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Clinicopathological profile of pancytopenia in adult patients attending a tertiary care hospital: a hospital-based cross-sectional study.

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Abstract

Background
Pancytopenia is a clinically important haematological presentation characterized by simultaneous reduction of erythrocytes, leukocytes and platelets. Its causes range from reversible nutritional deficiency to marrow failure and haematological malignancy.

Objectives
To evaluate the clinical presentation, haematological profile, peripheral smear findings, bone marrow patterns and etiological spectrum of pancytopenia in adult patients.

Methods
This hospital-based cross-sectional study was conducted among 100 adult patients with pancytopenia at Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, Andhra Pradesh, India, from September 2025 to February 2026. Adult patients fulfilling haematological criteria for pancytopenia were evaluated using clinical history, physical examination, complete blood count, peripheral smear and bone marrow examination when indicated. Data were analysed using descriptive statistics.

Results
All 100 eligible participants were included and analysed. The mean age was 43.6 ± 16.2 years, and the largest age group was 31–45 years. Males constituted 56% of cases. Generalized weakness was the most frequent symptom, followed by fever and dyspnoea on exertion. Pallor was seen in all patients. Mean haemoglobin, total leukocyte count and platelet count were 6.8 ± 1.7 g/dL, 2,180 ± 760 cells/mm³ and 62,400 ± 28,600/mm³, respectively. Macro-ovalocytes with hypersegmented neutrophils were the commonest peripheral smear finding. Hypercellular marrow was the predominant marrow pattern. Megaloblastic anaemia was the leading etiology, followed by aplastic anaemia, hypersplenism and acute leukaemia.

Conclusion
Megaloblastic anaemia was the most common cause of adult pancytopenia in this tertiary care setting. A systematic clinicopathological approach helps distinguish treatable causes from marrow failure and malignant disorders.

Recommendations
Routine peripheral smear review, early haematinic evaluation and selective bone marrow examination are recommended for timely diagnosis and rational management.

Keywords: *Adult pancytopenia; Bone marrow examination; Megaloblastic anaemia; Aplastic anaemia; Peripheral smear; Tertiary care hospital.*
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Introduction

Pancytopenia is a haematological condition in which all three major formed elements of blood are reduced below the normal reference range. It represents a final common laboratory expression of several diseases rather than a single diagnosis. The clinical picture depends on the dominant cytopenia and its severity. Anaemia commonly produces weakness, fatigue and dyspnoea; leukopenia increases vulnerability to infection; and thrombocytopenia results in mucocutaneous bleeding, petechiae or bruising. Because the same blood-count pattern can arise from benign, infectious, nutritional, autoimmune and malignant disorders, careful clinicopathological assessment is essential [1,2].

The mechanisms of pancytopenia broadly include decreased marrow production, ineffective haematopoiesis, marrow infiltration, peripheral destruction and sequestration. Nutritional deficiencies, especially vitamin B12 and folate deficiency, remain important in Indian clinical practice and often produce macrocytosis, macro-ovalocytes, hypersegmented neutrophils and hypercellular marrow with megaloblastic maturation [3,4]. In contrast, aplastic anaemia is characterized by hypocellular marrow and reduced haematopoietic elements, while acute leukaemia and lymphoma cause cytopenias through marrow replacement. Hypersplenism produces pancytopenia through splenic pooling and destruction, usually with splenomegaly and reactive or compensatory marrow changes [5,6].

Previous studies have shown considerable geographical variation in the etiological pattern of pancytopenia. Indian series have frequently reported megaloblastic anaemia as a leading cause, whereas referral-based haematology units have reported higher proportions of acute leukaemia, myelodysplastic syndrome and marrow infiltration [7,8]. Such variation is influenced by age structure, nutritional status, infection burden, referral pattern, availability of specialized tests and hospital level. Therefore, local data remain useful for diagnostic prioritization, laboratory planning and early clinical decision-making [9,10].

Peripheral smear examination and bone marrow evaluation together provide a practical framework for diagnosis. The peripheral smear gives rapid clues regarding macrocytosis, dimorphic anaemia, blasts, leukoerythroblastic reaction and dysplastic morphology. Bone marrow aspiration and trephine biopsy further define cellularity, maturation pattern, infiltration, fibrosis and marrow failure. Regional datasets also aid laboratory triage in resource-limited departments, where early separation of treatable deficiency from marrow pathology affects turnaround time. These findings help clinicians separate reversible causes from conditions needing urgent referral, chemotherapy, immunosuppression or supportive transfusion care [11,12].

The present study was conducted to assess the clinicopathological profile of pancytopenia among adult patients attending a tertiary care hospital. The objectives were to describe the demographic and clinical profile, evaluate haematological parameters, document peripheral smear and bone marrow findings, and determine the etiological distribution of pancytopenia in adult patients attending Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, Andhra Pradesh, India.

Methodology

Study design and setting

This hospital-based descriptive cross-sectional study was conducted in the Department of Pathology, in coordination with the Departments of General Medicine and other clinical units, at Konaseema Institute of Medical Sciences and Research Foundation (KIMS&RF), Amalapuram, Andhra Pradesh, India, from September 2025 to February 2026. KIMS&RF is a 1,100-bed multispecialty teaching hospital serving the Konaseema region and surrounding rural and semi-urban communities. The hospital provides outpatient and inpatient care, round-the-clock emergency and diagnostic services, advanced laboratory and digital imaging facilities, intensive care units, and a broad range of medical and surgical specialty services. The Department of Pathology provides routine and specialised haematology services, peripheral blood smear evaluation, and bone marrow diagnostic facilities. The study evaluated adult patients detected to have pancytopenia on complete blood count during routine diagnostic care.

Study population

The study included 100 adult patients aged 18 years and above who fulfilled the haematological criteria for pancytopenia. Pancytopenia was defined as haemoglobin less than 10 g/dL, total leukocyte count less than 4,000 cells/mm³ and platelet count less than 150,000/mm³. Patients were included consecutively until the required sample size was reached during the study period. Patients who had received recent chemotherapy or radiotherapy, patients with known haematological malignancy already under treatment, those with isolated or bicytopenia only,

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and patients with incomplete clinical or laboratory records were excluded.

Study size

The minimum study size was estimated using the single-proportion formula, $n = Z^2p(1-p)/d^2$. Because a reliable local estimate of the predominant clinicopathological pattern was not available, an expected proportion of 50% was used to provide the maximum variance, with a 95% confidence level and 10% absolute precision. The calculated sample size was 96.04 and was rounded to 100 participants. Consecutive eligible patients were recruited until this target was achieved.

Bias

Selection bias was reduced by consecutive enrolment of all eligible adult patients during the study period until the required sample size was reached and by applying prespecified inclusion and exclusion criteria uniformly. Information bias was limited through a structured data-collection form, automated complete blood count measurements, and standardised procedures for peripheral smear and bone marrow evaluation. Morphological findings were interpreted by trained pathologists, and equivocal findings were reviewed jointly before assigning the final diagnosis. Completed forms were checked for internal consistency and missing data before entry. As the study was descriptive and cross-sectional, causal inferences were not made.

Clinical evaluation

Relevant demographic details, symptoms and clinical signs were recorded using a structured data collection form. Presenting symptoms such as generalized weakness, fever, dyspnoea on exertion, bleeding manifestations and weight loss were documented. Physical examination findings included pallor, hepatomegaly, splenomegaly and lymphadenopathy. Clinical details were correlated with laboratory and marrow findings to arrive at the final etiological diagnosis.

Laboratory investigations

Complete blood count was performed using an automated haematology analyser. Haemoglobin, total leukocyte count, platelet count, mean corpuscular volume and reticulocyte count were recorded. Peripheral blood smears were stained and examined for red cell morphology, leukocyte abnormalities, platelet adequacy, hypersegmented neutrophils, blasts, dimorphic population and leukoerythroblastic reaction. Bone marrow aspiration and trephine biopsy were performed when clinically indicated and interpreted by trained pathologists. Marrow cellularity was categorized as hypercellular, hypocellular, normocellular or dry tap/inadequate aspirate. Diagnostic interpretation followed standard haematological principles and published diagnostic approaches to pancytopenia [1,2].

Statistical analysis

Data were entered into Microsoft Excel and analysed using descriptive statistics. Continuous variables were expressed as mean with standard deviation and range. Categorical variables were summarized as frequency and percentage. As the objective of the study was descriptive clinicopathological profiling, no hypothesis-testing model was applied. Tables were prepared to present demographic features, clinical findings, haematological parameters, smear findings, marrow cellularity and etiological diagnosis.

Ethical considerations

The study was conducted after institutional permission and ethics committee approval. Written informed consent was obtained from participants before marrow procedures when performed. Patient identity was kept confidential, and data were used only for academic analysis. The study followed accepted ethical principles for observational biomedical research.

Results

Participant flow

During the recruitment period, 100 adults with complete blood count-confirmed pancytopenia were identified as potentially eligible and assessed against the prespecified eligibility criteria. All 100 fulfilled the eligibility requirements. No patient was excluded, declined participation, or was lost after enrolment. All 100 completed the planned clinicopathological evaluation and were included in the final analysis (Figure 1).

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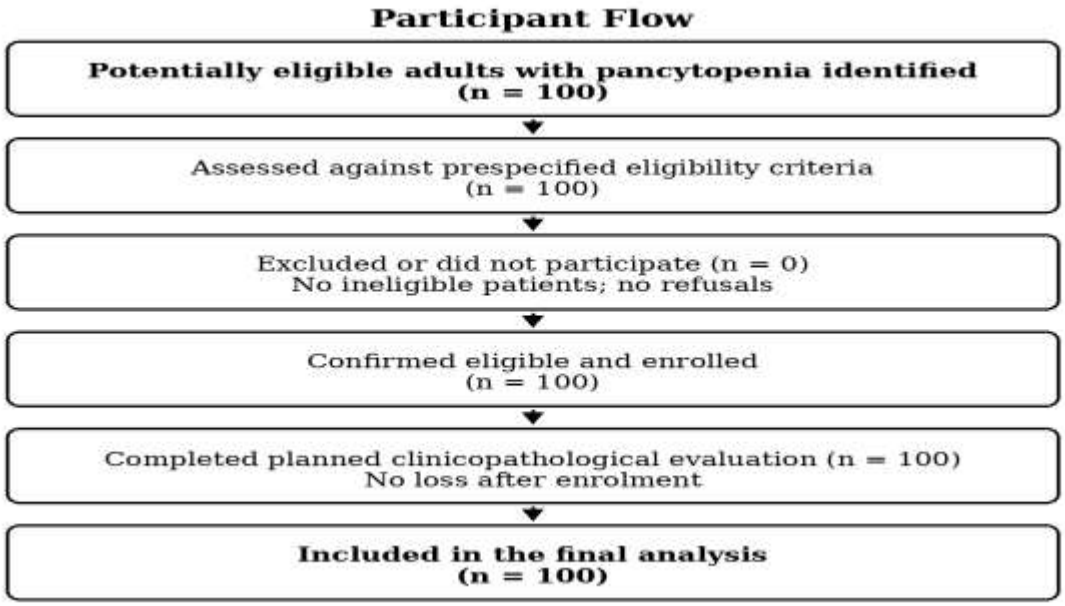

Figure 1. Flow of participants through the study

The mean age was 43.6 ± 16.2 years, with most patients belonging to the 31–45 years age group. Males were slightly more common than females. Generalized weakness was the most frequent presenting symptom, followed by fever and dyspnoea on exertion. Pallor was present in all patients. The demographic and clinical profile is shown in Table 1.

Table1. Demographic and clinical profile of patients with Pancytopenia

Variable	Frequency	Percentage
Age group		
18–30 years	22	22.0
31–45 years	34	34.0
46–60 years	27	27.0
>60 years	17	17.0
Sex		
Male	56	56.0
Female	44	44.0
Presenting symptoms/signs		
Generalized weakness	78	78.0
Fever	38	38.0
Dyspnoea on exertion	32	32.0
Bleeding manifestations	18	18.0
Weight loss	12	12.0
Pallor	100	100.0
Splenomegaly	34	34.0
Hepatomegaly	18	18.0
Lymphadenopathy	9	9.0

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The haematological profile showed marked reduction in all three blood cell lines. The mean haemoglobin was 6.8 ± 1.7 g/dL, mean total leukocyte count was 2,180 ± 760 cells/mm³, and mean platelet count was 62,400 ± 28,600/mm³. Severe anaemia was observed in nearly half of the patients. Platelet count below 50,000/mm³ was seen in 41 patients, while total leukocyte count below 2,000/mm³ was observed in 46 patients (Table 2).

Table 2. Haematological parameters among study participants

Parameter	Mean ± SD / Frequency	Range / Percentage
Haemoglobin, g/dL	6.8 ± 1.7	3.2–10.1
Total leukocyte count, cells/mm³	2,180 ± 760	800–3,900
Platelet count, /mm³	62,400 ± 28,600	12,000–145,000
Reticulocyte count, %	1.1 ± 0.6	0.2–3.4
Mean corpuscular volume, fL	96.8 ± 14.7	68–124
Haemoglobin <7 g/dL	48	48.0%
Platelet count <50,000/mm³	41	41.0%
Total leukocyte count <2,000/mm³	46	46.0%

Peripheral smear examination showed macro-ovalocytes with hypersegmented neutrophils in 40% of cases, suggesting megaloblastic anaemia. Normocytic normochromic anaemia was observed in 21% of cases and dimorphic anaemia in 13% of cases. Blasts were identified in 9% of cases. Bone marrow examination showed hypercellular marrow as the most common pattern, followed by hypocellular and normocellular marrow. Dry tap or inadequate aspirate was observed in 11 cases and required further correlation with biopsy findings (Table 3).

Table 3. Peripheral smear and bone marrow findings

Finding	Frequency	Percentage
Peripheral smear findings		
Macro-ovalocytes with hypersegmented neutrophils	40	40.0
Normocytic normochromic anaemia	21	21.0
Dimorphic anaemia	13	13.0
Blasts in peripheral smear	9	9.0
Microcytic hypochromic anaemia	6	6.0
Leukoerythroblastic picture	5	5.0
Other nonspecific findings	6	6.0
Bone marrow cellularity		
Hypercellular marrow	54	54.0
Hypocellular marrow	18	18.0
Normocellular marrow	17	17.0
Dry tap/inadequate aspirate	11	11.0

Megaloblastic anaemia was the most common cause of pancytopenia, accounting for 42% of cases. Aplastic anaemia was the second most common cause, followed by hypersplenism and acute leukaemia. Myelodysplastic syndrome accounted for 6% of cases. Infective causes included malaria, dengue and HIV-associated marrow suppression. Nutritional anaemias together formed the largest etiological group. The etiological distribution is presented in Table 4.

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Table 4. Etiological distribution of pancytopenia

Etiology	Frequency	Percentage
Megaloblastic anaemia	42	42.0
Aplastic anaemia	16	16.0
Hypersplenism	12	12.0
Acute leukaemia	9	9.0
Myelodysplastic syndrome	6	6.0
Mixed nutritional deficiency	5	5.0
Infective causes	5	5.0
Lymphoma/marrow infiltration	3	3.0
Autoimmune disorders	2	2.0
Total	**100**	**100.0**

Overall, megaloblastic anaemia was the leading clinicopathological diagnosis among adult patients with pancytopenia. Primary marrow failure, hypersplenism and haematological malignancies constituted other important causes, emphasizing the value of combined clinical, smear and marrow-based evaluation.

Discussion

This study evaluated 100 adults with pancytopenia and showed a broad age range, with the highest proportion in the 31–45 years group. A slight male predominance was observed. Generalized weakness, fever and dyspnoea on exertion were the leading presenting symptoms, while pallor was universal. These findings are consistent with the expected clinical expression of anaemia and have also been described in Indian clinicopathological studies of pancytopenia [3,5,10].

The haematological profile demonstrated moderate to severe cytopenias across all three cell lines. The mean haemoglobin was 6.8 g/dL, indicating that many patients presented after substantial anaemia had developed. Nearly half had haemoglobin below 7 g/dL, and 41% had platelet count below 50,000/mm³. Such values highlight the clinical burden of delayed presentation and the need for rapid assessment. Peripheral smear examination was highly informative, with macro-ovalocytes and hypersegmented neutrophils forming the dominant smear pattern. This observation matched the etiological pattern because megaloblastic anaemia was the leading diagnosis in the study [13,14].

Bone marrow findings provided important diagnostic confirmation. Hypercellular marrow was the commonest pattern and correlated with the high proportion of megaloblastic anaemia and other ineffective haematopoietic states. Hypocellular marrow was seen in 18% of cases and was most relevant to aplastic anaemia. Prior studies have also shown that marrow cellularity is a useful initial discriminator between nutritional anaemia, marrow failure and infiltrative disorders [2,6]. Bone marrow evaluation is particularly valuable when blasts, leukoerythroblastic reaction, unexplained severe cytopenia or dry tap is encountered [1,2].

Megaloblastic anaemia accounted for 42% of cases and was the most frequent etiology. This agrees with several Indian studies in which nutritional anaemia was a major contributor to pancytopenia [3,5,8,9]. In contrast, Patel and Prajapati reported acute leukaemia as the leading cause in a clinical haematology department, showing that referral pattern can substantially alter etiological ranking [11]. International data also show regional variation, with malignant, infectious and marrow failure causes contributing in different proportions [12]. Therefore, pancytopenia should not be interpreted through a single fixed etiological assumption.

The present findings support a stepwise diagnostic approach. Clinical history and examination narrow the differential diagnosis, while complete blood count and peripheral smear provide the first objective clues. Bone marrow examination is justified when the smear shows blasts or leukoerythroblastic reaction, when cytopenias are severe, or when initial evaluation does not reveal a clear reversible cause. Early identification of megaloblastic anaemia is clinically important because it is treatable, whereas aplastic anaemia, acute leukaemia, myelodysplastic syndrome and marrow infiltration require specialized management [1,7,12].

Generalizability: The findings are most applicable to adult patients attending tertiary care hospitals in coastal and semi-urban South Indian settings with similar nutritional, infectious and referral patterns. The high proportion of megaloblastic anaemia indicates that treatable nutritional causes remain important in comparable populations. However, centres with dedicated oncology referral, transplant services or different infectious disease burden can observe a higher frequency of

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malignant, aplastic or infiltrative marrow disorders in routine practice.

Conclusion

This cross-sectional study showed that pancytopenia in adults has a broad clinicopathological spectrum, with megaloblastic anaemia as the leading cause in the present tertiary care setting. Generalized weakness, fever, dyspnoea and pallor were the main clinical features. Peripheral smear examination gave valuable early diagnostic clues, particularly macro-ovalocytes and hypersegmented neutrophils. Bone marrow assessment helped distinguish hypercellular nutritional anaemia from hypocellular marrow failure and malignant infiltration. The findings emphasize that adult pancytopenia needs systematic evaluation rather than symptomatic treatment alone. Early diagnosis of reversible nutritional deficiency can reduce morbidity, while timely recognition of marrow failure and malignancy can guide urgent referral and targeted management, particularly in resource-constrained tertiary care settings.

Limitations

The study was single-centre and descriptive with a sample of 100 patients, so causal inference and subgroup comparisons were limited. Serum vitamin B12, folate, iron studies, viral markers, flow cytometry and cytogenetics were not uniformly available for every patient. Follow-up after diagnosis was not assessed. Selection of patients attending a tertiary hospital can overrepresent symptomatic and referred cases. These factors restrict external validity and detailed clinicopathological correlations.

Recommendations

All adult patients with pancytopenia should undergo structured evaluation beginning with clinical history, physical examination, complete blood count and careful peripheral smear review. Early testing for vitamin B12, folate and iron status is recommended where nutritional deficiency is suspected. Bone marrow aspiration and biopsy should be prioritized in severe cytopenia, unexplained cases, blasts, leukoerythroblastic picture, suspected aplastic anaemia or marrow infiltration. Hospitals should develop a local diagnostic algorithm for pancytopenia and strengthen coordination between pathology, medicine and haematology services. Patient education regarding nutrition and early consultation for weakness, fever or bleeding can support earlier diagnosis. Periodic audit of etiological trends is useful.

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Abbreviations

CBC: Complete blood count;
Hb: Haemoglobin;
HIV: Human immunodeficiency virus;
MCV: Mean corpuscular volume;
MDS: Myelodysplastic syndrome; n: Number;
SD: Standard deviation;
TLC: Total leukocyte count.

Source of funding

The study had no funding.

Conflict of interest

The authors declare no conflict of interest.

Author Contributions

Dr. Narendra Kumar Chandrashekar contributed to the conception and design of the study, supervision of pathological evaluation, data interpretation, manuscript drafting, and critical revision of the manuscript.

Dr. Thiragati Venu Gopala Krishna contributed to data collection, laboratory/pathological assessment, literature review, data organization, and preparation of the initial manuscript draft.

Dr. Kandanala Mallika contributed to histopathological/cytopathological evaluation, analysis of findings, interpretation of results, manuscript review, and intellectual refinement of the article.

Dr. Anand Acharya contributed to overall academic supervision, research methodology guidance, critical review of the manuscript, and final approval of the version to be submitted.

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All authors read and approved the final manuscript. All authors agree to be accountable for the accuracy and integrity of the work.

Data availability

Data available on request

Author Biographies

Dr. Narendra Kumar Chandrashekar is an Associate Professor in the Department of Pathology, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, Andhra Pradesh, India. He is actively involved in undergraduate and postgraduate teaching, diagnostic histopathology, cytopathology, and academic research. His areas of professional interest include surgical pathology, clinicopathological correlation, and pathology-based observational research.

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Dr. Anand Acharya, currently serves as Dean and Professor, Department of Pharmacology, at the Konaseema Institute of Medical Sciences & Research Foundation (KIMS&RF), Amalapuram, Andhra Pradesh, India. A distinguished academician, researcher, and medical education leader, he has been pivotal in transforming KIMS&RF from its formative phase into a premier medical institution with over 200 undergraduate and 100 postgraduate seats.

With more than 18 years of teaching and administrative experience, Dr. Acharya has held several leadership positions, including Vice Principal, Principal, Chief Warden, Member Secretary of Institutional Ethics and Animal Ethics Committees, and is an approved PhD Guide under Dr. NTR University of Health Sciences, Vijayawada. His visionary leadership has significantly enhanced the institution's academic quality, clinical exposure, research infrastructure, and postgraduate training standards.

He has completed prestigious national faculty development programs such as the Revised Basic Course Workshop (rBCW), Advanced Course in Medical Education (ACME), and National Teacher Training Course (NTTC, JIPMER, Puducherry). He also serves as Coordinator for Pharmacovigilance and Materiovigilance Programs under IPC–PvPI and MoHFW, Government of India, contributing actively to national drug safety and regulatory initiatives.

A prolific academician, Dr. Acharya has authored and co-authored more than 100 scientific publications in reputed national and international indexed journals. His wide-ranging research covers toxicology, pharmacovigilance, antimicrobial resistance, endocrinology, neuropharmacology, and clinical pharmacology. His recent studies include long-term analyses of pyrethroid, paraquat, and chlorpyrifos poisoning, investigations into antimicrobial resistance trends, and predictive models for treatment outcomes in dermatological and toxicological emergencies.

Dr. Acharya's professional interests include clinical pharmacology, toxicovigilance, rational drug use, pharmacovigilance systems, and innovations in medical education technologies. He continues to mentor numerous postgraduate and undergraduate researchers while playing an integral role in curriculum reform, ethics governance, and institutional academic advancement.**ORCID iD: https://orcid.org/0009-0000-7967-9092**

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