

ORIGINAL RESEARCH

Morphological and Etiopathological Profile of Anaemia in Older Adults at a Tertiary Care Centre in Upper Assam, India: A Hospital-Based Cross-Sectional Study

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ABSTRACT

Background: Anaemia is common in older adults and is associated with functional decline and death, yet hospital-based data from Northeast India remain scarce. This study described the morphological patterns and underlying causes of anaemia in older inpatients at a tertiary care centre in Upper Assam.

Methods: In this hospital-based cross-sectional study, 90 consecutive inpatients aged 60 years or older with anaemia (haemoglobin <13.0 g/dL in men and <12.0 g/dL in women) were enrolled over 12 months (December 2023 to November 2024). Patients with recent major surgery, transfusion, chemotherapy, radiotherapy or haematinic therapy were excluded. All underwent a complete blood count, peripheral smear examination, iron studies and serum vitamin B12 assay. Severity was graded as mild (haemoglobin >9.0 g/dL), moderate (7.0–9.0 g/dL) or severe (<7.0 g/dL). Proportions are reported with 95% Wilson score confidence intervals (CIs).

Results: The cohort comprised 47 men and 43 women (ratio 1.1:1); 57 (63.3%) were aged 60–69 years. Severe anaemia was present in 41 patients (45.6%; 95% CI 35.7–55.8), and mean haemoglobin did not differ across age groups ($p = 0.752$). Microcytic hypochromic anaemia was the predominant morphological pattern (57.8%; 95% CI 47.5–67.5), followed by normocytic normochromic anaemia (36.7%). Nutritional deficiency accounted for 65.6% of cases (95% CI 55.3–74.6): isolated iron deficiency 48.9%, isolated vitamin B12 deficiency 8.9% and combined iron and vitamin B12 deficiency 7.8%. Anaemia of chronic disease was the second most frequent cause (28.9%). Smear morphology corresponded imperfectly with the final diagnosis: 31.8% of patients with iron deficiency were normocytic, and only 2 of 8 with isolated vitamin B12 deficiency were macrocytic. **Conclusions:** Iron deficiency was the leading cause of anaemia among older inpatients in Upper Assam, and nearly half presented with severe anaemia. Because smear morphology alone frequently misclassified the cause, biochemical confirmation should be routine. Community-based screening of older adults for anaemia, coupled with appropriate evaluation for the source of iron deficiency, may allow earlier detection and treatment.

Keywords: Aged; Anaemia; Iron-deficiency anaemia; Anaemia of chronic disease; Vitamin B12 deficiency; Peripheral blood smear

INTRODUCTION

Anaemia is among the most frequent haematological problems of later life. Population-based studies indicate that it affects roughly one in ten community-dwelling adults aged 65 years and older, and the prevalence rises steeply with advancing age and is considerably higher among hospitalised and institutionalised older people [1–4]. Physiologically, anaemia denotes a reduction in red cell mass, and therefore in haemoglobin concentration, sufficient to compromise oxygen delivery to the tissues [5]. Most epidemiological and clinical studies of older adults apply the World Health Organization (WHO) definition of a haemoglobin concentration below 13.0 g/dL in men and below 12.0 g/dL in women [6]. Whether these thresholds are appropriate for older people has long been debated [3,7], and the 2024 WHO guideline, which retained

them for adults up to 65 years of age, identified the derivation of age-specific cut-offs for older adults as a research priority [8].

Anaemia in older adults is not a benign consequence of ageing. It has been independently associated with declining physical performance and mobility, impaired cognition, more frequent and longer hospital admissions, and higher mortality [9–11]. It may also precipitate or worsen heart failure and aggravate cerebrovascular insufficiency in patients with limited physiological reserve [2,12]. Because many of its causes are readily treatable, establishing the underlying etiology is central to management [1,12].

The causes of anaemia in older people are diverse and frequently coexist. Inadequate dietary intake can lead to deficiencies of iron, folate and vitamin B12, all of which are essential for effective erythropoiesis; malabsorption, notably food-cobalamin malabsorption associated with atrophic gastritis, further contributes to vitamin B12 deficiency [12,13]. Chronic gastrointestinal blood loss from peptic ulcer disease or gastrointestinal malignancy is an important cause of iron deficiency in this age group [14]. Chronic inflammatory disorders, infections and chronic kidney disease give rise to anaemia of chronic disease (ACD), also termed anaemia of inflammation [4,15]. In addition, primary haematological disorders such as myelodysplastic syndromes and other marrow failure states become progressively more common with age [12].

The definition of “older adult” itself varies. In many high-income countries, old age is conventionally defined as 65 years or above and is sometimes subdivided into “early elderly” (65–74 years) and “late elderly” (75 years and above) [16]. No universal chronological threshold exists, however, because biological ageing, functional status and socioeconomic circumstances differ widely between populations [17,18], and the cut-off of 60 years adopted by the United Nations is widely used in low- and middle-income countries [19]. In India, older persons are defined as those aged 60 years and above [20].

Indian data point to a substantial burden. In a community-based study from northern India, anaemia was the most prevalent morbidity among people aged over 60 years [21], and hospital-based studies have documented considerable variation in its morphological and etiological profile between centres [22–25]. More recently, a venous blood-based survey across eight Indian states reported anaemia in 45% of older women and 37% of older men, with striking regional heterogeneity: the overall prevalence ranged from 12.1% in Meghalaya to 69.8% in Assam, the highest of the states surveyed [26]. Despite this, hospital-based data on anaemia in older adults from Northeast India remain limited. The present study was therefore undertaken to describe the haematological and morphological patterns of anaemia, and to establish its underlying etiology, among patients aged 60 years and older at a tertiary care centre in Upper Assam.

MATERIALS AND METHODS

Study design and setting

This hospital-based, cross-sectional observational study was conducted over 12 months, from December 2023 to November 2024, in the Department of Pathology in collaboration with the Departments of Biochemistry and Medicine of a tertiary care teaching institution in Upper Assam, India. Ethical approval was obtained from the Institutional Ethics Committee (IEC) of Jorhat Medical College and Hospital (Approval No.: SMEJ/JMCH/MEU/841/Pt-2/2011/4983; Date: 23 November 2023), and the study was conducted in accordance with the Declaration of Helsinki [27]. Written informed consent was obtained from all participants or their legally authorised representatives. Patient data were anonymised before analysis.

Participants

Consecutive patients aged 60 years or older admitted to the medicine wards who had anaemia, defined as a haemoglobin concentration below 13.0 g/dL in men and below 12.0 g/dL in women [6,8], were eligible. To avoid secondary alterations in haematological and biochemical indices, patients who had undergone major surgery or received a blood transfusion within the preceding 3 months, those receiving chemotherapy or radiotherapy, and those who had received haematinic therapy within the preceding 30 days were excluded [28]. A total of 90 patients were enrolled. Anaemia severity was

graded by haemoglobin concentration as mild (>9.0 g/dL up to the sex-specific threshold), moderate (7.0–9.0 g/dL) or severe (<7.0 g/dL).

Sample size

The minimum sample size was calculated with Cochran's formula for estimating a single proportion, $n = Z^2 p(1 - p)/d^2$, where $Z = 1.96$ for a 95% confidence level and $d = 0.10$ is the absolute precision. Because the primary outcome was the etiological profile of anaemia, the anticipated proportion (p) was based on the frequency of iron deficiency anaemia, the principal nutritional cause, which was 24.8% and 30.0% in two previous Indian hospital-based studies of older adults with anaemia [23,29]. The higher value ($p = 0.30$) was used because it gives the larger sample size: $n = (1.96^2 \times 0.30 \times 0.70)/0.10^2 = 80.7$, i.e. a minimum of 81 participants. Ninety consecutive eligible patients were enrolled, which gives a precision of ± 9.5 percentage points for a proportion of 30% and ± 10.3 percentage points for the least favourable proportion of 50%.

Clinical and laboratory procedures

A detailed clinical history was obtained and a thorough physical examination was performed for each participant. Venous blood was collected under aseptic precautions into ethylenediaminetetraacetic acid (EDTA) and clot-activator vacutainers. A complete blood count was performed on an automated haematology analyser (Sysmex XN-550). Serum iron, total iron-binding capacity (TIBC), and serum creatinine were measured on a Beckman Coulter AU480 analyser. The estimated glomerular filtration rate (eGFR) was calculated based on the serum creatinine values. Serum vitamin B12, serum ferritin, and serum folate were analysed using the Beckman Coulter Access 2 immunoassay system. C-reactive protein (CRP) was quantified on a Mispia i2 analyser utilizing the principles of nephelometry and turbidimetry. The erythrocyte sedimentation rate (ESR) was determined using the manual Westergren pipette method. Haemoglobin typing was performed by cation-exchange high-performance liquid chromatography (HPLC) on a Bio-Rad D-10 system utilizing the D-10 Dual Program.

Peripheral blood smears were prepared manually, fixed in methanol and stained with Leishman stain. Red cells, leucocytes and platelets were examined by light microscopy to assign the morphological pattern of anaemia [30].

Diagnostic criteria

Morphological and etiological categories were assigned using the red cell indices, smear findings and confirmatory biochemical criteria summarised in Table 1 [15,30–34]. Each patient was assigned a single final etiological diagnosis, with combined iron and vitamin B12 deficiency recorded as a separate category.

Statistical analysis

Data were analysed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean $\pm$ standard deviation (SD) and categorical variables as frequencies and percentages. Proportions for severity, morphological and etiological categories are reported with 95% confidence intervals (CIs) calculated by the Wilson score method. Mean haemoglobin and haematocrit were compared across age groups (60–69, 70–79 and 80–89 years) by one-way analysis of variance (ANOVA). The relationship between smear morphology and final etiological diagnosis was examined descriptively by cross-tabulation. A p -value below 0.05 was considered statistically significant.

Table 1. Morphological and etiological diagnostic criteria

Category	Diagnostic and laboratory criteria	Reference
Microcytic hypochromic anaemia	MCV <80 fL, MCH <27 pg, MCHC <32 g/dL. Smear: red cells smaller than the nucleus of a small lymphocyte, with central pallor exceeding one-third of the cell diameter	[30]
Normocytic normochromic anaemia	MCV 80–100 fL with normal MCH and MCHC. Smear: red cells approximately the size of a small-lymphocyte nucleus, with central pallor about one-third of the cell diameter	[30]
Macrocytic anaemia	MCV >100 fL. Smear: macro-ovalocytes; hypersegmented neutrophils ($\geq 5\%$ of neutrophils with five lobes, or any with six or more lobes)	[30,32]

Category	Diagnostic and laboratory criteria	Reference
Dimorphic picture	Two distinct red cell populations (e.g. microcytic hypochromic and macrocytic) on the smear, usually with an increased RDW	[30]
Thalassaemia trait / haemoglobinopathy	MCV <80 fL with a raised red cell count, normal or near-normal RDW and Mentzer index <13; confirmed by HPLC	[33]
Iron deficiency anaemia	Serum ferritin <30 µg/L, transferrin saturation <16% and TIBC >400 µg/dL	[31]
Anaemia of chronic disease	Serum ferritin >100 µg/L, transferrin saturation <20%, low or normal TIBC, raised CRP/ESR, and an underlying chronic inflammatory, infective or systemic disorder	[15]
Vitamin B12 / folate deficiency	Serum vitamin B12 <200 pg/mL, or serum folate <4.0 ng/mL	[32]
Anaemia of chronic kidney disease	eGFR <60 mL/min/1.73 m ² (CKD stages 3–5) with no other identifiable cause	[34]

CKD, chronic kidney disease; CRP, C-reactive protein; eGFR, estimated glomerular filtration rate; ESR, erythrocyte sedimentation rate; HPLC, high-performance liquid chromatography; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; MCV, mean corpuscular volume; RDW, red cell distribution width; TIBC, total iron-binding capacity. Mentzer index = MCV (fL) ÷ red cell count ($\times 10^{12}/L$).

*Serum ferritin values of 30–100 µg/L are difficult to interpret, because inflammation and advanced age raise ferritin and can mask absolute iron deficiency. In this range, a transferrin saturation <20% indicates functional iron deficiency or a mixed aetiology (coexisting iron deficiency and anaemia of chronic disease) [15,31].

RESULTS

Participant characteristics and haematological parameters

Of the 90 patients enrolled, 47 (52.2%) were men and 43 (47.8%) were women, giving a male-to-female ratio of 1.1:1. Fifty-seven patients (63.3%) were aged 60–69 years, 24 (26.7%) were aged 70–79 years and 9 (10.0%) were aged 80–89 years. Mean haemoglobin was 7.19 ± 2.67 g/dL, 7.43 ± 2.17 g/dL and 6.69 ± 2.32 g/dL, respectively, in the three age groups, and the differences were not statistically significant ($F(2, 87) = 0.29$, $p = 0.752$). Mean haematocrit was likewise similar across groups ($23.46 \pm 7.71\%$, $23.65 \pm 6.45\%$ and $22.10 \pm 7.51\%$; $F(2, 87) = 0.16$, $p = 0.857$). Post hoc comparisons were therefore not performed (Table 2).

Table 2. Haemoglobin and haematocrit by age group (N = 90)

Parameter	60–69 years (n = 57)	70–79 years (n = 24)	80–89 years (n = 9)	F(2, 87)	p-value
Haemoglobin (g/dL)	7.19 ± 2.67	7.43 ± 2.17	6.69 ± 2.32	0.29	0.752
Haematocrit (%)	23.46 ± 7.71	23.65 ± 6.45	22.10 ± 7.51	0.16	0.857

Severity, morphology and etiology

Severe anaemia was the most frequent grade, present in 41 patients (45.6%; 95% CI 35.7–55.8), followed by moderate anaemia in 31 (34.4%; 95% CI 25.4–44.7) and mild anaemia in 18 (20.0%; 95% CI 13.0–29.4). On peripheral smear, microcytic hypochromic anaemia predominated (52 patients, 57.8%; 95% CI 47.5–67.5), followed by normocytic normochromic (33, 36.7%), macrocytic (3, 3.3%) and dimorphic (2, 2.2%) pictures (Table 3).

Nutritional deficiency was the commonest etiological category, accounting for 59 cases (65.6%; 95% CI 55.3–74.6). Within this category, isolated iron deficiency anaemia (IDA) was diagnosed in 44 patients (48.9%; 95% CI 38.8–59.0), isolated vitamin B12 deficiency in 8 (8.9%; 95% CI 4.6–16.6) and combined iron and vitamin B12 deficiency in 7 (7.8%; 95% CI 3.8–15.2). ACD was the second most frequent cause (26 patients, 28.9%; 95% CI 20.5–39.0). The remaining 5 patients (5.6%) had malignancy (n = 2), multifactorial anaemia (n = 2) or a haemoglobinopathy (n = 1) (Table 3).

Table 3. Severity, smear morphology and etiology of anaemia (N = 90)

Variable	n	%	95% CI
Severity			
Severe (Hb <7.0 g/dL)	41	45.6	35.7–55.8
Moderate (Hb 7.0–9.0 g/dL)	31	34.4	25.4–44.7
Mild (Hb >9.0 g/dL)	18	20.0	13.0–29.4
Smear morphology			
Microcytic hypochromic	52	57.8	47.5–67.5
Normocytic normochromic	33	36.7	27.4–47.0
Macrocytic	3	3.3	1.1–9.3
Dimorphic	2	2.2	0.6–7.7
Etiology			
Nutritional deficiency (total)	59	65.6	55.3–74.6
Isolated iron deficiency	44	48.9	38.8–59.0
Isolated vitamin B12 deficiency	8	8.9	4.6–16.6
Combined iron and vitamin B12 deficiency	7	7.8	3.8–15.2
Anaemia of chronic disease	26	28.9	20.5–39.0
Malignancy	2	2.2	0.6–7.7
Multifactorial	2	2.2	0.6–7.7
Haemoglobinopathy	1	1.1	0.2–6.0

CI, confidence interval (Wilson score method); Hb, haemoglobin. Mild anaemia denotes Hb >9.0 g/dL but below the sex-specific threshold (13.0 g/dL in men, 12.0 g/dL in women).

Relationship between smear morphology and final diagnosis

Smear morphology and final etiological diagnosis are cross-tabulated in Table 4. Among patients with IDA, 30 of 44 (68.2%; 95% CI 53.4–80.0) had a microcytic hypochromic picture, whereas 14 (31.8%; 95% CI 20.0–46.6) had normocytic normochromic red cells. Patients with ACD were almost evenly divided between normocytic normochromic (14 of 26, 53.8%; 95% CI 35.5–71.2) and microcytic hypochromic (11 of 26, 42.3%; 95% CI 25.5–61.1) morphology, with one macrocytic case (3.8%). Of the 8 patients with isolated vitamin B12 deficiency, only 2 (25.0%) showed macrocytosis; 3 (37.5%) were normocytic, 2 (25.0%) microcytic and 1 (12.5%) dimorphic. Combined iron and vitamin B12 deficiency was predominantly microcytic (5 of 7, 71.4%).

Table 4. Peripheral smear morphology by final etiological diagnosis (N = 90)

Smear morphology	IDA (n = 44)	Vitamin B12 deficiency (n = 8)	Combined deficiency* (n = 7)	ACD (n = 26)	Other† (n = 5)
Microcytic hypochromic	30 (68.2) [53.4–80.0]	2 (25.0) [7.1–59.1]	5 (71.4) [35.9–91.8]	11 (42.3) [25.5–61.1]	4 (80.0) [37.6–96.4]
Normocytic normochromic	14 (31.8) [20.0–46.6]	3 (37.5) [13.7–69.4]	1 (14.3) [2.6–51.3]	14 (53.8) [35.5–71.2]	1 (20.0) [3.6–62.4]
Macrocytic	0 [0.0–8.0]	2 (25.0) [7.1–59.1]	0 [0.0–35.4]	1 (3.8) [0.7–18.9]	0 [0.0–43.4]
Dimorphic	0 [0.0–8.0]	1 (12.5) [2.2–47.1]	1 (14.3) [2.6–51.3]	0 [0.0–12.9]	0 [0.0–43.4]

Values are n (% of the etiological group) [95% Wilson score CI]. ACD, anaemia of chronic disease; IDA, iron deficiency anaemia. *Combined iron and vitamin B12 deficiency. †Malignancy (n = 2), multifactorial anaemia (n = 2) and haemoglobinopathy (n = 1).

DISCUSSION

In this hospital-based study of older inpatients in Upper Assam, nutritional deficiency, chiefly iron deficiency, was the leading cause of anaemia, followed by ACD. Microcytic hypochromic morphology predominated, nearly half of the patients had severe anaemia, and smear morphology was an unreliable guide to the underlying cause in a substantial minority.

Men slightly outnumbered women in our cohort (1.1:1). Sharma *et al.* also observed a male predominance among older patients with anaemia in North India, although it was more pronounced (1.6:1) [23]. Most of our patients (63.3%) were aged 60–69 years, similar to the 51% aged 60–70 years reported by Krishnamurthy *et al.* [24]. This age distribution probably reflects the demographic structure of the population served and the smaller number of very old people who survive to, and are admitted to, tertiary care.

Severe anaemia was found in 45.6% of our patients, comparable to the 42% reported by Krishnamurthy *et al.*, in whose series most patients had moderate or severe anaemia [24]; the proportions with mild and moderate anaemia differed between the two studies, which may reflect differences in referral patterns and admission thresholds. Because only inpatients were studied, these figures overestimate the severity of anaemia among older adults in the community. Even so, the finding that almost half of these patients had a haemoglobin concentration below 7.0 g/dL at admission suggests that anaemia in many older people in the region is recognised late.

Microcytic hypochromic anaemia was the predominant morphological pattern (57.8%), followed by normocytic normochromic anaemia (36.7%). In contrast, a normocytic picture predominated in the series of Krishnamurthy *et al.* (49%), followed by a microcytic picture (34%) [24], and in the Bangalore series of Bhasin and Rao [22]. The higher proportion of microcytosis in our series is consistent with the larger share of iron deficiency we observed; differences in diet, the prevalence of chronic blood loss and access to primary care may each contribute, although our data cannot distinguish between these explanations.

Nutritional deficiency was the most common etiological category in our study, in agreement with Krishnamurthy *et al.*, who reported nutritional deficiency in 45% and anaemia of chronic inflammation in 40% of their patients [24]. IDA was likewise the single most frequent diagnosis in the series of Sharma *et al.*, although at a much lower proportion (24.8%) than in ours (48.9%) [23]. By contrast, ACD was the leading cause in other Indian hospital-based series [29,35]. Large population-based studies from high-income countries have described a roughly equal division between nutritional anaemia, anaemia of chronic inflammation or kidney disease, and unexplained anaemia [4]; the much larger nutritional share in Indian series underscores the importance of regional data. ACD was nevertheless a major contributor in our cohort (28.9%), comparable to the 22.9% reported by Sharma *et al.* [23]. Malignancy and multifactorial anaemia were each identified in only 2.2% of our patients, and no patient was left without a diagnosis, whereas malignancy accounted for 14% of cases in the Bangalore series [22], and unexplained anaemia for 8% in the series of Krishnamurthy *et al.* [24] and 8.6% in that of Sharma *et al.* [23]. The lower proportion of malignancy here may partly reflect our exclusion of patients receiving chemotherapy or radiotherapy, and the absence of bone marrow examination.

The classification of iron deficiency as “nutritional” requires caution. In older adults, iron deficiency often results from occult gastrointestinal blood loss, including from peptic ulcer disease and gastrointestinal malignancy, rather than from inadequate intake alone, and current guidelines recommend gastrointestinal evaluation for older patients with unexplained IDA [14,31]. In the Bangalore series, endoscopy revealed a gastrointestinal lesion in 73.3% of older patients with microcytic anaemia [22]. Endoscopic evaluation was not part of our protocol, so some cases of IDA may have had a bleeding source that went undetected. Identifying iron deficiency should therefore prompt a search for its cause as well as iron replacement.

The relationship between morphology and etiology has practical implications. Nearly a third of patients with IDA had normocytic red cells, which is consistent with early iron deficiency or coexisting inflammation [15,31]. Only a quarter of patients with isolated vitamin B12 deficiency were macrocytic, and the remainder showed normocytic, microcytic or dimorphic pictures. Coexisting conditions that reduce red cell size, such as unrecognised iron restriction, inflammation or

thalassaemia trait, can mask macrocytosis, and serum vitamin B12 concentration is an imperfect marker of tissue deficiency [32]. A normocytic or microcytic smear therefore does not exclude cobalamin deficiency, and biochemical assessment should routinely complement smear morphology to ensure accurate classification and timely treatment [30,32].

The cut-offs in Table 1 describe typical, uncomplicated cases. In older patients, serum ferritin behaves as an acute-phase reactant and rises with inflammation, so values between 30 and 100 µg/L are difficult to interpret, and reliance on ferritin alone risks missing clinically significant iron deficiency. In this range, a transferrin saturation below 20% indicates functional iron deficiency, in which iron is present but unavailable for erythropoiesis, and inflammatory markers such as CRP and ESR help to distinguish pure ACD from a mixed picture [15,31].

Taken together, a high proportion of severe anaemia and the predominance of correctable causes indicate a gap in the early detection of anaemia among older adults in this region. This interpretation accords with the high community prevalence of anaemia reported from Assam and among older adults in India [26]. Community-level screening of older adults for anaemia, together with nutritional assessment and appropriate investigation of iron deficiency, could allow treatment before patients require tertiary hospital care.

This study has several limitations. First, it was conducted at a single tertiary care centre. Second, the inclusion of inpatients only introduces selection bias towards more severe and complex disease, and the findings cannot be extrapolated to the general older population. Third, bone marrow examination was not performed; this was a deliberate decision to avoid an invasive procedure in frail, multimorbid patients when peripheral blood and biochemical findings were sufficient for initial management, but it may have led to under-recognition of myelodysplastic syndromes and other marrow disorders. Fourth, gastrointestinal endoscopy, methylmalonic acid and homocysteine assays, and markers such as soluble transferrin receptor were not used, which limits the distinction between dietary and blood-loss iron deficiency, the confirmation of borderline vitamin B12 deficiency, and the recognition of combined iron deficiency and ACD. Finally, although the overall sample met the calculated requirement, some etiological subgroups were small, as reflected in their wide confidence intervals. These data nevertheless provide a useful baseline for larger, multicentre studies in Northeast India.

CONCLUSION

In this cross-sectional study of 90 older inpatients with anaemia in Upper Assam, nutritional deficiency, predominantly iron deficiency, was the leading cause of anaemia, and ACD was the second most frequent. Nearly half of the patients had severe anaemia at presentation, which points to delayed detection, and smear morphology alone often failed to identify the underlying cause. Routine biochemical confirmation, investigation of the source of iron deficiency, and community-based screening and nutritional programmes for older adults are needed to detect and treat anaemia before it progresses to the point of requiring tertiary hospital care.

DECLARATIONS

Ethics approval: Approved by the Institutional Ethics Committee of Jorhat Medical College and Hospital (Approval No. SMEJ/JMCH/MEU/841/Pt-2/2011/4983; 23 November 2023).

Consent: Written informed consent was obtained from all participants or their legally authorised representatives.

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Conflict of interest: The authors declare that they have no competing academic, institutional, financial or personal interests.

Data availability: De-identified data are available from the corresponding author on reasonable request.

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