' tolerance to therapy, quality of life, and overall prognosis. Consequently, the present findings not only highlight the substantial burden of anemia among oncology patients in Saudi Arabia but also underscore the clinical value of systematic screening at diagnosis, laying the groundwork for targeted interventions that can enhance treatment tolerance and patient quality of life.

Limitations and future works

In the present investigation, the occurrence of specific cancer types was found to be minimal among the patient cohort, rendering the extrapolation of our findings problematic. Moreover, additional variables, including iron studies, evaluations of inflammatory biomarkers, and cellular morphology assessments, were not performed. The relationship between cancer stages and hemoglobin concentrations was similarly not evaluated. Subsequent research should encompass longitudinal follow-up, biochemical assessments (including iron profile, and C-reactive protein), as well as nutritional evaluations to further clarify the mechanisms and progressions of anemia in patients with cancer. Furthermore, establishing a correlation between the type of anemia and tumor stage, therapeutic approach, and patient survival could provide enhanced clinical understanding.

CONCLUSION

This study provides a reliable baseline on anemia in newly diagnosed solid tumor patients by eliminating confounding factors such as pre-existing anemia and chronic or acute diseases. Its findings highlight the importance of integrating early anemia assessment and management into oncology care, offering valuable evidence to improve treatment tolerance and patient's overall health and inform healthcare policy, particularly within the Saudi context.

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Ethical Approval:
This study was reviewed and approved by the Institutional Review Board (IRB) of King Abdullah International Medical Research Center (KAIMRC), Ministry of National Guard Health Affairs, Jeddah, Saudi Arabia (IRB Approval No.: NRJ25/022/1.

Declaration of Interest:
None.

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