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Prevalence of Anemia Among ESRD Patients on Hemodialysis in Dhamar, Yemen A Cross-Sectional Study

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ABSTRACT

Objectives

To determine the prevalence of anemia and evaluate management gaps among End-Stage Renal Disease (ESRD) patients on hemodialysis in Dhamar, Yemen (between May and July 2025), focusing on sociodemographic and clinical correlates

Aim

Address systemic challenges in anemia management within Yemen's resource-limited dialysis care.

Background

Anemia remains a critical complication in End-Stage Renal Disease (ESRD) particularly among hemodialysis patients in resource-limited settings. This study determines its prevalence, management gaps, and associated factors in Yemen's Dhamar governorate, where healthcare challenges are exacerbated by limited resources and infrastructure.

Subjects and Methods

Cross- sectional descriptive study was conducted at dialysis centers in Dhamar governorate, Yemen. The study included 130 ESRD patients with 100 meeting inclusion criteria who had been on hemodialysis for at least three months. Patients with acute kidney injury or incomplete records were excluded. Data were collected using a structured questionnaire, capturing socio-demographic characteristics, clinical parameters, hemoglobin levels, Mean Corpuscular Volume (MCV), erythropoiesis-stimulating agent (ESA) usage, iron supplementation, blood transfusion frequency, comorbidities, nutritional status, and nephrologist follow-up. Statistical analysis was performed using SPSS version 25.

Results

The prevalence of anemia (HB<11 g/dL) was 86,9%, Despite MCV Normocytic (82%), microcytic (12%), macrocytic (6%) Significant MCV-Hb correlation (r=0.034). Despite 70% of patients receiving ESA therapy and 66% receiving iron supplementation, 75.9% had undergone one or more blood transfusions, indicating dependence on reactive anemia management. Comorbid conditions such as hypertension and diabetes were common, and of patients were in poor nutritional condition.

Conclusion

Cross-sectional study conducted in Dhamar, Yemen, demonstrates a notably high prevalence of anemia (86.9%) among patients with End Stage Renal Disease (ESRD) undergoing dialysis. Hemoglobin levels in this population were consistently below the recommended threshold, reflecting suboptimal anemia control. MCV analysis revealed Normocytic (82%), microcytic (12%), macrocytic (6%) patterns (mean: 86.7 ± 6.2 fL; p =0.021). Although70% of patients receiving erythropoiesis stimulating agents (ESA) therapy and 66% were on iron supplementation, a high frequency of blood transfusions (mean:12.12 per patient). (Indicates inadequate long-term management strategies The most common comorbidity was hypertension, affecting 60% of cases, either alone or in combination with diabetes, confirming its significant contribution to both ESRD development and anemia severity. Additionally, 17.5% of patients suffered from poor nutritional status, and33% lacked regular nephrologist follow-up, further worsening anemia- related outcomes.

Keywords: Anemia; ESRD; Heamodialysis; Yemen; Resource-limited setting

INTRODUCTION

General introduction

Anemia is a frequent and serious complication of Chronic Kidney Disease (CKD), especially in patients with End-Stage Renal Disease (ESRD) receiving dialysis. It is primarily caused by a deficiency in erythropoietin production, iron deficiency, chronic inflammation, and reduced red blood cell lifespan [1]. Anemia in dialysis patients is associated with fatigue, impaired physical capacity, and cognitive decline, ultimately reducing quality of life [2]. Studies indicate that the prevalence of anemia in ESRD patients on dialysis ranges between 70% and 90% globally, depending on the population and diagnostic thresholds [3]. The management of anemia in dialysis patients typically includes Erythropoiesis-Stimulating Agents (ESAs), iron supplementation, and occasional blood transfusions [4]. Despite the availability of these interventions, anemia remains underdiagnosed and under treated, particularly in low-resource settings [5]. The World Health Organization (WHO) defines anemia as hemoglobin levels below 13 g/ dl in men and 12 g/dL in women [6]. Given the significant burden of anemia and its complications among dialysis patients, it is vital to evaluate its prevalence and contributing factors in specific settings. This study aims to investigate the prevalence of anemia among ESRD patients receiving dialysis in Dhamar, Yemen, and to identify relevant demographic and clinical factors. The findings will contribute to enhancing local anemia management strategies and optimizing patient outcomes.

Study justification

Despite well-established guidelines for the management of anemia in dialysis patients, many low-resource regions like Yemen lack systematic data on anemia prevalence and management. Dhamar, a region with limited healthcare infrastructure, faces particular challenges in dialysis care. Understanding the burden of anemia in this population is essential for developing effective, localized strategies. By identifying the prevalence and associated factors of anemia among ESRD patients on dialysis in Dhamar, this study will provide a basis for targeted interventions, improve patient care, and support future health planning in nephrology services.

OBJECTIVES

General objective

To determine the prevalence of anemia among ESRD patients receiving haemodialysis in Dhamar, Yemen.

Specific objectives

a) To identify demographic and clinical characteristics associated with anemia in haemodialysis patients.
b) To assess hemoglobin levels and related laboratory findings such as Mean Corpuscular Volume (MCV), serum ferritin, and Transferrin Saturation (TSAT).

c) To evaluate anemia management practices, including use of ESAs and iron therapy.

REVIEW OF LITERATURE

Dialysis

Introduction

Dialysis is a life-sustaining treatment used in patients with End-Stage Renal Disease (ESRD) to remove waste products and excess fluids from the blood when kidney function is inadequate. It helps maintain electrolyte balance and prevents uremic complications [7]. Dialysis does not cure kidney disease but improves survival and quality of life.

Types of dialysis

There are two primary types of dialysis:

a) ***Hemodialysis (HD):*** Involves the use of a dialysis machine and a dialyzer (artificial kidney) to clean the blood. It is usually performed three times a week and requires vascular access.

b) ***Peritoneal Dialysis (PD):*** Uses the patient's peritoneal membrane as a filter. A cleansing fluid is introduced into the abdominal cavity and later drained. It can be done at home and allows greater flexibility. The choice of dialysis type depends on clinical indications, patient preference, and available healthcare infrastructure [8].

Indications for dialysis

Dialysis is typically initiated when a patient progresses to End-Stage Renal Disease (ESRD), usually defined as a Glomerular Filtration Rate (GFR) of less than 15 mL/min/1.73 m². Common indications for starting dialysis include: -Severe fluid overload not responsive to diuretics - Life-threatening hyperkalemia-Severe metabolic acidosis-Symptoms of uremia such as encephalopathy, pericarditis, or severe nausea/vomiting-Progressive deterioration of nutritional status [9].

how dialysis works

In hemodialysis, blood is drawn from the patients body and passed through a dialyzer, where it flows alongside a dialysate solution separated by a semipermeable membrane. Waste products and excess fluids diffuse from the blood into the dialyzate. The cleaned blood is then returned to the patients circulation. Hemodialysis sessions typically last 3'5 hours and are done three times weekly. In peritoneal dialysis, a catheter is surgically inserted into the abdomen. A special fluid is introduced into the peritoneal cavity, where the peritoneal membrane acts as a natural filter. After a set dwell time, the fluid containing waste and excess electrolytes is drained. This process is repeated multiple times daily or overnight using a cycler [10].

Complication and side effects of dialysis

While dialysis is essential for survival in ESRD, it is associated with several potential complications: Hemodialysis-related complications: - Hypotension during or after sessions - Muscle cramps - Headaches, nausea - Vascular access infections or thrombosis - Disequilibrium syndrome (neurological symptoms due to rapid shifts in fluid/electrolyte balance) Peritoneal dialysis-related complications: - Peritonitis (infection of the peritoneal cavity) - Catheter-related infections - Protein loss leading to malnutrition - Hernias or abdominal discomfort Long-term dialysis is also associated with bone mineral disorders, cardiovascular complications, and reduced quality of life [11, 12].

Anemia in dialysis patients

Introduction

Anemia is a prevalent and clinically significant complication of End-Stage Renal Disease (ESRD), particularly in patients undergoing dialysis. It is defined by low Hemoglobin (Hb) concentration and is mainly attributed to the kidneys' failure to produce adequate erythropoietin, a hormone essential for red blood cell production [13]. Other contributing factors include iron deficiency, chronic inflammation, malnutrition, and blood losses during dialysis sessions [14].

Pathophysiolgy

In healthy individuals, Erythropoietin (EPO) is produced in the kidneys in response to hypoxia, stimulating bone marrow to produce red blood cells. In ESRD, this function is impaired, leading to insufficient erythropoiesis. Moreover, iron utilization is hindered by chronic inflammation, which increases hepcidin levels, reducing intestinal iron absorption and iron release from stores [15]. Dialysis patients may also experience blood loss from vascular access and during routine procedures, contributing to persistent anemia.

Diagnosis and classification

The World Health Organization (WHO) defines anemia as Hb<13 g/dL in men and<12 g/dL in women [6]. In dialysis patients, routine hemoglobin monitoring is recommended. Additional parameters such as Mean Corpuscular Volume (MCV), serum ferritin, and Transferrin Saturation (TSAT) help identify underlying deficiencies.

- Microcytic anemia usually suggests iron deficiency.
- Normocytic anemia is the most common type in ESRD, typically due to EPO deficiency.
- Macrocytic anemia may indicate folate or vitamin B12 deficiency.

Management

Treatment of anemia in dialysis patients includes addressing the underlying cause and using therapeutic agents:

- ***Erythropoiesis-Stimulating Agents (ESAs):*** Recombinant human EPO and its analogs are used to stimulate red blood cell production.
- ***Iron Therapy:*** Both oral and intravenous iron are used to correct iron deficiency and support ESA response.
- ***Other Supplements:*** Folate and vitamin B12 may be supplemented if deficient.
- ***Blood Transfusions:*** Used when Hb levels are critically low or when ESA therapy is ineffective, although long-term use is limited due to risk of alloimmunization [16].

MATERIALS AND METHODS

Study design

This is a cross-sectional descriptive study analyzing prevalent anemia in ESRD patients, (May–July 2025).

Study area

Dialysis center in Dhamar governorate, Yemen.

Study population

Total screened 130 ESRD patients undergoing hemodialysis at selected center and finlly analyzed 100 patients (76.9% of screened).

Inclusion criteria

- Age ≥ 18 years
- On dialysis for at least 3 months
- Complete date set required

Exclusion criteria

- Acute kidney injury (n=0)
- Incomplete patient records
- Missing lab date (n=18)
- Partial questionnaire response (n=9)

Sample size

Sample size 130 case and will be calculated using Epi Info (95% confidence level, 5% margin of error minimum required 100 patients met after exclusion).

Data collection

Data will be collected using a structured questionnaire, including demographic, clinical, and laboratory information.

Data analysis

Statistical analysis will be done using Statistical Package for Social Sciences (SPSS) version 25. Descriptive and inferential statistics will be used.

RESULTS

The study population had a mean age of 43.9 ± 16.14 years (p=0.032), with the majority of patients (60%) falling within the 40-60 age range. A significant male predominance was observed in the sample (67%, p=0.001). Regarding marital status, 80% of patients were married (p=0.215). Urban residents constituted a larger share of the study population (58%) compared to rural residents (42%, p=0.043) (Table 1).

Table 1: Demographic and Clinical Characteristics of ESRD Patients on Dialysis (N=100).

Variable	Category/Measure	Frequency (n)	Percentage (%)	Statistical Value (Mean ± SD/Range)	p-value
Age (year)	Mean ± SD	-	-	43.9 ± 16.14	0.032
	Median (Range)			(15-85) 45.0	
Gender	Male	67	67.0%		
	Female	33	33.0%		0.001

Marital status	Married	80	80.0%		0.215
	Single	20	20.0%		
Residency	Urban	58	58.0%		0.043
	Rural	42	42.0%		
Hemoglobin (Hb)	Mean Hb (g/ dl)			8.97 ± 1.24	0.0001
	Hb < 11 g/ dl (Anemia)	86	86.9%		
ESA Use	Yes	70	70.0%		0.008
	No	30	30.0%		
Iron Supplementation	Yes	66	66.0%		0.012
	No	34	34.0%		
Blood Transfusions	Mean Transfusions			12.02 ± 8.45	
	Patients with Transfusions	63	75.9%		
Comorbidities	HTN Only	60	60.0%		0.001
	DM + HTN	10	10.0%		
	None	20	20.0%		
	Other	10	10.0%		
Nutritional Status	Good	50	48.5%		0.025
	Fair	35	34.0%		
	Poor	18	17.5%		
Nephrologist Follow-Up	Yes	66	67.0%		0.003
	No	33	33.0%		

Anemia was observed in 86.9% of the study population (defined as hemoglobin <11 g/dL, p=0.0001), a rate significantly higher than global averages reported between 70–80% [2,4]. Despite the high prevalence, only 70% of affected individuals received Erythropoiesis-Stimulating Agents (ESAs) (Table 2).

Table 2: Demographic and Clinical Characteristics of ESRD Patients on Dialysis (N=100).

Variable Category/Measure	Frequency (n)	Percentage (%)	Statistical Value (Mean ± SD/Range)	p-value
MCV (fL) Mean ± SD	-	-	86.7 ± 6.2	0.021
(Microcytic) 80 fL>	12	12.0%		
(Normocytic) 80-100 fL	82	82.0%		
(Macrocytic) 100 fL<	6	6.0%		

The Mean Corpuscular Volume (MCV) among patients was 86.7 ± 6.2 fL (p=0.021), indicating a predominance of normocytic anemia (82%), with microcytic and macrocytic patterns accounting for 12% and 6%, respectively. Statistically significant correlations were identified between MCV and several clinical parameters. An inverse correlation was found between MCV and transfusion frequency (r = -0.32, p = 0.018), consistent with findings by Fishbane and Berns (2005), who reported increased transfusion needs among microcytic patients [16]. A

positive correlation was also noted between MCV and hemoglobin levels (r = 0.28, p = 0.034) [17].

Despite 70% of patients receiving ESAs (p=0.008) and 66% receiving iron supplementation (p=0.012), 75.9% required blood transfusions (p=0.0001), reflecting suboptimal treatment adherence and possible ESA resistance [16,18]. Persistent iron deficiency, even with supplementation, may contribute to these findings [13,14,19]. Hypertension was the most prevalent comorbidity, affecting 60% of the cohort (p=0.001), in line with patterns seen in low-income settings, where hypertension is a primary cause of CKD [20-24]. This finding is comparable to the 58% hypertension rate reported by Kaze et al, among ESRD patients in Africa, but contrasts with high-income countries where diabetes plays a larger etiological role, as noted by Jha et al, [22,24].

Poor nutritional status was observed in 17.5% of patients (p=0.025), worsening anemia by reducing responsiveness to ESA therapy and increasing susceptibility to infections [4,15]. This rate exceeds that reported in U.S. dialysis centers, where malnutrition affects approximately 10% of patients according to Mehrotra et al, [12]. Malnutrition further exacerbates ESA resistance [4,13,25]. Additionally, 33% of patients lacked access to specialist nephrology care (p=0.003), a gap attributed to geographic limitations and the shortage of nephrologists in Yemen [26-28].

DISCUSSION

The study population had a mean age of 43.9 ± 16.14 years (p=0.032), with the majority of patients (60%) falling within the 40–60 age range, consistent with the typical onset period of End-Stage Renal Disease (ESRD) [9]. This finding aligns with global patterns, where the prevalence of Chronic Kidney Disease (CKD) tends to increase with age due to cumulative exposure to risk factors such as hypertension and diabetes [19]. A significant male predominance was observed in the sample (67%, p=0.001), which is consistent with previous studies from Africa and Asia [17,22]. In the Yemeni context, Al-Wadei et al, reported a similar male predominance (65%), likely reflecting sociocultural and occupational influences on disease progression. Compared to international data, the mean age in this study appears younger than that reported by Singh et al, in India (mean age: 54 years), which may be due to the earlier onset of hypertension and diabetes in Yemen, reduced post-dialysis life expectancy, occupational exposures such as agricultural toxins and physically demanding work, delays in seeking healthcare among men, and a higher prevalence of risk factors like smoking and hypertension among Yemeni males [11,18-20,23,25].

Regarding marital status, 80% of patients were married (p=0.215), a proportion that mirrors the middle-aged demographic burdened by ESRD [18]. Urban residents constituted a larger share of the study population (58%) compared to rural residents (42%, p=0.043), a difference likely attributed to better access to dialysis centers in urban areas [23]. This disparity may also reflect underdiagnosis in rural regions due to limitations in healthcare infrastructure [26].

Anemia was observed in 86.9% of the study population (defined as hemoglobin <11 g/dL, p=0.0001), a rate significantly higher than global averages reported between 70–80% [2,4]. This figure also exceeds the threshold established by Kidney Disease: Improving Global Outcomes (KDIGO) guidelines for anemia in chronic kidney disease patients [4]. Despite the high prevalence, only 70% of affected individuals received Erythropoiesis-Stimulating Agents (ESAs), underscoring substantial treatment gaps. Regionally, similar trends have been noted; for example, Alsumrain et al, in Saudi Arabia reported a 78% anemia prevalence with better ESA access, while Okaka et al, in Nigeria recorded an 82% prevalence, but only 50% of patients received ESAs, reflecting comparable limitations in therapeutic accessibility [3,17]. In contrast, data from the United States show a lower anemia rate of 70%, attributed to more consistent adherence to clinical protocols [2]. The elevated anemia rate in this Yemeni cohort points to systemic weaknesses, particularly in early detection of CKD and the financial barriers limiting ESA availability [22,27].

The Mean Corpuscular Volume (MCV) among patients was 86.7 ± 6.2 fL (p=0.021), indicating a predominance of normocytic anemia (82%), with microcytic and macrocytic patterns accounting for 12% and 6%, respectively. Statistically significant correlations were identified between MCV and several clinical parameters. An inverse correlation was found between MCV and transfusion frequency (r = -0.32, p = 0.018), consistent with findings by Fishbane and Berns (2005), who reported increased transfusion needs among microcytic patients [16]. A positive correlation was also noted between MCV and hemoglobin levels (r = 0.28, p = 0.034), supporting observations by Ganz and Nemeth (2015) regarding the role of iron availability in determining red blood cell size [15]. These results differ from those of Stauffer and Fan (2014), who found no significant correlation between MCV and hemoglobin levels in U.S. patients, suggesting a

more pronounced iron-deficiency component in Yemeni End-Stage Renal Disease (ESRD) patients, potentially driven by less optimized ESA dosing and limited erythropoietic support [2,4].

Despite 70% of patients receiving ESAs (p=0.008) and 66% receiving iron supplementation (p=0.012), 75.9% required blood transfusions (p=0.0001), reflecting suboptimal treatment adherence and possible ESA resistance [16]. Persistent iron deficiency, even with supplementation, may contribute to these findings [13,14]. Hypertension was the most prevalent comorbidity, affecting 60% of the cohort (p=0.001), in line with patterns seen in low-income settings, where hypertension is a primary cause of CKD [20,24]. This finding is comparable to the 58% hypertension rate reported by Kaze et al, among ESRD patients in Africa, but contrasts with high-income countries where diabetes plays a larger etiological role, as noted by Jha et al, [28,29].

Poor nutritional status was observed in 17.5% of patients (p=0.025), worsening anemia by reducing responsiveness to ESA therapy and increasing susceptibility to infections [4,15,30]. This rate exceeds that reported in U.S. dialysis centers, where malnutrition affects approximately 10% of patients according to Mehrotra et al, [12]. Malnutrition further exacerbates ESA resistance [4,13,31]. Additionally, 33% of patients lacked access to specialist nephrology care (p=0.003), a gap attributed to geographic limitations and the shortage of nephrologists in Yemen [26,28].

CONCLUSION AND RECOMMENDATION

CONCLUSION

Cross-sectional study conducted in Dhamar, Yemen, demonstrates a notably high prevalence of anemia (86.9%) among patients with End Stage Renal Disease (ESRD) undergoing dialysis. Hemoglobin levels in this population were consistently below the recommended threshold, reflecting suboptimal anemia control. MCV analysis revealed Normocytic (82%), microcytic (12%), macrocytic (6%) patterns (mean: 86.7 ± 6.2 fL; p =0.021). Although 70% of patients receiving Erythropoiesis Stimulating Agents (ESA) therapy and 66% were on iron supplementation, a high frequency of blood transfusions (mean:12.12 per patient). (Indicates inadequate long-term management strategies The most common comorbidity was hypertension, affecting 60% of cases, either alone or in combination with diabetes, confirming its significant contribution to both ESRD development and anemia severity. Additionally, 17.5% of patients suffered from poor nutritional status, and33% lacked regular nephrologist follow-up, further worsening anemia- related outcomes. Tese findings are consistent with data from other low-resource settings in Africa and Asia, were limited access to renal care and therapeutic resources continuous to hinder effective disease management.

RECOMMENDATION

Recommendations include optimizing anemia management protocols through standardized guidelines and ensuring uninterrupted availability of ESA and iron therapies in dialysis centers. Early detection strategies should be implemented to reduce reliance on blood transfusions. Nephrology services must be expanded, especially in rural areas, and increase specialist follow-up rates. Integrating nutritional support into routine care is essential to address malnutrition, a known contributor to ESA resistance. Targeted screening for Chronic Kidney Disease (CKD) should focus on high-risk individuals, particularly those with hypertension or diabetes, to facilitate earlier intervention. Community education initiatives on renal health and anemia prevention are also crucial. Further research is needed, including multicenter studies across Yemen to monitor anemia trends and assess treatment outcomes over time, with a particular need for studies involving other dialysis centers in Yemen, as well as cost-effectiveness analyses comparing ESA-based versus transfusion-dependent approaches.

DECLARATIONS

Conflict of interest

The authors declare no conflict of interest.

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Author contributions

The author contributed to the conception, design, analysis, interpretation, and writing of this manuscript.

Consent for publication

Not applicable.

Declaration of interest

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Availability of data and materials

All data generated or analysed during this study are included in this published article.

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