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A Study on the Prevalence and Causative Factors of Anemia in Patients Undergoing Maintenance Hemodialysis

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Abstract

Anemia is a common and serious issue in individuals with chronic kidney disease (CKD) who are on maintenance hemodialysis (MHD), greatly affecting their overall health and quality of life (QoL). Despite advancements in treatment, anemia remains a challenging issue in this population. This study investigates the prevalence of anemia and identifies the contributing factors in CKD patients on MHD with the aim of enhancing clinical management strategies. This study focused on evaluating the prevalence of anemia and identifying its contributing factors in a group of 70 CKD patients receiving MHD. A cross-sectional study was conducted at Meliora Kidney Institute and its affiliated hospitals: Paras Hospital in Panchkula, and Shalby Hospital in Mohali with 70 MHD patients. Participants aged 18 years or older with ESRD on MHD for at least six months were included. Data was collected through interviews, medical records, physical exams, and lab tests, focusing on Hemoglobin (Hb) levels, dialysis duration, comorbidities, and various factors related to anemia. Anemia was observed in 97.14% of patients, with a higher prevalence of severe anemia in females (52.17%) compared to males (38.30%). Older patients had lower Hb levels. Those on MHD for 0-6 months had the lowest average Hb (8.17 g/dL). Major contributing factors included bleeding episodes (42.86%), nutritional deficiencies (27.14%), liver disease (10%), and medication use (20%). Despite treatment with Erythropoiesis-Stimulating Agents (ESAs) and iron supplementation, 32.35% of anemic patients required blood transfusions. This study analyzed anemia in 70 MHD patients, revealing a 97.14% prevalence. It identified bleeding episodes as a significant and novel contributor to anemia, with a higher prevalence of severe anemia in females. Despite treatment with ESAs and iron supplements, 32.35% of patients needed blood transfusions, highlighting the need for improved anemia management strategies and further research.

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INTRODUCTION

Anemia is a medical condition characterized by a deficiency of circulating Red Blood Cells (RBCs) or Hemoglobin (Hb) levels below the normal values defined by the World Health Organization (WHO).

According to the Kidney Disease Improving Global Outcomes (KDIGO) guidelines, anemia is defined as having Hb levels below 12 g/dL in females and below 13 g/dL in males. This condition is prevalent among patients undergoing Maintenance Hemodialysis (MHD) for End-Stage Renal Disease (ESRD), often associated with

symptoms, such as fatigue, depression, reduced exercise tolerance, and dyspnea [1]. Anemia is linked to adverse clinical outcomes, including higher morbidity and mortality rates due to cardiovascular disease, and it significantly affects the patient's Quality of Life (QoL) [2–4]. As kidney disease progresses, anemia often worsens due to several factors. One significant cause is the reduced ability of the kidneys to produce Erythropoietin (EPO), a hormone essential for stimulating RBC production in the bone marrow. This reduced EPO production leads to decreased RBC formation and subsequent anemia. Uremia also affects platelet function, exacerbating the development and progression of anemia in individuals with kidney disease. Additionally, patients on long-term MHD often experience reduced RBC production due to abnormal erythropoiesis caused by the accumulation of aluminum in the bone marrow. Blood loss from frequent blood sampling, Gastrointestinal (GI) bleeding, and hemolysis further contribute to anemia in MHD patients [5]. The risk of upper GI bleeding is increased in patients with ESRD, raising their mortality risk [6]. Gastric and duodenal ulcers are leading causes of bleeding in this population, and long-term use of proton-pump inhibitors (PPIs) – often prescribed for reflux esophagitis or to prevent peptic ulcers in MHD patients – has been associated with severe anemia due to the development of gastric hyperplastic polyps [7–9]. Furthermore, deficiencies in vitamin B12 and folate, which are essential for RBC production, are prevalent in MHD patients and contribute to increased mortality. These deficiencies are often a result of poor appetite, reduced food intake due to advanced uremia, and chronic dialysis treatment [10, 11]. Iron deficiency, both absolute and functional, is another significant contributor to anemia in patients with ESRD. Absolute iron deficiency occurs when iron stores are depleted, limiting Hb synthesis and RBC production. Functional iron deficiency arises when the demand for iron exceeds the available supply, often due to inflammation or other underlying conditions [12–14]. Moreover, cardiovascular diseases, including heart failure, are major contributors to mortality in ESRD patients. Anemia exacerbates the severity of these conditions and is linked to higher morbidity and mortality rates [15, 16]. Additionally, the use of temporary vascular catheters in dialysis patients increases the risk of infections, which may contribute to hemolysis and further exacerbate anemia [17, 18]. The multifactorial nature of anemia in CKD patients undergoing MHD requires comprehensive management strategies to address all underlying causes. This study aims to investigate the prevalence and contributing factors of anemia in a cohort of patients undergoing MHD, providing valuable insights that could lead to more effective anemia management strategies and improved clinical outcomes.

MATERIALS AND METHODS

Study Site

The study was conducted at the Meliora Kidney Institute and its affiliated hospitals: Paras Hospital in Panchkula and Shalby Hospital in Mohali. These facilities are accredited by the National Accreditation Board for Hospitals and Healthcare Providers (NABH) for MHD. The Meliora Kidney Institute is well known for its specialized nephrology services, while Paras Hospital and Shalby Hospital are recognized for their comprehensive care and advanced medical infrastructure. The selection of these hospitals provided access to a varied patient population, ensuring a broad representation of individuals undergoing MHD. This diverse setting facilitated a thorough evaluation of anemia in CKD patients, supporting the study's goal of capturing a wide range of data on prevalence, and associated factors of anemia in this cohort.

Study Design

This cross-sectional observational study was designed to assess patients undergoing MHD at the Meliora Kidney Institute, Paras Hospital, and Shalby Hospital. The primary objectives were to determine the prevalence of anemia in patients with CKD receiving MHD, as well as to identify the factors associated with anemia in this cohort. Data collection involved personal interviews and a predesigned questionnaire, which captured a range of parameters related to anemia among the study participants.

Study Population

The study included 70 patients undergoing MHD. Participants were selected based on the following criteria:

Inclusion Criteria

- Patients aged 18 years and older.
- Patients diagnosed with ESRD who undergo MHD.
- Patients who have been receiving MHD treatment for at least six months.
- Patients who provided informed consent to participate in the study.

Exclusion Criteria

- Patients undergo peritoneal dialysis.
- Patients with active malignancies or blood disorders that could affect Hb levels.
- Patients who were unable to provide informed consent or participate in data collection.

This selection process ensured a representative sample of individuals with CKD undergoing MHD, allowing for a comprehensive analysis of anemia and its contributing factors within this patient population.

Sample Size

To determine the sample size required for estimating the proportion of patients with anemia among those undergoing MHD, we used the formula for sample size estimation for proportions:

$$\text{n} = \frac{Z^2\, P(1-P)}{E_2}$$

where:

(Z) is the Z-value for a 95% confidence level, which is 1.96.

(P) is the estimated proportion of patients with anemia. In our study, 68 out of 70 patients were identified with anemia, giving (P = 68/70 = 0.971).

(E) is the margin of error, set at 0.05 for a 5% margin.

Substituting these values into the formula:

$$\text{n} = \frac{(1.96^2)\cdot 0.971\cdot(1-0.971)}{0.05^2}$$

$$\text{n} \approx \frac{0.107}{0.0023} \approx 43 \text{ patients.}$$

Thus, a sample size of approximately 43 is sufficient for this study. Given our sample size of 70, the study is well-powered to estimate the proportion of patients with anemia accurately.

DATA COLLECTION

Data collection for this study involved several methods. Structured interviews were conducted with the patients using a pre-designed questionnaire that aligned with the study's objectives. Through these interviews, demographic details, medical histories, and information about dialysis treatment were gathered. In addition to the interviews, medical records were reviewed, including laboratory reports, to assess Hb levels and iron studies, which provided valuable insights into the anemia status of the patients and helped identify potential causes. Physical examinations were performed to observe clinical signs of anemia, such as pallor, fatigue, and difficulty breathing. Furthermore, laboratory assessments were conducted, focusing primarily on complete blood count (CBC) to determine Hb levels and other blood parameters. Iron studies were also included in the assessments; however, due to cost constraints, not all patients had sufficient data available for these tests, and certain assessments, such as endogenous EPO

levels, were not measured. Despite these limitations, the selected tests provided essential information on the anemia status of patients and helped identify the contributing factors in patients undergoing MHD.

Ethical Considerations and Confidentiality

The study received ethical approval from the appropriate research ethics committee and permission from the administrative authorities. Participants were provided with comprehensive information about the study's objectives, procedures, and potential risks and benefits. Informed consent was obtained both verbally and in writing. Participant confidentiality was rigorously upheld throughout the study.

RESULTS

Demographics

Gender Distribution

In our study population of 70 patients undergoing MHD, a clear predominance of male patients was observed, with a ratio of approximately 2:1 compared to female patients. Specifically, 47 individuals (67.14%) were male, while 23 individuals (32.85%) were female (Table 1 and Figure 1).

Table 1. Gender Distribution of Patients undergoing MHD.

Gender	Number of Patients (n = 70)	Percentage (%)	Male-to-Female Ratio
Male	47	67.14%	2:1
Female	23	32.86%	–

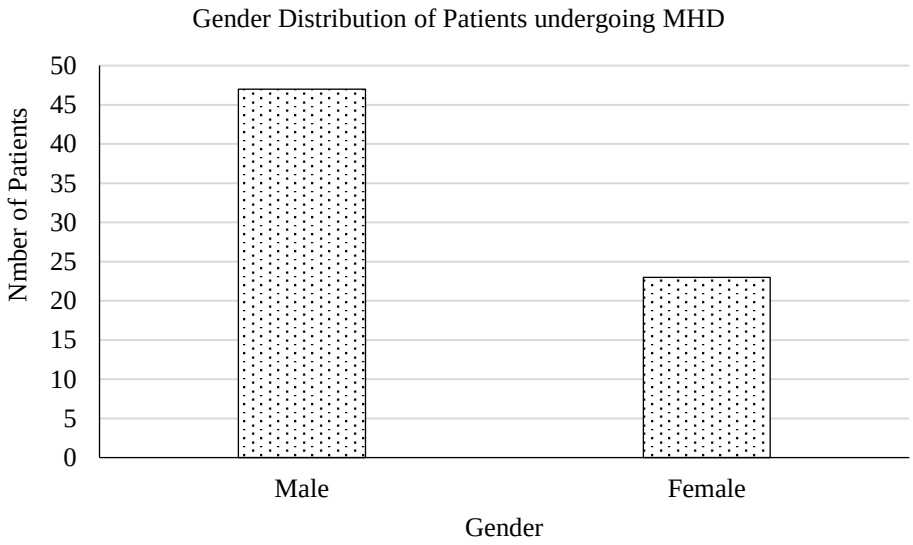

Figure 1. Gender distribution of patients undergoing MHD.

Age Group Distribution

The age distribution of the 70 patients undergoing MHD in our study reveals a significant prevalence of CKD among older age groups. The cohort included 3 patients (4.29%) aged 20–30 years, 8 patients (11.43%) aged 30–40 years, 13 patients (18.6%) aged 40–50 years, and 16 patients (22.86%) aged 5060 years. The prevalence was high in the 60–70 years group, with 15 patients (21.43%), decreased in the 70–80 years group to 11 patients (15.71%), and was lowest in the 80–90 years group with 4 patients (5.71%) (Table 2 and Figure 2).

This distribution indicates that CKD prevalence increases with advancing age. Several factors contribute to this pattern, including the natural decline in renal function with age, the cumulative burden of comorbidities, such as HTN and DM, prolonged exposure to nephrotoxic agents, and age-related physiological changes in renal structure and function. These factors contribute to the higher prevalence of CKD in older age groups.

Table 2. Age distribution of patients undergoing MHD.

Age Group (Years)	Number of Patients (n = 70)	Percentage (%)
20–30 years	3	4.29%
30–40 years	8	11.43%
40–50 years	13	18.57%
50–60 years	16	22.86%
60–70 years	15	21.43%
70–80 years	11	15.71%
80–90 years	4	5.71%

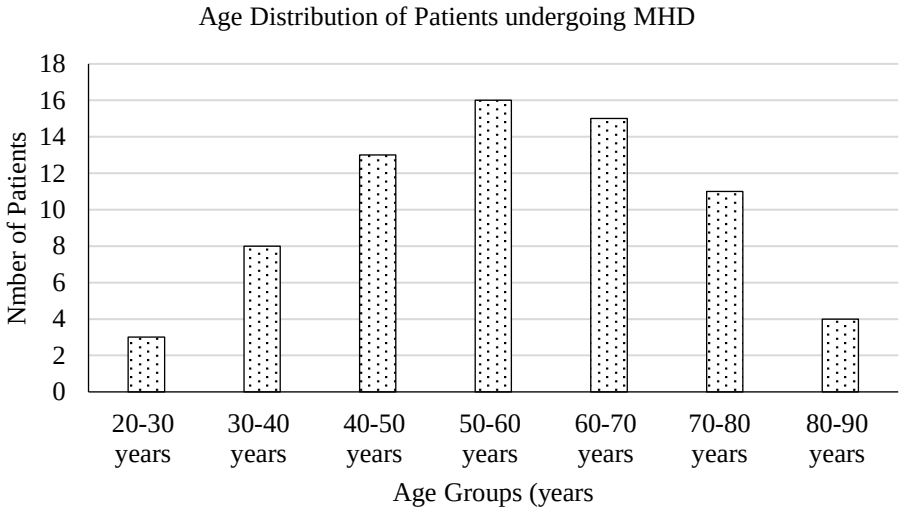

Figure 2. Age distribution of patients undergoing MHD.

Spectrum of Time Period of MHD

In our study cohort of 70 patients undergoing MHD, the duration of dialysis varied significantly. Most patients (44.29%) had been on dialysis for 0-6 months, comprising 31 individuals. A smaller group (5.71%) had been on dialysis for 6-12 months, accounting for 4 patients. Patients who had been on dialysis for 1-2 years constituted 27.14% of the cohort, with 19 individuals. Another 18.57% of patients had been on dialysis for 2-6 years, with 13 individuals in this category. A small percentage (4.29%) had been on dialysis for more than 6 years, consisting of 3 patients. This variation in dialysis duration among our study participants reflects the different stages of CKD progression and the diverse experiences of patients undergoing treatment. The predominance of patients in the early stages of dialysis (0-6 months) may indicate a recent increase in CKD diagnoses or a shift to MHD treatment. In contrast, the presence of patients with longer dialysis durations reflects the ongoing and chronic nature of CKD, suggesting the need for continuous and long-term management. These variations in dialysis duration can have significant clinical consequences, potentially affecting patient outcomes, QoL, and the risks associated with prolonged treatment. Further research could investigate how different dialysis durations influence patient care and outcomes, offering valuable insights for refining treatment approaches and enhancing overall patient management (Table 3 and Figure 3).

Table 3. Distribution of patients by duration of MHD.

Duration of Dialysis	Number of Patients (n = 70)	Percentage (%)
0–6 months	31	44.29%
6–12 months	4	5.71%
1–2 years	19	27.14%
2–6 years	13	18.57%
More than 6 years	3	4.29%

Etiology of CKD

In our cohort, Hypertension (HTN) was the leading cause of CKD, accounting for 58% of cases. Diabetes Mellitus (DM) followed closely, being the cause in 35% of cases. Other causes included Chronic Glomerulonephritis (CGN) in 2%, Chronic Interstitial Nephritis (CIN) in 2%, Autosomal Polycystic Kidney Disease (APKD) in 2%, and Congenital Anomalies of the Kidney and Urinary Tract (CAKUT) in 1%. The high prevalence of HTN and DM as causes of CKD in our study aligns with global trends as both conditions are well-known risk factors for CKD. HTN damages blood vessels in the kidneys, reducing their function over time. Similarly, DM can lead to diabetic nephropathy, damaging the kidney's filtering units due to prolonged high blood sugar levels. Although less common in our cohort, other causes, such as CGN, CIN, APKD, and CAKUT still play a significant role in CKD. CGN involves inflammation of the glomeruli, resulting in progressive kidney damage. CIN is characterized by inflammation and scarring of the kidney's interstitial tissue. ADPKD, a genetic disorder, leads to the formation of numerous cysts in the kidneys, impairing their function. CAKUT includes various structural abnormalities in the kidneys and urinary tract present at birth, which can also lead to CKD (Table 4 and Figure 4).

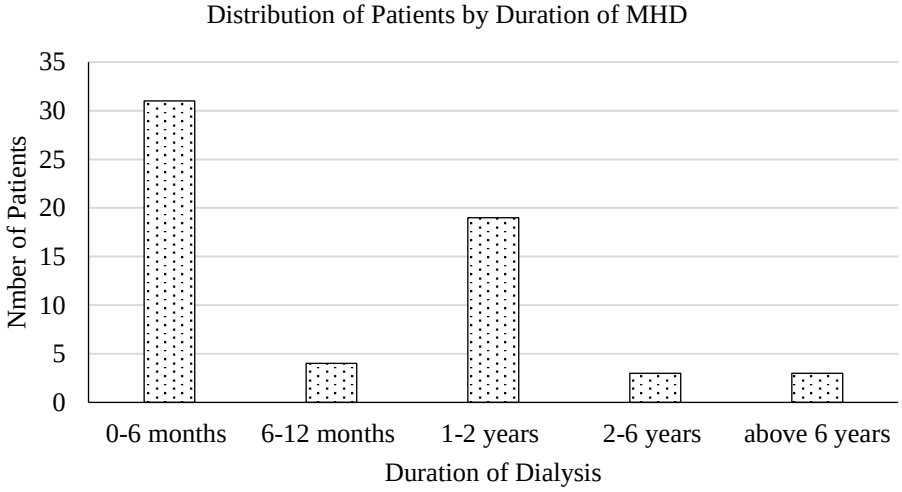

Figure 3. Distribution of patients by duration of MHD.

Table 4. Etiology of CKD.

Causes of CKD	Percentage (%)
HTN	58%
DM	35%
CGN	2 %
CIN	2%
APKD	2%
CAKUT	1%

Prevalence of Anemia

In our study of 70 patients undergoing MHD, we evaluated the prevalence and severity of anemia. Out of the total cohort, 68 patients (97.14%) were diagnosed with anemia, while 2 patients (2.86%) were non-anemic. Anemia severity was classified as mild, moderate, severe, based on Hb levels: mild anemia was defined as Hb levels between 10–12 g/dL, moderate anemia as Hb levels between 10–8 g/dL, and severe anemia as Hb levels below 8 g/dL. Among the anemic patients, 12 (17.14%) had mild anemia, 26 (37.14%) had moderate anemia, and 30 (42.86%) had severe anemia. When analyzed by gender, among the 47 male patients, 10 had mild anemia, 17 had moderate anemia, and 18 had severe anemia. In contrast, among the 23 female patients, 2 had mild anemia, 9 had moderate anemia, and 12

had severe anemia. The data shows a higher percentage of severe anemia among female patients (52.17%) compared to male patients (38.30%). However, the absolute number of severe anemia cases is greater in males, with 18 cases compared to 12 cases among females. This variation between the percentage and the absolute number of cases is attributed to the larger sample size of male patients in the study (Table 5 and Figure 5).

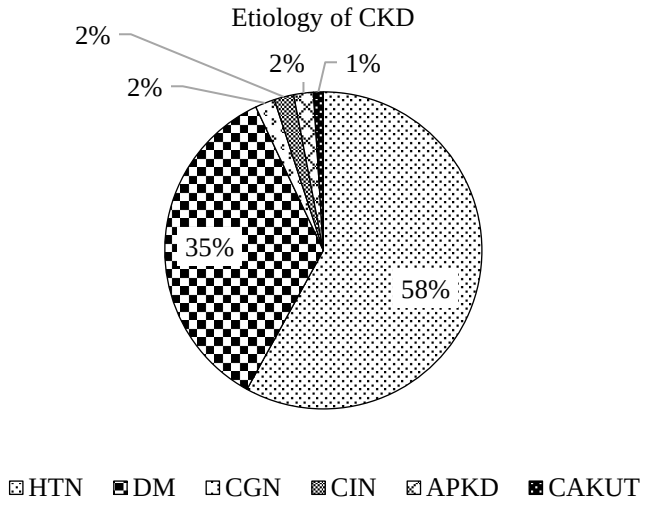

Figure 4. Etiology of CKD.

Table 5. Prevalence and Severity of Anemia in Relation to Gender in Patients Undergoing MHD.

Category	Total (n = 70)	%	Male (n = 70)	%	Female (n = 70)	%
Anemic Patients	68	97.14%	45	64.28%	23	32.85%
Non-Anemic Patients	2	2.28%	2	2.85%	0	0%
Mild Anemia (10–12 g/dL)	12	17.14%	10	14.28%	2	2.85%
Moderate Anemia (10–8 g/dL)	26	37.14%	17	24.28%	9	12.85%
Severe Anemia (>8 g/dL)	30	42.86%	18	38.30%	12	52.17%

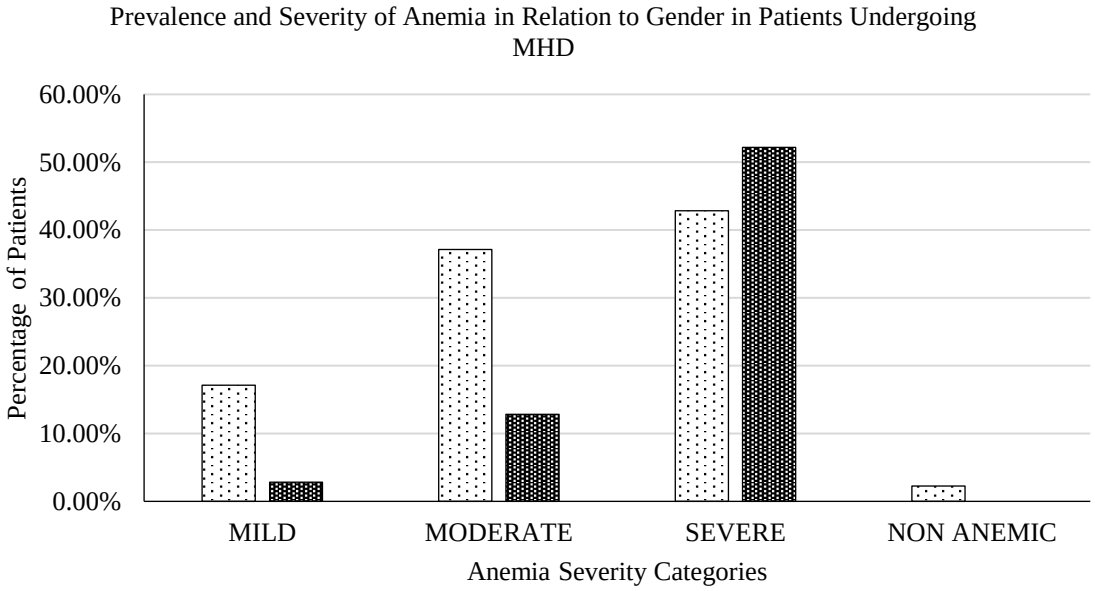

Figure 5. Prevalence and Severity of Anemia in Relation to Gender in Patients Undergoing MHD.

Contributing Factors

In our study cohort of 70 patients undergoing MHD, various factors significantly contributed to the prevalence of anemia. The most common factor was bleeding episodes, which affected 30 patients (42.86%). These episodes included GI bleeding, hematuria, nasal bleeding, frequent blood sampling, and the use of antiplatelet drugs. Antiplatelet medications, used to prevent clotting, increased the risk of bleeding and further exacerbated anemia by causing additional blood loss. Liver disease was identified in 7 patients (10%), with hepatitis B and C being significant contributors. Liver dysfunction impairs the production of essential clotting factors and proteins involved in iron metabolism, which are crucial for maintaining adequate RBC levels. Consequently, liver disease can worsen anemia by disrupting these critical processes. Nutritional deficiencies were present in 19 patients (27.14%), with deficiencies in vitamin B12 and folate being particularly common. Both vitamin B12 and folate are vital for RBC production. Deficiencies in these nutrients can severely impair erythropoiesis, the process by which new RBCs are produced, leading to further anemia. Medications were a contributing factor in anemia for 14 patients (20%). Angiotensin-Converting Enzyme Inhibitors (ACEIs) and Angiotensin Receptor Blockers (ARBs) were identified. These medications can worsen anemia by interfering with EPO production or leading to GI bleeding (Table 6 and Figure 6).

Table 6. Contributing factors of anemia in patients on MHD.

Contributing Factors	Number of Patient (n=70)	Percentage (%)
Bleeding Episodes	30	42.86%
Liver Disease	7	10.00%
Nutritional Deficiencies	19	27.14%
Medications	14	20.00%

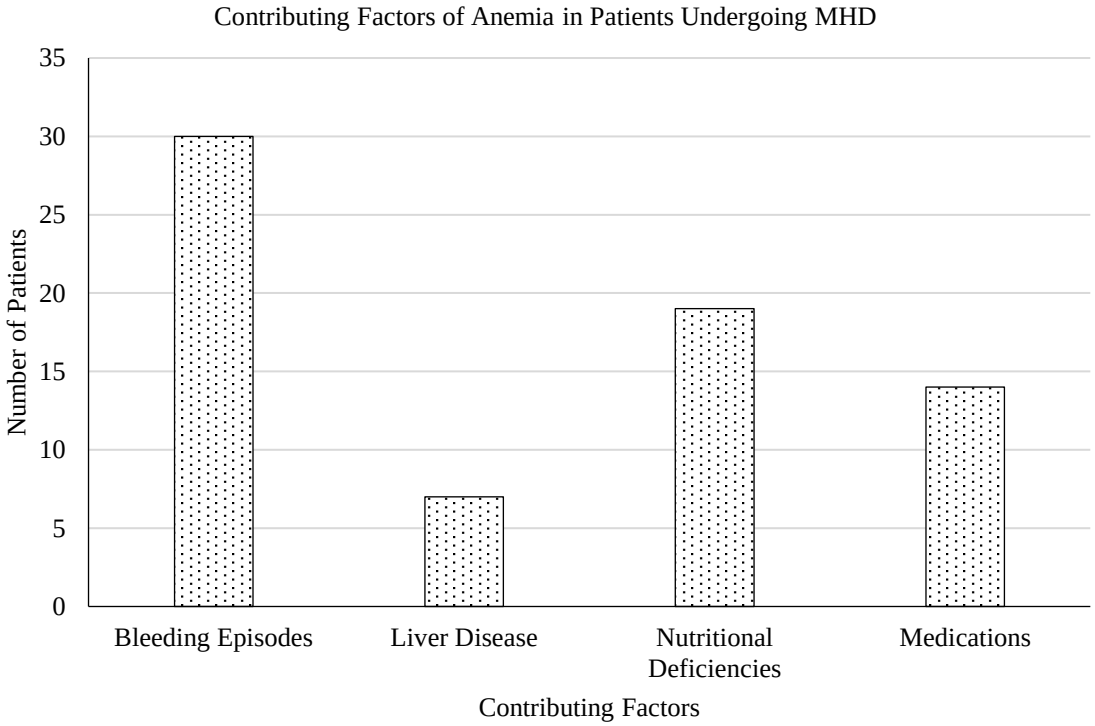

Figure 6. Contributing Factors of Anemia in Patients on MHD Relationship between Hemoglobin Levels and Contributing Factors.

In our study of 70 MHD patients, we analyzed the average Hb levels in relation to various contributing factors. The results demonstrated that bleeding episodes had the most pronounced adverse

effect on Hb levels, with an average Hb level of 7.87 g/dL, significantly lower than other factors. Liver disease, which was present in a subset of patients, correlated with an average Hb level of 8.4 g/dL. Patients with nutritional deficiencies had an average Hb level of 9.29 g/dL, while those receiving medications, ACEIs and ARBs, had the highest average Hb level of 9.5 g/dL. These findings highlight that bleeding episodes had the most severe impact on Hb levels, compared to liver disease, nutritional deficiencies, and medication use, indicating that among the factors examined, bleeding episodes were the most significant contributor to reduced Hb levels in this cohort (Table 7 and Figure 7).

Table 7. Relationship between Hb levels and contributing factor in patients undergoing MHD.

Contributing Factors	Number of Patients (n = 70)	Average Hemoglobin Levels (g/dL)	Impact on Hb Levels
Bleeding Episodes	30	7.87	Significant
Liver Disease	7	8.40	Moderate
Nutritional Deficiencies	19	9.29	Moderate
Medications	14	9.50	Mild

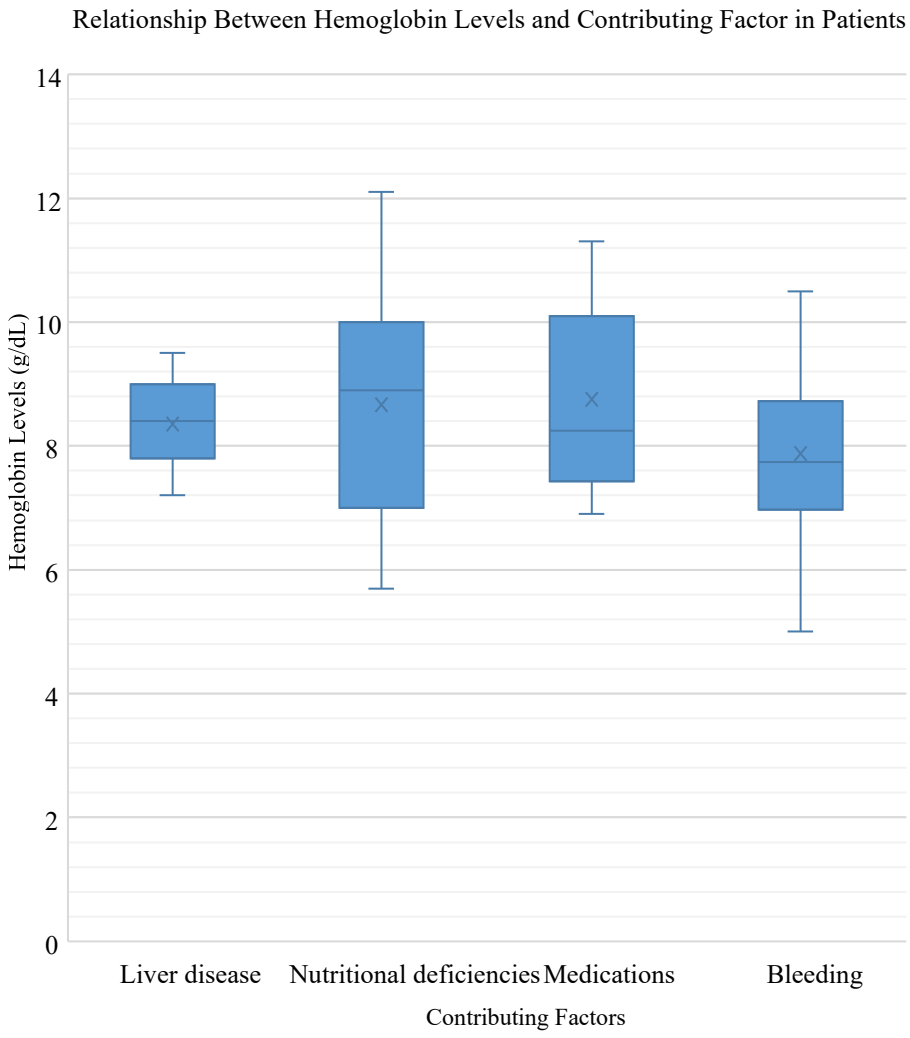

Figure 7. Relationship between Hb levels and contributing factor in patients undergoing MHD.

Relationship Between Hemoglobin Levels and Age

In our study cohort of 70 MHD patients, we examined the relationship between age and Hb levels. The findings indicate that younger patients tend to have higher Hb levels, whereas Hb levels generally decrease with advancing age. The average Hb levels observed were: 9.23 g/dL for patients aged 20–30

years, 8.39 g/dL for those aged 30–40 years, 7.73 g/dL for the 40–50 years age group, 7.00 g/dL for those aged 50–60 years, 8.04 g/dL for the 60–70 years age group, 8.62 g/dL for patients aged 70–80 years, and 8.00 g/dL for those aged 80–90 years.

This trend demonstrates a general decline in Hb levels as age increases, with the lowest average Hb recorded in the 50-60 years age group. These results suggest that older patients may be more susceptible to lower Hb levels and potentially more severe anemia. Therefore, monitoring and managing anemia in older MHD patients is crucial for optimizing their health outcomes (Table 8 and Figure 8).

Table 8. Relationship between Hb levels and age in patients undergoing MHD.

Age Group (Years)	Average Hb levels (g/dL)	Observation
20–30 years	9.23	High Hb levels
30–40 years	8.39	Initial Decline
40–50 years	7.73	Ongoing Reduction
50–60 years	7.00	Lowest Hb Levels
60–70 years	8.04	Slight Increase
70–80 years	8.62	Significant Recovery
80–90 years	8.00	Stabilized Levels but lower than Younger Cohort

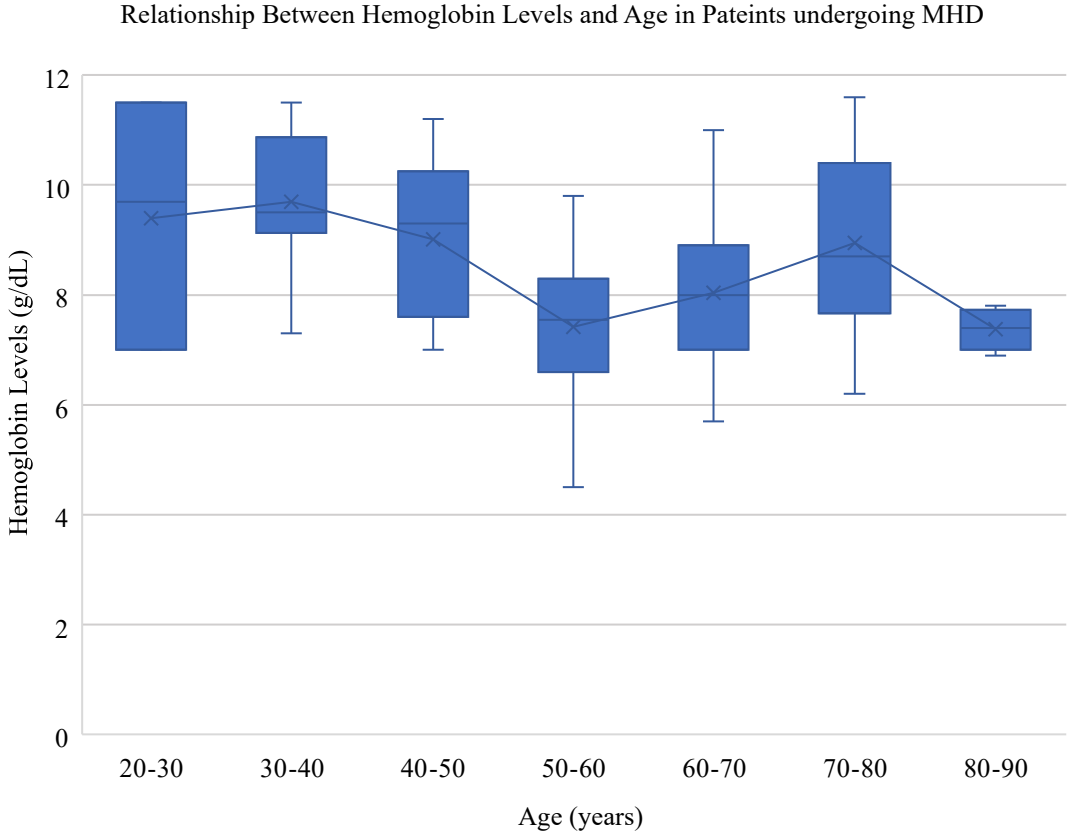

Figure 8. Relationship between Hb levels and age in patients undergoing MHD.

Relationship Between Hemoglobin Levels and Dialysis Duration

In our study cohort of 70 MHD patients, we examined the relationship between the duration of MHD and Hb levels. The analysis showed that patients undergoing MHD for 1–2 years had the highest average Hb levels, at 9.25 g/dL. In contrast, those with less than 1 year of MHD had lower average Hb levels, at 8.17 g/dL, indicating potential initial difficulties in managing anemia. Patients with MHD durations of 6–12 months and those exceeding 6 years had average Hb levels of 8.93 g/dL and 8.89 g/dL,

respectively. Patients in the 2-6 years category had an average Hb level of 8.36 g/dL. These results suggest that while anemia management may improve over time, patients in the 1–2 years group achieved the highest Hb levels, and those with longer MHD durations generally had more stable Hb levels (Table 9 and Figure 9).

Table 9. Relationship between Hb levels and duration of HD.

Dialysis Duration	Average Hb Levels (g/dL)	Observations
0–6 months	8.17	Lower Hb levels
6–12 months	8.93	Rising Hb levels
1–2 years	9.25	High Hb levels
2–6 years	8.36	Moderate decline
Above 6 years	8.89	Stabilized levels

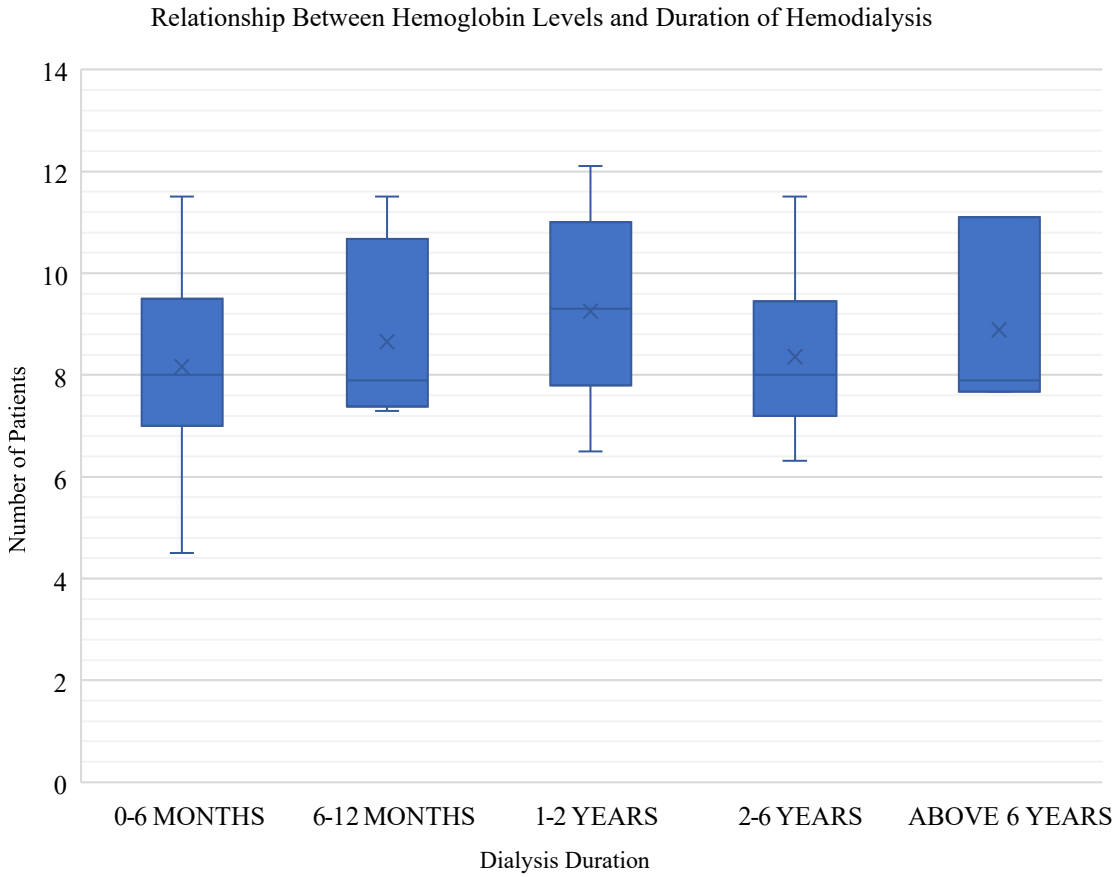

Figure 9. Relationship between Hb levels and duration of MHD.

Assessment of Treatment Strategies for Anemia Management in MHD Patients

In our study of 70 MHD patients, 68 were diagnosed with anemia. All 68 patients received ESAs and IV iron supplementation as part of their anemia management. Oral iron was not administered due to its limited effectiveness in this patient population. Additionally, 22 patients who had severe anemia received blood transfusions. The results demonstrated that the combination of ESAs and IV iron was generally effective in managing anemia, with ESAs stimulating RBC production and IV iron ensuring adequate iron availability for Hb synthesis. Blood transfusions provided additional measure to rapidly improve Hb levels in cases of severe anemia. Overall, these interventions contributed to the improved Hb levels among the patients. However, the varying effectiveness of these treatments highlights the importance of individualized management strategies to address the specific needs of each patient (Table 10 and Figure 10).

Descriptive Analysis of Demographics and Baseline Characteristics of the Study Population

This table provides the descriptive statistics for the key demographics and baseline characteristics of the study population. The mean age of the participants was 55.71 years (±15.21), with a minimum age of 21 and a maximum age of 86. The mean Hb level was 8.57 g/dL (±1.74), with values ranging from 4.50 to 12.60 g/dL. The mean Hematocrit (HCT) value was 26.03% (±5.31), with a minimum of 11.48% and a maximum of 36.40%. The average RBC count was 2.92 million cells/μL (±0.71), while the Mean Corpuscular Volume (MCV) was 90.79 fL (±16.30), ranging from 9.10 fL to 110.10 fL. These statistics offer a detailed overview of the population's hematological status (Table 11).

Table 10. Distribution of treatment methods for anemia in patients undergoing MHD.

Treatment Strategy	Patients Receiving Treatment	Role
ESAs	68	Stimulate RBC production
Intravenous Iron	68	Provide sufficient iron for Hb synthesis
Oral Iron	Not Administered	Less effective
Blood Transfusion	22	Rapid improvement of Hb levels in severe cases

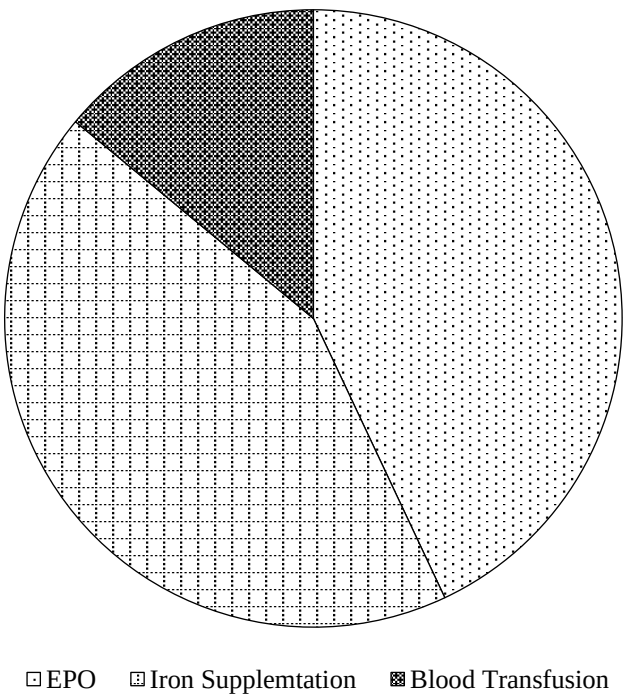

Figure 10. Distribution of treatment methods for anemia in patients undergoing MHD.

Table 11. Descriptive analysis of demographics and baseline characteristics of the study population.

	N	Minimum	Maximum	Mean	Std. Deviation
Age	70	21.00	86.00	55.7143	15.20692
Hb	70	4.50	12.60	8.5741	1.74213
HCT	70	11.48	36.40	26.0270	5.30552
RBC	70	1.54	4.66	2.9236	0.70680
MCT	70	9.10	110.10	90.7933	16.30172
Valid N (listwise)	70				

Note: n = 70.

Distribution of Anemia by Demographic and Clinical Variables

The distribution of Anemia was assessed across various demographic and clinical variables, including sex, age, duration of dialysis, and comorbid conditions, such as HTN and DM, along with other contributing factors. The detailed findings are presented in Table 12 and illustrated in Figure 11.

Table 12. Distribution of anemia by demographic and clinical variable.

Variables	Category	Anemia (n = 68)				Total (n = 70)	
		Yes		*No*		*Yes*	*No*
		N	*%*	*N*	*%*	*N*	*%*
Sex	Male	45	66.17	2	2.94	47	67.14
	Female	23	33.82	0	0	23	32.85
Age	20–30	3	4.41	0	0	3	4.28
	30–40	8	11.76	0	0	8	11.42
	40–50	13	19.11	0	0	13	18.57
	50–60	14	20.58	2	2.94	16	22.85
	60–70	15	22.05	0	0	15	21.42
	70–80	11	16.17	0	0	11	15.71
	80–90	4	5.88	0	0	4	5.71
Duration of Dialysis	0–6 months	31	45.58	0	0	31	44.28
	6–12 months	3	4.41	1	1.47	4	5.71
	1–2 years	18	26.47	1	1.47	19	27.14
	2–6 years	13	19.11	0	0	13	18.57
	Above 6 years	3	4.41	0	0	3	4.28
HTN	Yes	66	97.05	0	0	66	94.28
	No	2	2.94	2	2.94	4	5.71
DM	Yes	39	57.35	1	1.47	40	57.14
	No	29	42.64	1	1.47	30	42.85
Liver disease	Yes	7	1.02	0	0	7	10
	No	61	89.7	2	2.94	63	90
Medications	Yes	13	19.11	1	1.47	14	20
	No	55	80.8	1	1.47	56	80
Bleeding	Yes	30	44.11	0	0	30	42.85
	No	38	55.88	2	2.94	40	57.14
Nutritional Deficiency	Yes	19	27.94	0	0	19	27.14
	No	49	70.05	2	2.94	51	72.85

DISCUSSION

Anemia is a prevalent and significant complication in patients with CKD, particularly among those undergoing MHD. Our study found a high prevalence of anemia (97.14%) in a cohort of 70 MHD patients, which aligns with previous studies reporting anemia rates as high as 96.5% in this population [19]. Gender differences in anemia severity were also noted, with a higher percentage of females (52.17%) experiencing severe anemia compared to males (38.30%). This finding may be linked to physiological differences or disparities in anemia management, as suggested by Akizawa et al. (2011), who observed that severe anemia is more common among female MHD patients [20].

In terms of patient demographics, our study found that the majority (65.71%) of the cohort were aged over 50 years, a group more prone to anemia due to age-related declines in erythropoiesis and the impact of comorbid conditions, such as HTN and DM [21]. We observed a negative correlation between age and Hb levels, which further supports existing research highlighting the higher prevalence of anemia in older CKD patients and those undergoing MHD [22].

HTN and DM were identified as the primary causes of CKD in our study population, with 94.28% of patients affected by HTN and 57.14% by DM. The strong link between these comorbidities and CKD progression is well-documented in the literature, with previous studies reporting that up to 90% of MHD patients suffer from HTN, and diabetes, particularly type 2, is a significant risk factor for CKD due to its association with diabetic nephropathy [23, 24]. In fact, the high prevalence of HTN and DM in our study supports the notion that these conditions are key contributors to both CKD and anemia in MHD patients. Furthermore, both HTN and DM can exacerbate anemia through mechanisms, such as impaired erythropoietin (EPO) production and inflammation, which disrupt normal erythropoiesis [25].

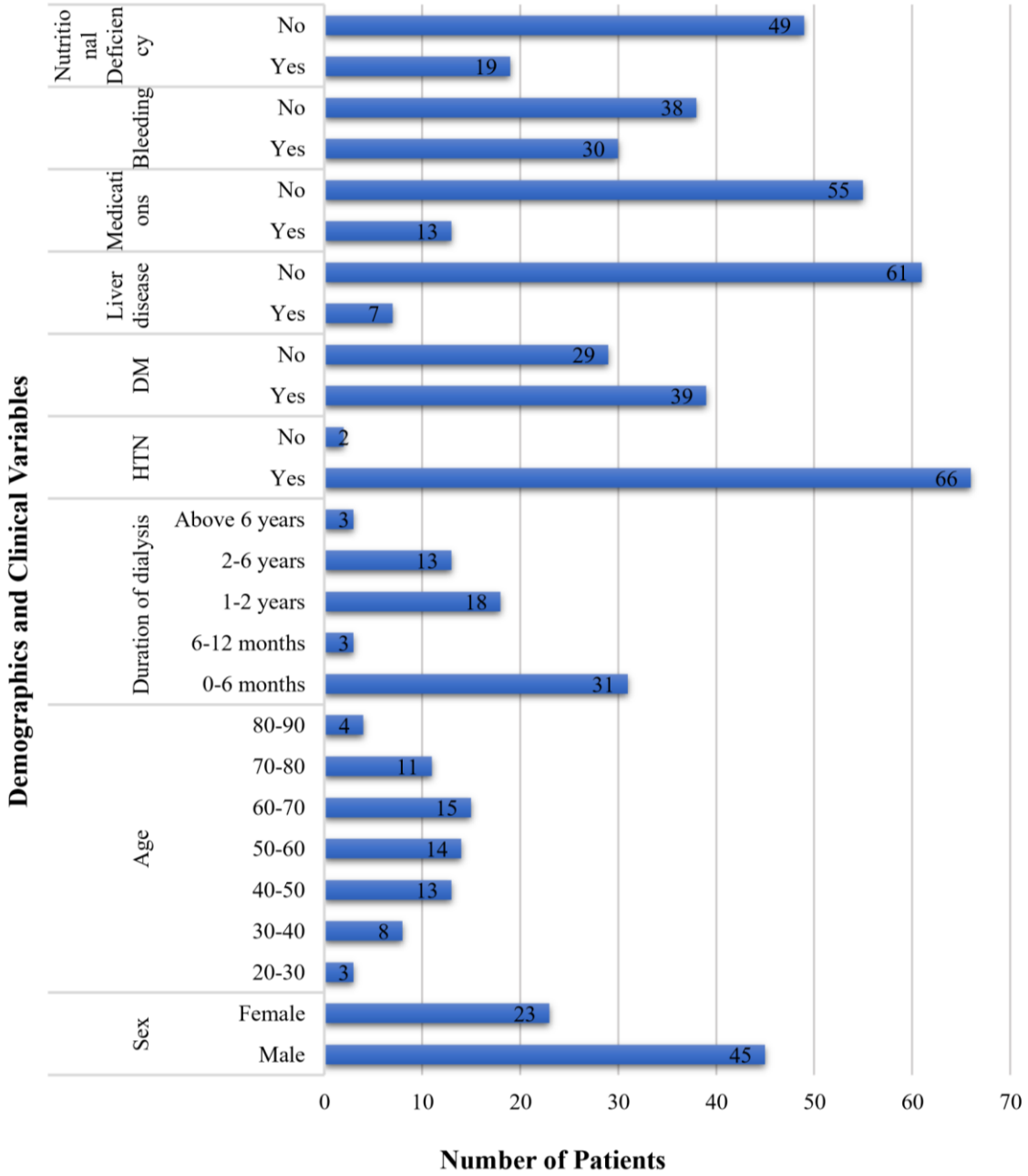

Figure 11. Distribution of anemia by demographic and clinical variables.

We also observed that the duration of MHD influenced anemia levels. Patients who had been on dialysis for less than six months exhibited the lowest average Hb levels, suggesting that anemia is more prevalent and difficult to manage during the early stages of MHD. In contrast, patients who had been

undergoing MHD for 1–2 years showed higher average Hb levels, indicating potential improvement in anemia management over time. This contrasts with findings by Shibiru et al. (2013), who reported higher rates of anemia in patients undergoing MHD for 1–5 years [26]. We hypothesize that the early stages of dialysis may be associated with inadequate management strategies, including optimal dialysis duration, iron supplementation, and ESAs, which are more commonly implemented in patients with longer dialysis histories.

One of the novel findings in our study was the significant role of bleeding episodes in the development of anemia. Nearly 43% of our patients experienced bleeding events, including GI bleeding, hematuria, nasal bleeding, frequent blood draws, and the use of antiplatelet drugs. This suggests that bleeding may be an underrecognized contributor to anemia in MHD patients, and future studies should explore this relationship further.

Additionally, liver disease, particularly hepatitis B and C, was observed in 10% of our cohort. Previous studies have highlighted that hepatitis B infection worsens anemia in dialysis patients by impairing renal function and erythropoiesis [27]. Hepatitis C infection is similarly associated with a higher incidence of anemia due to liver fibrosis, cirrhosis, and the subsequent impact on iron metabolism [28].

Nutritional deficiencies, particularly vitamin B12 and folate deficiencies, were found in 27.14% of our patients. These deficiencies can impair erythropoiesis and contribute to anemia, as seen in previous studies highlighting the role of nutritional factors in anemia management in MHD patients [29].

Medications, such as ACEIs, including captopril and enalapril, and ARBs, such as losartan are commonly prescribed for the management of HTN and CKD. However, these medications were also implicated in the development of anemia in 14 patients (20%) in our study. ACEIs and ARBs can contribute to anemia through two main mechanisms. First, they may suppress EPO production, a crucial hormone for red blood cell formation, leading to lower Hb levels. Second, these medications can induce GI bleeding, which further exacerbates anemia by increasing blood loss [30, 31]. Studies have shown that the use of ACEIs and ARBs can significantly reduce Hb concentration, sometimes by more than 10 g/L, with the reduction typically starting within weeks of initiating therapy and reaching its lowest point around three months after the start of the medication. This effect is often reversible upon discontinuation of the medication [32, 33].

Despite treatment with ESAs and iron supplements, 32.35% of our patients required blood transfusions, suggesting that current treatment regimens may not always be sufficient to fully address anemia in MHD patients. This finding is consistent with the observations of Kaushik et al. (2013), who highlighted the limitations of ESA and iron therapy in managing anemia, particularly in patients with more severe forms of the condition or those with poor responses to treatment [34].

CONCLUSIONS

In conclusion, our study confirms that anemia is highly prevalent in MHD patients, with age, gender, and bleeding episodes contributing significantly to its severity. We also identified nutritional deficiencies and medication-related anemia as important factors in this cohort. The findings underline the need for targeted interventions to address bleeding complications, optimize anemia management strategies, and consider gender-specific approaches to treatment. Limitations of this study include the small sample size, the cross-sectional design, and the lack of EPO and iron profile data, which restricts a more comprehensive evaluation of anemia causes. Future research should focus on longitudinal studies to examine causal relationships, incorporate EPO and detailed iron assessments, and explore gender-specific treatment strategies and targeted interventions to address bleeding complications. This will help enhance anemia management and improve the quality of life for MHD patients.

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