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Prescribing patterns of nutritional supplements in hemodialysis patients: Insights from a multi-centric study in Karnataka, India

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ABSTRACT

Multivitamins, multi-minerals, hematinics, and dietary supplements (MMHDSs) are commonly prescribed to hemodialysis (HD) patients to mitigate the risk of nutrient deficiencies. This cross-sectional, multi-centric study analyzes MMHDS prescribing patterns among HD patients. Patient demographics, medical history, and dialysis-related data were collected. Findings reveal a high prevalence of MMHDS prescriptions, with diverse supplement types, including water-soluble vitamins and essential minerals. Prescription trends were influenced by factors such as patient age, comorbidities, and dialysis duration. The study highlights variations in MMHDS prescribing practices across different centers, emphasizing the need for personalized dietary therapy. Supplements are commonly prescribed to address nutrient deficiencies, manage chronic kidney disease complications, and improve overall well-being. The findings of the study are crucial for nephrologists, clinical pharmacists, and dietitians in optimizing patient care and minimizing risks. Understanding MMHDS prescription trends enables healthcare providers to tailor interventions and enhance treatment outcomes. The study underscores the importance of evidence-based guidelines to ensure safe and effective supplement use in HD patients. Future research should explore the long-term impact of these prescribing patterns on health outcomes, dietary balance, and quality of life, ultimately improving patient care and well-being.

INTRODUCTION

Chronic kidney disease (CKD) has emerged as an escalating global public health concern, with its prevalence rising consistently over the past few decades. Hemodialysis, an essential aspect of kidney replacement therapy, is vital for supporting the quality of health and well-being among patients with end-stage renal disease (ESRD) [1]. Despite progress in hemodialysis technology and management, individuals undergoing hemodialysis remain prone to nutritional deficiencies due to metabolic changes, dietary restrictions, and increased nutrient losses during dialysis sessions [2].

Nutritional imbalances in patients undergoing hemodialysis (HD) can result in complications such as anemia, bone disorders, and weakened immune function. Consequently, healthcare providers frequently prescribe a variety of dietary supplements, including multivitamins and multi-minerals, to correct these deficiencies and enhance patient outcomes. However, the rationale and consistency of prescribing practices for these supplements within the HD context continue to raise concerns [3].

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Vitamins are essential organic compounds required in small quantities to support critical biochemical functions. Since the body cannot synthesize most vitamins, they must be obtained from dietary sources [4]. Chronic HD patients are at an increased risk of vitamin deficiencies due to multiple factors. Dietary restrictions associated with kidney disease often limit vitamin intake, while dialysis itself removes water-soluble vitamins from the bloodstream. In addition, uremic toxins may impair vitamin metabolism and reduced appetite or poor dietary intake can further contribute to deficiencies. Certain medications and comorbid conditions commonly seen in HD patients may also interfere with vitamin absorption or efficacy, exacerbating the risk of nutritional imbalances [5–7].

The Kidney Disease Outcome Quality Initiative (KDOQI) 2005 advocates prioritizing supplementation to prevent deficiencies, especially when it is safe to do so at prescribed dosages. As a result, dialysis patients are likely to benefit from daily vitamin supplementation that matches the recommended vitamin profile for their needs, with an emphasis on B vitamins and folic acid [8]. According to the Kidney Disease Improving Global Outcomes (KDIGOs) guidelines, vitamin D insufficiency in HD patients should be managed similarly to the general population. However, calcitriol or a vitamin D analog is recommended only for individuals with elevated parathyroid hormone levels to help regulate bone and mineral metabolism [9]. These suggestions are backed by the European Kidney Clinical Excellence guidelines [10]. Hemodialysis patients are frequently prescribed multivitamins due to an increased risk of deficiencies, particularly in water-soluble vitamins. However, our study indicates insufficient evidence to encourage habitual supplementation with these vitamins. A recent epidemiological investigation of dialysis outcomes and practice patterns investigation discovered that increased usage of water-soluble vitamin supplements was related to a decreased death rate [11].

Patients on long-term HD are typically advised to limit their intake of extra fluids, potassium, and phosphates in their diet, while also managing interdialytic weight gain within the recommended guidelines as part of their daily routine. Patients on long-term HD are generally advised to limit extra fluid, sodium, and phosphorus intake and to keep weight gain between dialysis sessions within recommended limits as part of their daily regimen. This suggests their diets may be limited to vegetables, fruits, and dairy products such as milk, yogurt, cheese, and fruit juices. Consequently, these dietary restrictions may lead to inadequate consumption of essential macro- and micronutrients. Furthermore, throughout their lives, individuals on long-term HD may experience anorexia, resulting in an even more diminished intake of macro- and micronutrients [12–14]. Studies repeatedly indicate that patients with long-term HD often exhibit significantly lower plasma levels of various minerals and certain vitamins compared to healthy control participants [15,16].

High-flux, high-efficiency dialysis may eliminate more water-soluble vitamins from the body than initially anticipated during the early stages of HD therapy [17]. Emerging evidence links hyperhomocysteinemia to an increased risk of vascular and cardiac complications [18–20]. Individuals with ESRD and CKD often exhibit elevated homocysteine levels, making them particularly vulnerable to these adverse outcomes [21–23]. Recent studies suggest that supplementation with cyanocobalamin (B12), pyridoxine (B6), and folic acid can effectively lower homocysteine levels in HD patients [24,25]. Given the potential benefits of these water-soluble vitamins, further research is needed to assess their long-term impact on cardiovascular health and overall outcomes in HD patients.

The southern part of Karnataka region in India, marked by its diverse population and distinct healthcare practices, provides a unique backdrop to examine the prescribing patterns of multivitamins, multi-minerals, and dietary supplements among HD patients. While studies have explored supplement usage in CKD populations globally, there is a lack of research explicitly investigating these practices in the South Karnataka region. This multi-centric study aims to bridge the research gap by analyzing the prescribing patterns of multivitamins, multi-minerals, and dietary supplements among HD patients in South Karnataka. By examining patient demographics, the types of supplements prescribed, and the key factors influencing prescription decisions, this study seeks to provide valuable insights into the patterns and rationale behind supplement utilization in this patient population.

Currently, India lacks standardized guidelines for the prescription of multivitamins, multi-minerals, hematinics, and dietary supplements (MMHDSs) in HD patients. Unlike international organizations such as KDIGO and KDOQI, which provide evidence-based recommendations for managing nutritional deficiencies in CKD, Indian healthcare providers rely on individual clinical judgment, leading to significant variability in prescribing practices. This inconsistency increases the risk of both under-supplementation, which may leave deficiencies unaddressed, and over-supplementation, which can lead to toxicity and adverse interactions. The absence of national guidelines underscores the urgent need for India-specific recommendations tailored to regional dietary patterns, economic factors, and patient needs to ensure the safe and effective use of MMHDS in HD care.

This multi-centric study aims to bridge the knowledge gap by investigating the prevalence, types, and factors associated with multivitamin, multi-mineral, and dietary supplement prescriptions among South Karnataka, India, HD patients. The study provides insights that can guide healthcare practitioners in making informed decisions regarding supplement therapies by uncovering the nuances of these prescribing patterns. In addition, a better understanding of these patterns can contribute to developing guidelines and interventions to improve HD patients' nutritional status and overall well-being.

Pharmacists can play a crucial role in guiding the appropriate use of nutritional supplements in HD patients by providing evidence-based recommendations, monitoring potential interactions, and optimizing therapy to improve patient outcomes.

METHODOLOGY

This multicentric prospective observational study was conducted from August 2021 to August 2022 at HD units in three hospitals in South Karnataka, India: Dr. TMA Pai

Hospital Udupi (200 beds), Father Muller Medical College Hospital Mangalore (FMMCH) (1,250 beds), and Kasturba Medical College Hospital Manipal (KMC) (2,032 beds). The study included 384 participants: 22 from Dr. TMA Pai Hospital, 134 from Father Muller Medical College, and 228 from KMC Hospital.

Sample size calculation

Cochran's formula was used for sample size calculations.

$$n0 = \frac{Z^2 \times p \times (1-p)}{e^2}$$

n0 = Sample size
Z = Z-score (1.96 for 95% confidence level)
p = Expected proportion of MMHDS use (0.5 was used for the maximum sample size)
e = Margin of error (0.05).

Sources of data collection

Medical and pharmaceutical data were collected from patient case sheets, medication prescription charts, and demographic interviews with patients and caregivers. Each participant provided written informed consent for a 3-month follow-up to meet the inclusion criteria.

Inclusion criteria

- Outpatient HD patients.
- Age ≥ 18 years.
- Patients who voluntarily consent to participate in the study.
- Ability to speak and understand English or Kannada.
- Mentally alert and cooperative individuals.

Exclusion criteria

- Patients undergoing HD for acute kidney failure.
- Individuals who did not provide informed consent.
- Pregnant or breastfeeding women.
- Patients undergoing post-kidney transplant follow-up.
- Pediatric patients (age < 18 years).
- Individuals with cancer or traumatic injuries.
- Patients requiring occasional continuous HD due to severe medical conditions.
- Individuals with kidney stones requiring laparoscopic intervention.
- Patients receiving peritoneal dialysis instead of HD.
- Critical care unit patients.
- Patients who declined treatment on the study visit day.

Data acquisition and procedures

Data were collected from individuals who met the eligibility criteria, focusing on outpatient HD patients. A custom questionnaire was developed to gather comprehensive patient information, including demographics, medical history, medication charts, pharmaceutical records, laboratory test results, social history, HD treatment details, and primary complaints. Study-specific data were extracted from patient event files, with a justification recorded for each prescribed medication.

Medications were categorized based on the anatomical therapeutic chemical (ATC) classification system, documenting prescribed drugs, associated medical conditions, and prognosis. The data were analyzed using descriptive statistics, with findings presented as categories and proportions to assess prescribing trends.

To maintain patient confidentiality, all names were excluded from case records, and laboratory investigations were based on the most recent test results available in clinical records. The data collection process adhered to strict confidentiality protocols, ensuring ethical compliance. In addition, pharmaceutical brand names were standardized to their generic equivalents using the current index of medical specialties, India, 2022 edition.

The data collection process and questionnaire focused on the challenges faced by hemodialysis patients.

Information was collected from individual treatment records of 384 HD patients who were followed up throughout the study period. Dialysis-related complications were documented, and potential consequences were assessed by reviewing nursing records, patient symptoms, and physicians' treatment plans.

A custom-designed questionnaire was used to record HD frequency, gender, age group, dialysis duration, and the underlying cause of ESRD. Complications were classified into three categories: technical, interdialytic, and intradialytic issues. Appropriate medical interventions were provided whenever complications arose, ensuring timely patient management.

Evaluating patterns of drug use

Drug data and patient characteristics were analyzed to identify medication usage patterns among individuals with CKD. Each drug was divided into groups according to its therapeutic and pharmacological effects.

Statistical analysis

Information was gathered using Microsoft Excel's spreadsheet platform. Frequency and percentage were used to describe the data. The mean and SD demonstrate quantitative aspects of patients' clinical profiles.

RESULTS

The study's findings highlight the diverse patterns of supplement utilization, patient demographics, and the most commonly prescribed supplements in HD care. The analysis revealed significant variability in prescribing practices among healthcare providers, with most HD patients receiving some form of nutritional supplementation. Prescriptions included a broad range of supplements, such as multivitamins, individual dietary supplements, B-complex vitamins, vitamin D, and essential minerals such as iron, calcium, and zinc. The frequent use of combination supplements reflects an effort to address the complex nutritional needs of HD patients and compensate for dialysis-related nutrient losses.

Multivitamins emerged as the most prescribed supplements, given their comprehensive formulations

designed to cater to the intricate nutrient demands of HD patients. Vitamin D supplementation was prevalent, likely driven by the well-documented incidence of serum vitamin D insufficiency among individuals with persistent renal failure. Iron supplementation was frequently prescribed, particularly among patients exhibiting signs of anemia. Including individual vitamins and minerals in the prescription regimen highlighted a tailored approach to supplement selection based on specific patient requirements.

The duration of HD treatment showed a significant correlation with the frequency of supplement prescriptions. Patients undergoing long-term HD were more likely to receive supplementation, likely due to cumulative nutrient losses over time. In addition, the presence of comorbidities influenced supplement utilization, with patients managing multiple health conditions receiving specific supplements tailored to their needs.

Table 1 presents the prescribing patterns of multivitamins, multi-minerals, and nutritional supplements among CKD patients undergoing maintenance HD at FMMCH, KMC, and Dr. TMA Pai Hospital (Udupi).

In this study, 384 HD patients received a total of 1,399 medications across 12 different classes of vitamins, minerals, and nutritional supplements. The five most commonly prescribed classes were vitamins, minerals, and antianemics (38.31%), vitamin B complex (20.3%), calcium supplements (13.63%), vitamins and minerals (10.65%), and agents affecting bone metabolism (6.07%). Other prescribed categories included vitamin C (3.35%), protein and calorie-rich supplements for renal nutrition (2.64%), multivitamins and multi-minerals

Table 1. Usage patterns of multivitamins, multi-minerals, and nutritional supplements among CKD patients undergoing maintenance HD at FMMCH, KMC, and Dr. TMA Pai Hospital in Udupi.

Drug classes	Brand/generic drug names, compositions of multivitamins, minerals, and nutritional supplements	ATC code	(*N* = 384) & (%) Total drugs (1,399)
Calcium with vitamins	Calcium supplements		191 (13.63)
	Tab. Shelcal 500 mg	A12AX	126 (9.00)
	(Supplementation with 250 IU of vitamin D3 and 1250 mg of calcium carbonate)		
	Tab. CCM	A12AX	1 (0.07)
	(Folate 50 mcg, calcium citrate malate 250 mg, and vitamin D3 100 IU)		
	Tab. Jocal	-	1 (0.07)
	(Calcium citrate maleate 1,000 mg, vitamin D3 200 IU)		
	Tab. Aptcal-CC	A12AX	3 (0.21)
	(D3 vitamin 500 IU; calcium supplementation 250 mg)		
	Tab. Calcimax	A12AX	1 (0.07)
	(This formulation contains 1 mg of copper, 4 mg of zinc, 35 mcg of this selenium, 200 IU of vitamin D3, 1 mg of boron, 500 mg of calcium carbonate, 25 mg of L-lysine hydrochloride, and 75 mg of magnesium)		
	Tab. Calcit	A12AX	30 (2.14)
	(Magnesium 100 mg, zinc 4 mg, vitamin D3 200 IU, calcium citrate 1,000 mg)		
	Tab. Calcimax forte	A12AX	8 (0.57)
	(Vitamin D3 200 IU, zinc sulphate monohydrate 11 mg calcium carbonate 1,000 mg zinc sulphate monohydrate 11 mg, magnesium hydroxide 240 mg)		
Calcium with vitamins and minerals	Tab. Calcirin	-	2 (0.14)
	(Zinc sulphate monohydrate 4 mg magnesium hydroxide 100 mg, calcium citrate 1,000 mg, vitamin D3 200 IU)		
	Cap. Jocal – C	A12AX	2 (0.14)
	(Calcium citrate malate 500 mg, calcitriol 0.25 mcg, magnesium oxide 50 mg, zinc oxide 7.5 mg)		
	Tab. Calbo - D3	-	6 (0.42)
	(Elemental magnesium 100 mg + calcium citrate 1000 mg, elemental zinc 4 mg +vitamin D3 200 IU)		
	Tab. Calcirin	-	8 (0.57)
	(Vitamin D3 200IU, magnesium hydroxide 100 mg, zinc sulphate monohydrate 4 mg, calcium citrate 1,000 mg)		
	Tab Crocal	-	3 (0.21)
	(Magnesium 100 mg calcium citrate 1,000 mg, vitamin D3 200 IU, Zinc 4 mg)		

Continued

Drug classes	Brand/generic drug names, compositions of multivitamins, minerals, and nutritional supplements	ATC code	(*N* = 384) & (%) Total drugs (1,399)
Agents affecting bone metabolism	Agents affecting bone metabolism		85 (6.07)
	Cap. Rocaltrol	A11CC04	51 (3.64)
	(Calcitriol, 0.25 mcg)		
	Cap. Laretol	A11CC04	11 (0.78)
	(Calcitriol, 0.25 mcg)		
	Cap. Bio-D3 Plus	A12AX	1 (0.07)
	(Calcium carbonate 500 mg, Calcitriol 0.25 mcg)		
	Cap. Bio D3 Max	A12AX	1 (0.07)
	(Docosahexaenoic acid 120 mg, methylcobalamin 1,500 mcg, calcitriol 0.25 mcg, folic acid 400 mcg, boron 1.5 mg, eicosapentaenoic acid 180 mg, calcium carbonate 500 mg)		
	Cap. Alpha D3	A11CC03	1 (0.07)
	(Alfacalcidol, 0.25 mcg)		
	Tab. Shelcal-CT	A12AX	6 (0.42)
	(Calcitriol 0.25 mcg calcium carbonate 500 mg)		
	Cap. Alcal	A12AX	3 (0.21)
	(Calcium carbonate 625 mg alfacalcidol 0.25 mcg)		
	Cap. Marshel plus	M05BX	1 (0.07)
	(Zinc 7.5 mg, calcium 200 mg, calcitriol 0.25 mcg)		
	Tab. Albonate	A12AX	8 (0.57)
	(Calcium carbonate 500 mg alfacalcidol 0.25 mcg)		
	Cap. Alphadol	A11CC03	2 (0.14)
	(Alfacalcidol, 0.25 mcg)		
Vitamin D analogues	Vitamin D analogues		17 (1.21)
	Tab. D3 Must 60K	-	4 (0.28)
	(Cholecalciferol, 60,000 IU)		
	Tab. Micro-D3	A11CC05	3 (0.21)
	(cholecalciferol, 60,000 IU)		
	Cap. D-rise	A11CC05	8 (0.57)
	(Cholecalciferol, 60,000 IU)		
	Granules. Calcirol	A11CC05	2 (0.14)
	(Cholecalciferol, 60,000 IU)		
Multivitamins and multi-minerals	Multivitamins and multi-minerals		24 (1.71)
	Tab. Supradyne	A11AA	17 (1.21)
	(Vitamin D3 1,000 IU, 10 mg, riboflavin 10 mg, nicotinamide 100 mg, 16.3 mg, ascorbic acid 150 mg, biotin 0.25 mg, tribasic calcium phosphate 129 mg, magnesium oxide, light 60 mg, vitamin B6 3 mg phosphorus 25.8 mg, thiamine mononitrate vitamin A acetate 10,000 IU copper sulphate 3.39 mg, zinc sulphate 2.2 mg, ferrous sulphate, dried 32.04 mg, sodium borate 0.88 mg calcium pantothenate vitamin B12 15 mcg manganese sulphate monohydrate 2.03 mg sodium molybdate dihydrate 0.25 mg vitamin E acetate 25 mg)		
	Cap. Sanovit SG	-	3 (0.21)
	(Citrus bioflavonoids 10 mg biotin 50 mcg, calcium pantothenate 6 mg, choline 10 mg, coenzyme Q10 2 mg, elemental chromium 75 mcg, elemental green tea powder 20 mg, levocarnitine 10 mg, beta-carotene 2 mg, copper 1 mg, elemental iron 15 mg, elemental magnesium 60 mg, elemental manganese 0.5 mg, elemental selenium 120 mcg, elemental zinc 15 mg, folic acid 500 mcg lutein 2 mg, niacinamide 30 mg, vitamin B1 14 mg, vitamin B12 10 mcg, vitamin B2 4 mg, vitamin B6 10 mg, vitamin C 60 mg, vitamin D3 15 mcg, vitamin E 15 mg alpha lipoic acid 20 mg)		

Continued

Drug classes	Brand/generic drug names, compositions of multivitamins, minerals, and nutritional supplements	ATC code	(*N* = 384) & (%) Total drugs (1,399)
	Cap. NU-36	A11AA03	4 (0.28)
	(Magnesium 3 mg, zinc 7.5 mg, selenium 25 mcg, copper 0.5 mg, manganese 0.5 mg, chromium 25 mcg, molybdenum 45 mcg, potassium 10 mg, iodine 150 mcg, nickel 5 mcg, vanadium 15 mcg, chloride 10 mg, calcium pantothenate 5 mg, vitamin K 25 mcg, biotin 100 mcg, betaine 25 mg, glutamic acid 20 mg, inositol 10 mg, para-aminobenzoic acid 25 mg, lutein 15 mcg, choline 25 mg, calcium 50 mg, iron 18 mg, vitamin A palmitate 2,500 IU, vitamin C 40 mg, vitamin D3 200 IU, vitamin E acetate 10 IU, vitamin B1 1 mg, vitamin B2 1 mg, niacinamide 25 mg, vitamin B6 1 mg, folic acid 100 mcg, vitamin B12 5 mcg)		
	Vitamin C		47 (3.35)
	Tab. Celin	A11GA01	32 (2.28)
Vitamin C	(Ascorbic acid 500 mg)		
	Tab. Limcee	A11GB	15 (1.07)
	(Sodium ascorbate 400 mg, Ascorbic acid 100 mg,)		
Vitamin B complex	Vitamin B complex		284 (20.30)
	Cap. Becosules	A11EX	202 (14.43)
	(Biotin 100 mcg calcium pantothenate 50 mg, vitamin B12 15 mcg pyridoxine hydrochloride 3 mg, niacinamide 100 mg, ascorbic acid 150 mg, folic acid 1.5 mg, thiamine mononitrate 10 mg, riboflavin 10 mg)		
	Tab. Multi-8	A11EC	13 (0.92)
	(Thiamine hydrochloride 1.5 mg, mecobalamin 500 mcg, biotin 300 mcg, folic acid 10 mg, riboflavin 1.5 mg, niacinamide 20 mg, pyridoxine hydrochloride 10 mg, calcium pantothenate 5 mg)		
	Inj. Optineuron	A11EA	8 (0.57)
	(Cyanocobalamin 1,000 mcg, nicotinamide 100 mg, D-panthenol 50 mg/3 ml, riboflavin sodium phosphate 5 mg, thiamine hydrochloride 100 mg, pyridoxine hydrochloride 100 mg)		
	Inj. Nurokind gold	B03BA51	4 (0.28)
	(Pyridoxine 100 mg, niacinamide 100 mg, methylcobalamin 1,500 mcg)		
	Tab. Evion LC	A11JC	18 (1.28)
	(Levocarnitine 150 mg, vitamin E 200 mg)		
	Cap. Mega neuron	B03BA51	3 (0.21)
	(Folic acid 1.5 mg, alpha lipoic acid 100 mg, methylcobalamin 750 mcg)		
	Tab. Neurobion forte	B03BA51	4 (0.28)
	(Nicotinamide 45 mg, calcium pantothenate 50 mg riboflavin 10 mg, pyridoxine hydrochloride 3 mg, cyanocobalamin 15 mcg, thiamine mononitrate 10 mg)		
	Inj. Neurobion forte	A11EA	5 (0.35)
	(D-panthenol 50 mg, cyanocobalamin 1,000 mcg, nicotinamide 100 mg, Thiamine hydrochloride 100 mg, riboflavin sodium phosphate 5 mg, pyridoxine hydrochloride 100 mg)		
	Syr. Polybion	A11EX	5 (0.35)
	(Pyridoxine 0.75 mg, riboflavin 2.5 mg, thiamine 2 mg, cyanocobalamin 2 mg, D-panthenol 3 mg, nicotinamide 15 mg)		
	Tab. Neurokind LC	B03BA51	8 (0.57)
	(Folic acid 1.5 mg L-carnitine L-tartrate 500 mg, methylcobalamin 1,500 mcg)		
	Tab. Mynerve plus	A11JB	3 (0.21)
	(Vitamin E acetate 25 mg, inositol 100 mg mecobalamin 1,500 mcg, vitamin B6 1.5 mg, vitamin B1 hydrochloride 10 mg, alpha lipoic acid 100 mg, folic acid 1.5 mg, calcium pantothenate 10 mg, vitamin A acetate 5,000 IU, zinc methionine 25 mg)		
	Inj. Renerve plus	B03BA51	2 (0.14)
	(Mecobalamin 1,000 mcg, pyridoxine hydrochloride 100 mg, nicotinamide 100 mg/2 ml)		
	Cap Renerve Plus	-	1 (0.07)
	(Alpha lipoic acid 200 mg, Inositol 100 mg, selenomethionine 55 mcg, zinc monomethionine 25 mg, methylcobalamin, 1,500 mcg, folic acid 1.5 mcg, chromium polynicotinate 200 mcg)		

Continued

Drug classes	Brand/generic drug names, compositions of multivitamins, minerals, and nutritional supplements	ATC code	(*N* = 384) & (%) Total drugs (1,399)
	Inj. M.V.I.	A11JA	1 (0.07)
	(Vitamin B3 10 mg, vitamin E 0.5 mg/1 ml, vitamin B2 1.4 mg, vitamin B5 2.5 mg, vitamin A 1,000 IU, vitamin B1 5 mg vitamin B6 1.5 mg)		
	Tab. Carnisure plus	B03BA51	7 (0.50)
	(Folic acid 1.5 mg levocarnitine 250 mg methylcobalamin 1,500 mcg)		
	Vitamins and minerals		149 (10.65)
Vitamins and minerals	Tab. Cobadex – CZS	A11JB	29 (2.07)
	(Folic acid 1,500 mcg, zinc sulphate monohydrate 61.8 mg, pyridoxine hydrochloride 3 mg nicotinamide 100 mcg, cyanocobalamin 15 mcg, chromium picolinate 250 mcg, elemental selenium 100 mcg)		
	Cap. Eido	A11EX	44 (3.14)
	(Mecobalamin 500 mcg, biotin 300 mcg vitamin C 50 mg, vitamin B2 3 mg, vitamin B1 2 mg, vitamin B6 10 mg, folic acid 10 mg, calcium pantothenate 6 mg, vitamin B3 25 mg)		
	Tab. Oxyevion	-	1 (0.07)
	(Niacinamide 100 mg, pyridoxine 3 mg, selenium 100 mcg, cyanocobalamin 15 mcg, elemental chromium 250 mcg, folic acid 1,500 mcg, elemental zinc 22.5 mg)		
	Cap. Cromoplex forte	A11JB	2 (0.14)
	(Cyanocobalamin 10 mcg, nicotinamide 50 mg, benfotiamine 50 mg, biotin 2 mg, vitamin B6 3 mg folic acid 1 mg, zinc sulphate monohydrate 61.8 mg chromium picolinate 200 mcg)		
	Tab. Alcomax	A11JB	1 (0.07)
	(Thiamine 300 mg elemental selenium 200 mcg, elemental zinc 50 mg, folic acid 1.5 mg, elemental copper 2 mg, magnesium citrate 375 mg, pyridoxine 50 mg)		
	Inj. Alcomax	A11JB	1 (0.07)
	(Riboflavin 4 mg, thiamine 250 mg, ascorbic acid 500 mg, niacinamide 160 mg, pyridoxine 50 mg, anhydrous dextrose 1,000 mg)		
	Tab. Supreo forte	-	2 (0.14)
	(Vitamin B1 1 mg, vitamin B12 1 mcg, vitamin B2 1.5 mg, vitamin B6 1 mg, vitamin C 50 mg, vitamin D3 200 IU, vitamin E 5 mg, zinc oxide 10mg) ferrous fumarate 30 mg, folic acid 0.15 mcg, + ginseng 42.5 mg, iodine 0.1 mg, magnesium sulphate 3 mg, niacinamide 10 mg, potassium 2 mg, vitamin A 2,500 IU, elemental calcium 75 mg, elemental copper 0.5 mcg, elemental manganese 0.5 mg		
	Tab. Medineuron	A11JC	2 (0.14)
	(L-glutamic acid 100 mg, zinc sulphate 25 mg niacinamide 50 mg, calcium pantothenate 15 mg, cyanocobalamin 15 mcg Thiamine mononitrate 10 mg, pyridoxine hydrochloride 3 mg)		
	Tab. Benadon	A11HA02	1 (0.07)
	(Pyridoxine hydrochloride, 40 mg)		
Vitamins and minerals	Tab. Nurokind-D3	B03BA51	4 (0.28)
	(Pyridoxine 3 mg, folic acid 1.5 mg vitamin D 1,000 IU alpha lipoic acid 100 mg, mecobalamin 1,500 mcg)		
	Tab. Neurogard	A11EX	9 (0.64)
	(Vitamin B12 5 mcg, calcium pantothenate 12.5 mg, vitamin B6 3 mg, nicotinamide 50 mg, vitamin C 150 mg, vitamin B1 10 mg, vitamin B2 10 mg, zinc sulphate monohydrate 61.8 mg, L-glutamic acid 100 mg)		
	Tab. Zincovit	A11AA03	3 (0.21)
	(Carbohydrate 0.2 g, vitamin C 40 mg, grape seed extract 50 mg, vitamin B3 18 mg, chromium 25 mcg, vitamin E 10 mg, selenium 30 mcg, vitamin B5 3 mg, copper 30 mcg, vitamin B2 1.6 mg, iodine 100 mcg, vitamin B1 1.4 mg, manganese 250 mcg, vitamin B6 1 mg, zinc 10 mg, vitamin A 600 mcg, vitamin D3 5 mcg, folic acid 100 mcg, vitamin B12 1 mcg, biotin 150 mcg)		
	Tab. Nuhenz	B03BA51	6 (0.42)
	(Pyridoxine hydrochloride 3 mg, mecobalamin 1,500 mcg, myo-inositol 100 mg, chromium polynicotinate 200 mg, alpha lipoic acid 200 mg, folic acid 1.5 mg, benfotiamine 200 mg)		

Continued

Drug classes	Brand/generic drug names, compositions of multivitamins, minerals, and nutritional supplements	ATC code	(*N* = 384) & (%) Total drugs (1,399)
	Tab. Immuset	-	4 (0.28)
	(Zinc sulphate 50 mg, vitamin C 500 mg, vitamin E 200 IU, vitamin D3, 1,000 IU)		
	Cap. Becozinc	A11EX	4 (0.28)
	(Vitamin B12 15 mcg, vitamin C 150 mg, zinc sulphate monohydrate 54.93 mg, folic acid 1 mg, vitamin B1 10 mg, calcium pantothenate 12.5 mg, vitamin B2 10 mg, niacinamide 50 mg, vitamin B6 3 mg)		
	Tab Revit FE	-	8 (0.57)
	(Methylcobalamin 500 mcg, vitamin B6 10 mg, biotin 300 mcg, vitamin B3 25 mcg, calcium pantothenate 6 mg, vitamin B2 3 mg, elemental iron 100 mg, vitamin B1 2 mg, folic acid 10 mg)		
	Cap. HHOMEGA	V06DX	2 (0.14)
	(Biotin 5 mg, elemental selenium 75 mcg, omega-3 fatty acids 300 mg, elemental copper 1 mg, wheat germ oil 100 mg, zeaxanthin 1 mg, green tea extracts 25 mg, lutein 5 mg, elemental zinc 12.5 mg)		
Vitamins and minerals	Tab. Nuhenz	B03BA51	7 (0.50)
	(Folic acid 1.5 mg, pyridoxine hydrochloride 3 mg, mecobalamin 1,500 mcg, myo-inositol 100 mg, alpha lipoic acid 200 mg, chromium polynicotinate 200 mg, benfotiamine 200 mg)		
	Cap. Nervijen plus	B03BA51	5 (0.35)
	(Folic acid 0.75 mg, pyridoxine 1.5 mg, Mecobalamin 750 mcg, alpha lipoic acid 100 mg, niacinamide 50 mg, benfotiamine 7.5 mg)		
	Syr. Feroglobin B12	-	4 (0.28)
	(Zinc 12 mg, Copper 2 mg, iron 24 mg, vitamin B9 500 mcg, vitamin B1 10 mcg, vitamin B6 5 mg)		
	Tab. Chew-C	-	7 (0.50)
	(Vitamin C 100 mg, Zinc citrate 5.0 mg, Sodium Ascorbate 450 mg)		
	Cap. Pepferrin	-	3 (0.21)
	(Pyridoxal 5-phosphate 1.5 mg, elemental iron 100 mg, methylcobalamin 1,500 mcg, elemental zinc 22.5 mg, L-methylfolate 1 mg)		
	Minerals		4 (0.28)
	Tab. Ultra Magnesium	-	1 (0.07)
	(Magnesium hydroxide, 200 mg)		
Minerals	Granules. Addphos	-	3 (0.21)
	(Sodium acid phosphate, 1.936 gm)		
	Vitamins, minerals, and antianemics		536 (38.31)
Vitamins, minerals, pre & post-natal) antianemics	Tab. Orofer XT	B03AD	9 (0.64)
	(Folic acid 1.1 mcg, elemental iron 100 mg)		
	Cap. Autrin	B03AE01	3 (0.21)
	Folic acid 1.5 mg, vitamin B12 15 mcg, ferrous fumarate 300 mg)		
	Tab. Livogen	B03AD	10 (0.71)
	(Folic acid 1,500 mcg, Ferrous fumarate 152 mg)		
	Tab. Livogen XT	B03AE	3 (0.21)
	(Zinc sulphate monohydrate 61.8 mg, elemental iron 100 mg, folic acid 1.5 mg)		
	Cap. Fefol Spansule	B03AD	3 (0.21)
	(Folic acid 0.5 mg, ferrous sulphate 150 mg)		
	Syr. Tonoferon	B03AE01	5 (0.35)
	(Vitamin B12 5 mcg/5 ml, iron 250 mg, folic acid 500 mcg)		
	Tab. Hemogold-XT	B03AD	3 (0.35)
	(Folic acid 1.5 mg, elemental iron 100 mg)		

Continued

Drug classes	Brand/generic drug names, compositions of multivitamins, minerals, and nutritional supplements	ATC code	(*N* = 384) & (%) Total drugs (1,399)
Supplements & adjuvant therapy	Tab. Folvite	B03BB01	221 (15.79)
	(Folic acid, 5 mg)		
	Inj. Venofer	B03A	279 (19.94)
	(Iron sucrose, 100 mg/5 ml)		
	Supplements & adjuvant therapy		14 (1.00)
	Sachet K- Bind	V03AE01	6 (0.42)
	(Calcium polystyrene sulphonate, 15 g)		
	Sachet K-Check		1 (0.07)
	(Calcium polystyrene sulfonate, 15 g)	V03AE01	
	Syr. K-CIT	G04BX	3 (0.21)
	(Citric acid monohydrate 334 mg/5 ml, potassium citrate monohydrate 1,100 mg)		
	Becelac fortz	V06DX	4 (0.28)
	(Biotin 100 mcg, lactobacillus acidophilus 200 million cells, niacinamide 100 mg, folic acid 1.5 mg, cyanocobalamin 15 mcg)		
	Sachet Nefrosave Keto	A16AA	2 (0.14)
	(Tyrosine 90 mg, L-histidine 114 mg, L-lysine 315 mg, tryptophan 69 mg, L-threonine 159 mg)		
Rich sources of protein and calories for renal nutrition/ Dietary supplements	Rich sources of protein and calories for renal nutrition		37 (2.64)
	Nephro – HP powder oral for suspension	V06DB	23 (1.64)
	(Fat/carbohydrates/proteins/minerals/vitamins, combinations, 360 g)		
	Renopro HP powder oral for suspension	V06DB	6 (0.42)
	(Fats/carbohydrates/proteins/vitamin, combinations/25 g)		
	Nepro-LP powder oral suspension	V06DB	5 (0.35)
	(Fats/carbohydrates/proteins/vitamin, combinations/350 g)		
	Pro360 Nephro powder oral suspension		3 (0.21)
	(L-carnitine, high-calorie HP, formula fortified with L-taurine/400 g)	-	
Enteral/nutritional products	Enteral/nutritional products		11 (0.78)
	Biscuit threptin	V06DX	1 (0.07)
	(Vitamin B6 1.26 mg, protein 30 g, sugar 23 g, carbohydrate 48 g, nicotinamide 14 mg, fat 14 g, vitamin B2 0.25 mg, vitamin B1 1.06 mg)		
	Tab. Renolog	V06DX	5 (0.35)
	(Calcium 0.05 g, calcium -3 -methyl-2oxo-valerate 67 mg, nitrogen 36 mg, calcium -4- methyl-2-oxo-valerate 101 mg, 1-tyrosine 30 mg, calcium -2-oxo-3-phenyl-propionate 68 mg, L-histidine 38 mg, calcium -3-methyl-2-oxo- butyrate 86 mg, L-tryptophan 23 mg, calcium-dl-2-hydroxy-4-methyl-thio-butyrate, L-threonine 53 mg, lysine acetate 105 mg)		
	Cap. Beneficiale	V06DE	2 (0.14)
	(Potassium iodide 0.13 mg, L-arginine 13.28 mg, copper sulphate 0.4 mg, L-isoleucine 5.9 mg, magnesium oxide 4.15 mg, L-leucine 18.3 mg, manganese sulphate 6.25 mg, ferrous sulphate dried 20.5 mg, L-lysine hydrochloride 25 mg, elemental zinc 15 mg, DL-methionine 5 mg, L-threonine 4.2 mg, omega-3 fatty acids 250 mg, L-valine 6.7 mg, chromium picolinate 200 mcg, L-tryptophan 5 mg, L-phenylalanine 5 mg, reduced glutathione 1 mg, sodium selenite 10 mcg, cholecalciferol 200 IU, folic acid 200 mcg, vitamin A 2,500 IU, ascorbic acid 50 mg, alpha tocopheryl acetate 7.5 IU, calcium d-pantothenate 16.3 mg, vitamin B1 5 mg, vitamin B12 2 mcg, vitamin B2 3 mg, vitamin B6 1.5 mg, nicotinamide 25 mg)		
	Tab. Alfalog	V06DX	3 (0.21)
	(Calcium 0.05 g, calcium -3 -methyl-2oxo-valerate 67 mg, nitrogen 36 mg, calcium -4- methyl-2-oxo-valerate 101 mg, 1-tyrosine 30 mg, calcium -2-oxo-3-phenyl-propionate 68 mg, L-histidine 38 mg, calcium -3-methyl-2-oxo- butyrate 86 mg, L-tryptophan 23 mg, calcium-dl-2-hydroxy-4-methyl-thio-butyrate, L-threonine 53 mg, lysine acetate 105 mg)		

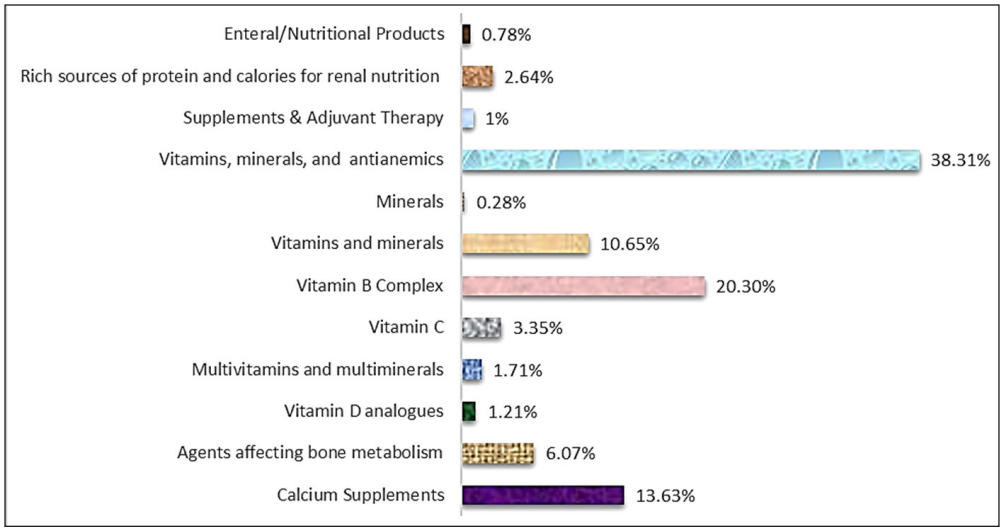

Figure 1. Overall consumption of multivitamins, multi-minerals, and dietary supplements among CKD patients undergoing HD at FMMCH Mangalore, KMC Manipal, and Dr. TMA Pai Hospital.

(1.71%), vitamin D analogs (1.21%), supplements and adjuvant therapy (1%), enteral/nutritional products (0.78%), and minerals (0.28%).

Figure 1 illustrates the overall consumption of multivitamins, multi-minerals, and dietary supplements among CKD patients undergoing HD at FMMCH Mangalore, KMC Manipal, and Dr. TMA Pai Hospital.

Vitamins, minerals

In vitamins and minerals, cap. Eido is the highly prescribed drug 44 (3.14%), followed by Tab. Cobadex – CZS 29 (2.07%), Tab. Neurogard (0.64%), Tab. Revit FE (0.57%), and Tab. Chew-C (0.50%). Figure 2 shows the percentage of vitamins and minerals used in hemodialysis patients.

Vitamin B complex

In vitamin B complex Cap., Becosules is the highly prescribed drug (14.43%), followed by Inj. Nuro kind gold (1.28%), Tab. Multi-8 (0.92%), Inj. Optineuron (0.57%), Tab. Neurokind LC (0.57%), and Tab. Carnisure plus (0.50%). Figure 3 shows the percentage of B complex vitamin medications employed on patients receiving dialysis.

Calcium with vitamins

In calcium with vitamins Tab., Shelcal 500 mg is the highly prescribed drug (9.00%), followed by Tab. Aptcal-CC (0.21%), Tab. CCM (0.07%), and Tab. Jocal (0.07%).

Calcium with vitamins and minerals

Tab. Calcit is the highly prescribed drug (2.14%), followed by Tab. Calcimax forte 0.57%, Tab. calcirin 0.57%, Tab. Calbo-D3 (0.42%), and Tab. Crocal (0.21%).

Agents affecting bone metabolism

Cap. Rocaltrol is the highly prescribed drug (2.14%), followed by Cap. Laretol 0.78%, Tab. Albonate (0.57%), Tab. Shelcal-CT (0.42%), and Cap. Alcal (0.21%).

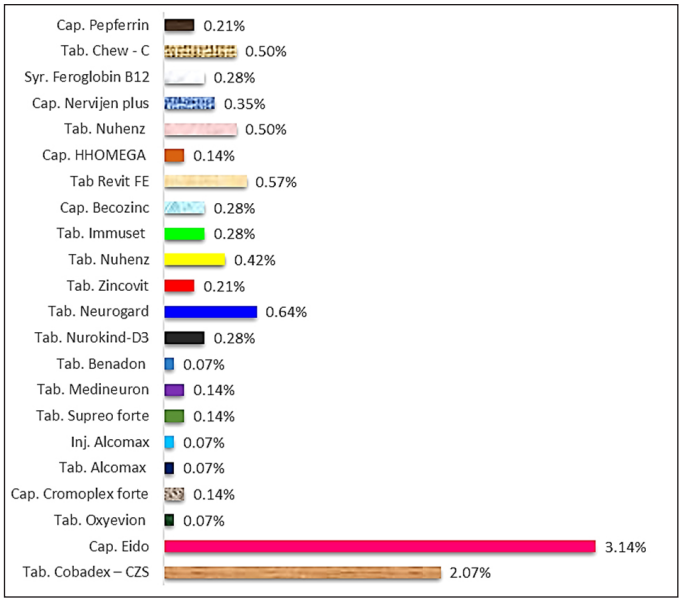

Figure 2. Percentage of different vitamins and minerals medications used in hemodialysis patients.

Vitamin D analogues

Cap. D-rise is the highly prescribed drug (0.57%), followed by Tab. D3 60K (0.28%), Tab. Micro-D3 (0.21%), and Granules Calcirol (0.14%).

Multivitamins and multi-minerals

Tab. Supradyne is the highly prescribed drug (1.21%), followed by Cap. NU-36 (0.28%), and Cap. Sanovit SG (0.21%).

Vitamin C

Tab. Celin 2.28% is the highly prescribed drug (2.28%), followed by Tab. Limcee (1.07%).

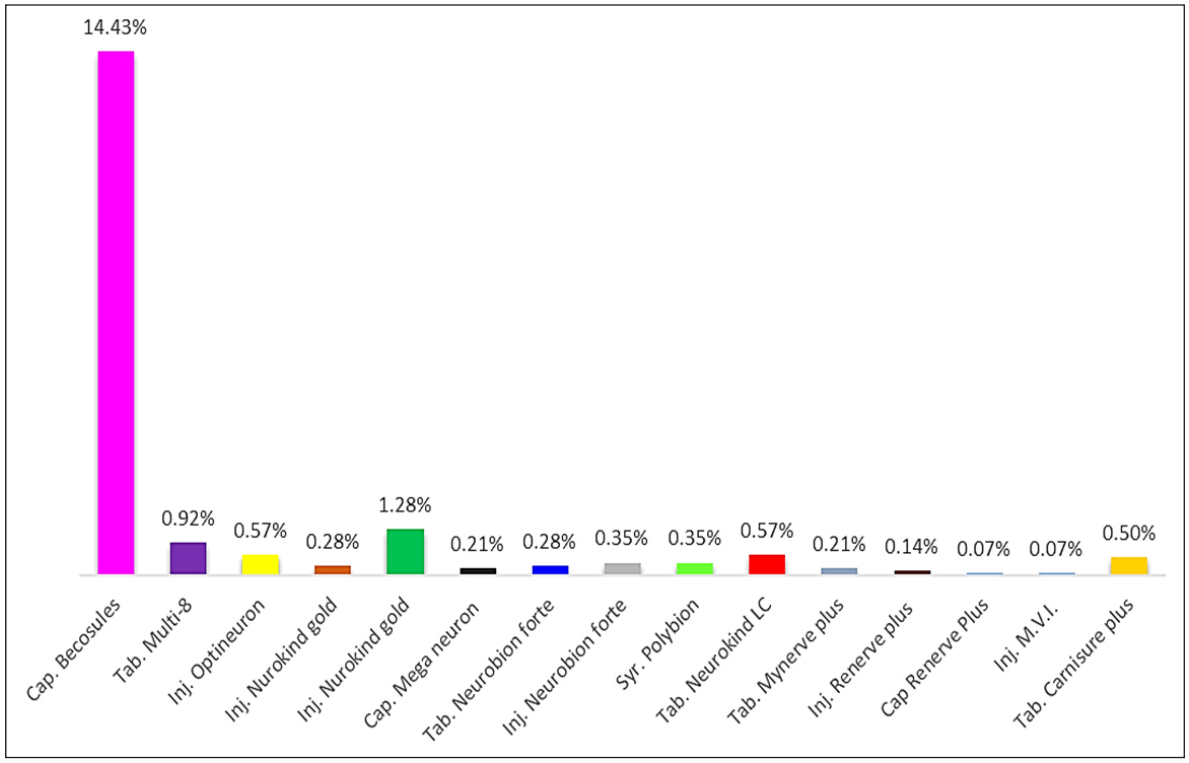

Figure 3. Percentage of different B complex vitamins employed on patients receiving dialysis.

Minerals

Granules. Addphos is the highly prescribed drug (0.21%), followed by Tab. Ultra magnesium (0.07%).

Rich sources of protein and calories for renal nutrition

Nephro–high protein (HP) powder is the highly prescribed drug (0.21%), followed by Renopro HP powder (0.42%), Nepro-low protein (LP) powder (0.35%), and Pro360 Nephro powder (0.21%).

Enteral/nutritional products

Tab. Renolog is the highly prescribed drug (0.35%), Tab. Alfalog (0.21%), Cap. Beneficiale (0.14%), and Biscuit threptin (0.07%).

Vitamins, minerals, and antianemics

Inj. Venofer (19.94%) and Tab. Folvite (15.79%) is the highly prescribed drug, followed by Tab. Livogen (0.71%), Tab. Orofer XT (0.64%), Syr. Tonoferon (0.35%), Tab. Hemogold-XT (0.35%), Tab. Livogen XT (0.21%), and Cap. Autrin (0.21%).

DISCUSSION

This study analyzes the prescribing patterns and usage of multivitamins, multi-minerals, and dietary supplements among HD patients in South Karnataka, India. The discussion below highlights vital findings, contextualizes them within the broader medical landscape, and provides insights into the clinical implications and potential directions for future research.

The study identified significant variability in prescribing patterns among healthcare providers treating HD patients. A key observation was the inconsistency in the types and combinations of supplements prescribed, highlighting the absence of standardized guidelines. This underscores the urgent need for evidence-based protocols and a unified consensus on supplement prescriptions, ensuring that supplementation aligns with the nutritional requirements and clinical needs of HD patients.

Patient perspectives offered valuable insights into the multifaceted aspects of supplement use. Many patients reported a positive outlook toward supplement use, citing improved energy levels, overall well-being, and symptom management. However, challenges related to financial constraints and the burden of adhering to a complex medication regimen were also voiced. Addressing these patient-centered concerns is vital for enhancing adherence and optimizing the potential benefits of supplementation.

Patients with longer HD durations and higher comorbidity burdens appeared more likely to receive supplements. This could reflect a clinical strategy to mitigate potential nutrient deficiencies due to prolonged HD and compromised renal function. However, caution must be exercised to avoid excessive supplementation, which could lead to adverse effects.

The study's nutritional status and outcomes examination revealed intriguing correlations between supplement use and certain biomarkers. HD patients receiving specific supplements demonstrated improved levels of crucial nutrients, such as iron, vitamin D, and B vitamins. These findings suggest the potential

efficacy of targeted supplement interventions in ameliorating nutritional deficiencies commonly observed in this patient population. Moreover, the study's findings open avenues for investigating the association between improved nutrient status and enhanced clinical outcomes, including reduced morbidity and mortality.

Collaborative efforts involving clinical pharmacists, nephrologists, dietitians, and other healthcare professionals are pivotal for devising patient-specific supplement regimens that address nutritional deficiencies and avoid potential risks. Future studies should investigate the long-term impact of supplement use on patient outcomes, focusing on dietary improvements, quality of life, hospitalization rates, and mortality.

Several studies have analyzed the prescription patterns of vitamins and minerals in HD patients, revealing significant variability in supplementation practices. Abhisek *et al*. [26] reported that oral iron (90.43%) was the most frequently prescribed supplement, followed by folic acid (89.56%), parenteral iron (68.69%), multivitamins and minerals (66.95%), and vitamin B12 (64.34%). Similarly, Narayana Murthy *et al*. [27] found that 15% of patients received iron supplements (e.g., livogen, folic acid, and iron sucrose), while 11% were prescribed multivitamins, with methylcobalamin being the preferred choice for diabetic patients.

In a multidisciplinary review, Battistella *et al*. [28] reported 18,710 annual prescriptions for calcitriol, highlighting its widespread use. Bajait *et al*. [29] found that vitamins and minerals (24.71%) were the most commonly prescribed, followed by multivitamins and minerals (14.82%), iron (8.65%), folic acid (8.55%), calcitriol (5.60%), and vitamin D3 (4.27%). In addition, Oommen *et al*. [30] noted that 94.66% of medical facilities and 65.06% of tertiary hospitals recommended vitamin and mineral supplementation.

Tadvi *et al*. [31] reported iron (92.68%) as the most prescribed drug, followed by multivitamins and minerals (87.8%) and calcitriol (63.41%). Konduru *et al*. [32] found that calcium carbonate and vitamin D (66.66%) were highly prescribed, followed by multivitamins (43.80%). Pothen *et al*. [33] observed a 13% prescription rate for multivitamins, while Anil *et al*. [34] reported that among hematinics, parenteral iron (67%) was the most prescribed, followed by folic acid (26%) and oral iron (7%). Commonly prescribed multivitamin brands included Polybion (44%), Neurobion Forte (18%), Revit Fe (15%), and others [34].

Chundu *et al*. [35] noted that vitamin supplements were prescribed at 0.79%, while electrolytes were prescribed at 0.53%. Raja *et al*. [36] found that vitamin B complex was prescribed to 85% of patients at the initial visit and 78.5% at the last visit, with iron supplements given to 58% and 57% of patients, respectively. Other frequently recommended supplements included α-cholecalciferol, folic acid, and niacin [36].

Kumar *et al*. [37] reported that minerals and vitamins accounted for 32.03% of total prescriptions, while Chakraborty *et al*. [38] found that mineral and vitamin supplements were among the most commonly recommended medications (12.29%), followed by multivitamins and multi-minerals (5.56%), vitamin D3 (4.55%), and calcitriol (2.18%). Al-Ramahi *et al*. [39] highlighted that vitamin B complex and folate were the second most frequently prescribed medications, with 42.3% and 54.3% of patients receiving them in two study phases, while overall vitamin prescriptions increased from 71.0% in phase one to 78.0% in phase two [39].

The differences in MMHDS prescribing patterns across hospitals may stem from institutional policies, physician preferences, patient demographics, and resource availability. Some hospitals may adhere to international guidelines (e.g., KDIGO and KDOQI), while others rely on clinician discretion due to the lack of standardized national protocols in India. Variations in patient populations, dietary habits, comorbid conditions, and access to nutritional counseling may also influence prescribing trends. In addition, differences in healthcare infrastructure and availability of supplements can impact prescribing decisions, leading to inconsistencies in MMHDS use.

Excessive supplementation can lead to toxicity, metabolic imbalances, and adverse drug interactions. Iron overload from excessive supplementation increases the risk of oxidative stress, cardiovascular disease, and infections, while excessive vitamin B6 can cause neuropathy. Polypharmacy, common in dialysis patients due to multiple comorbidities—raises concerns about drug-supplement interactions, reduced adherence, and increased pill burden, potentially affecting treatment efficacy. To mitigate these risks, routine biochemical monitoring, patient-specific dosing, and evidence-based prescribing guidelines are essential for ensuring safe and effective MMHDS use in HD care.

Pharmacist-led interventions

For HD patients, pharmacists are essential in the proper selection, monitoring, and optimization of nutritional supplements. Because this population has complex nutritional needs and is at risk for deficiencies, pharmacists can offer evidence-based advice on supplement use that minimizes potential interactions and ensures compatibility with prescribed medications. Pharmacists assist in customizing supplementation regimens to meet the needs of each patient through medication therapy management, patient counseling, and coordination with nephrologists and dietitians. Pharmacists can also evaluate adherence, keep an eye out for side effects, and inform patients about the significance of eating the right foods, all of which can help HD patients' general health.

Recommendations and future research

Recommendations

- MMHDS prescriptions should be individualized based on patient comorbidities, dialysis duration, and nutritional status.
- Findings support the need for regional guidelines for MMHDS use in Indian HD patients.
- Nephrologists should ensure MMHDS prescriptions align with clinical needs.
- Clinical pharmacists should monitor supplement interactions and adjust dosages accordingly.

- Dietitians should be involved in nutritional assessments to prevent over-supplementation.
- Hospitals should adopt standardized prescription protocols to minimize variability in MMHDS use.

Future research

Researchers can aim at longitudinal studies to evaluate the long-term effects of MMHDS on patient outcomes, including mortality and quality of life. Future research should explore the long-term impact of pharmacist-led interventions on nutritional supplement adherence, clinical outcomes, and quality of life in HD patients, as well as the development of standardized guidelines for pharmacist involvement in renal nutrition management.

Limitations of the study

The study was limited to three hospitals, which may not fully represent other regions in India; therefore, a larger multicentric study including hospitals from different states is needed to enhance generalizability. As a cross-sectional study, it captures prescribing patterns at a single time point, making it essential for future research to include long-term follow-up studies to assess the clinical outcomes of MMHDS use. In addition, patient-reported supplement adherence may be subject to recall bias, highlighting the need for future studies to incorporate objective biochemical assessments of nutrient levels for more accurate evaluations. Variability in prescribing practices across hospitals, influenced by institutional policies and prescriber preferences, further underscores the necessity of developing a standardized MMHDS prescription guideline to ensure consistency and optimize patient care.

CONCLUSION

The study's findings highlight diverse prescribing practices, reflecting a cautious approach to supplement use in addressing nutritional deficiencies while minimizing unnecessary polypharmacy. Given the complex health challenges faced by HD patients, optimizing supplement prescriptions is crucial for improving treatment outcomes and preventing complications.

To enhance patient care, immediate steps should include the development of evidence-based guidelines specific to the Indian healthcare context. Standardized protocols will help streamline prescription practices, improve patient safety, and reduce variability across healthcare centers. In addition, collaborative strategies among nephrologists, clinical pharmacists, and dietitians should be implemented to ensure personalized and effective supplementation.

Hospitals and healthcare policymakers should prioritize training programs for healthcare providers to enhance awareness of rational supplement use in HD patients. Furthermore, future longitudinal studies should assess the long-term impact of supplementation on clinical outcomes, morbidity, and mortality.

This multi-centric study provides a strong foundation for improving MMHDS prescribing practices. By integrating evidence-based decision-making, patient-centered approaches, and ongoing guideline refinement, healthcare professionals can significantly enhance the quality of life and overall well-being of HD patients in South Karnataka and beyond.

Pharmacist-led interventions in the use of nutritional supplements for HD patients enhance patient safety, optimize therapy, and improve adherence, highlighting the critical role of pharmacists in multidisciplinary renal care teams.

LIST OF ABBREVIATIONS

ATC, anatomic therapeutic chemicals; CKD, chronic kidney disease; DOPPS, global dialysis outcomes, and practice patterns study; ESRD, end-stage renal disease; HD, hemodialysis; KDIGO, kidney disease improving global outcomes; KDOQI, kidney disease outcome quality initiative; MMHDS, multivitamins, multi-minerals, hematinics, and dietary supplements.

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AUTHOR CONTRIBUTIONS

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the International Committee of Medical Journal Editors (ICMJE) requirements/guidelines.

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CONFLICTS OF INTEREST

The authors report no financial or any other conflicts of interest in this work.

ETHICAL APPROVALS

The Institutional Ethics Committee approved this study before its initiation. Everyone who participated provided cautious approval, ensuring anonymity, confidentiality, and true engagement. Throughout the study, strong security measures were used to preserve data and participant confidentiality. The

study was duly approved by multiple Institutional Committees (IEC: 471/2019 from KMC Manipal, covering both TMA Pai Hospital Udupi and KMC Manipal; and FMIEC/CCM/294/2021 from FMMCH Mangalore). In addition, the study was registered with the Clinical Trial Registry-India (CTRI) under the registration number CTRI/2019/08/020874.

DATA AVAILABILITY

The researchers retain full access to the data and will make it available after your request is submitted.

PUBLISHER'S NOTE

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USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declares that they have not used artificial intelligence (AI)-tools for writing and editing of the manuscript, and no images were manipulated using AI.

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