RESEARCH PAPER

Determinants of Health-Related Quality of Life in Indian Hemodialysis Patients: A Cross-Sectional Study Using EQ-5D-5L and EQ-VAS

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Abstract

Background: Health-related quality of life (HRQoL) is an important patient-centered outcome in maintenance hemodialysis (MHD). Indian data examining functional and nutritional determinants of both EQ-VAS and EQ-5D-5L utility are limited. This study evaluated the determinants of HRQoL, focusing on hand-grip strength (HGS), anthropometry, and nutritional screening in an Indian MHD cohort.

Methods: This single-center cross-sectional study included 190 adult MHD patients from November 2024 to April 2025 at Ruby Hall Clinic. Data collected included demographics, comorbidities, anthropometry (BMI, TSF, MUAC, MAMC), SNAQ, HGS, EQ-5D-5L (EQ-Index), and EQ-VAS. Distributional checks, Spearman correlations, Mann–Whitney tests, and partial correlations (controlling for age and gender) were performed. Multivariable ordinary least squares regression was used to predict EQ-VAS, while beta regression was used to model EQ-Index. The significance threshold was set at $p < 0.05$.

Results: Mean age was 53.5 ± 14.0 years; 76% male. Mean HGS = 15.5 ± 7.0 kg, EQ-VAS = 70.5 ± 12.5, EQ-Index = 0.86 ± 0.17. HGS correlated positively with EQ-VAS ($r = 0.269$, $p < 0.001$) and EQ-Index ($r = 0.217$, $p = 0.003$). Patients with diabetes had lower EQ-VAS and lower EQ-Index (Mann–Whitney $p = 0.0007$ and $p = 0.033$, respectively). In multivariable OLS predicting EQ-VAS, HGS ($\beta = 0.32$, $p = 0.021$) and age ($\beta = -0.14$, $p = 0.046$) were independent predictors ($R^2 = 0.12$, adj $R^2 = 0.09$). In beta regression predicting EQ-Index, HGS was the sole significant predictor (estimate = 0.026, $p = 0.033$; pseudo-$R^2 = 0.065$). Other anthropometric and SNAQ measures showed weaker or non-independent associations after adjustment.

Conclusions: Hand-grip strength was the most reliable independent predictor of both subjective and utility-based HRQoL in this Indian MHD cohort. Routine HGS assessment, along with interventions such as exercise and dietary modification to maintain or improve muscle strength, may help enhance the quality of life of dialysis patients. Longitudinal multicenter studies incorporating psychosocial and dialysis-specific factors are needed to further clarify these associations and inform targeted interventions.

Keyword - Health-Related Quality of Life (HRQoL), Maintenance Hemodialysis, Hand-Grip Strength, EQ-5D-5L, EQ-VAS, Nutritional Status, Chronic Kidney Disease, Beta Regression Analysis

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Introduction

Chronic Kidney Disease is a major global health

challenge with a steadily rising prevalence and substantial clinical and economic burden.[1] More than 850 million people worldwide are affected by kidney-related disorders, including Acute Kidney Injury, CKD, and conditions requiring renal replacement therapy (RRT).[2] Community-based studies have reported CKD prevalence rates ranging from 10% to 17%, while population-based studies from India estimate a pooled prevalence of approximately 10.2%, with individual studies reporting rates between 4% and 21%.[3]

These findings underscore the considerable and growing burden of CKD in India. The impact of CKD is further intensified by delayed access to nephrology care. A substantial proportion of patients present late to specialist services, often with little or no predialysis follow-up.[4] Late referral is strongly associated with unplanned dialysis initiation, frequently through temporary catheter access, and is linked to significantly poorer survival outcomes. Socioeconomic disadvantage further exacerbates these risks, as patients initiating dialysis with suboptimal vascular access, lower educational attainment, or dependence on public insurance experience higher mortality rates.[5]

Furthermore, dialysis patients bear an unmanageable financial strain: in Kerala, over 90% of households receiving maintenance hemodialysis incur catastrophic medical costs, and many turn to distress financing even though they receive some subsidy.[6] Low reimbursement rates in publicly funded dialysis programs make it challenging to sustain high-quality care on a systemic level. Cost pressures often lead to compromises in staffing, infrastructure, and consumables, which exacerbate outcome disparities.[7]

A change in focus from purely biochemical or disease-focused outcomes to patient-centered outcomes like health-related quality of life (HRQoL) has occurred as dialysis survival continues to improve over time. HRQoL refers to a patient's subjective physical and mental well-being. It functions as a clinical index that can predict outcomes such as hospitalization and mortality in patients with CKD and ESKD.[8] The EQ-5D-5L is one of the most widely used generic tools for HRQoL assessment in chronic disease populations worldwide.[9] Mobility, self-care, routine activities, pain/ discomfort, and anxiety/depression are the five dimensions that make up the EQ-5D-5L. Each dimension has five levels, ranging from no problems to severe problems. These answers specify health states that, when combined with value sets unique to each nation, can be transformed into a single index value.[10] Additionally, the tool includes a vertical visual analogue scale (VAS) that allows users to rate their general health on a scale of 0 to 100. With 100 denoting the best possible health and 0 the worst, higher scores indicate better perceived health status.[11]

Understanding of patients' well-being is improved by combining the two metrics: The EQ-VAS measures subjective health assessment, which can differ among demographic and clinical subgroups, whereas the EQ-Index provides a standardized, societal-based measure appropriate for economic evaluation (e.g., QALYs) and cross population comparison. Research indicates that EQ-Index and EQ-VAS frequently differ among age, gender, and urbanicity subgroups, highlighting the importance of examining them independently.[12-13]

Current research in the Indian setting is limited in examining how specific combinations of chronic diseases affect HRQoL scores obtained from the EQ-5D-5L.[14] There is a lack of comprehensive research evaluating HRQoL in Indian MHD patients that incorporate functional, clinical, nutritional, and demographic factors.[15-16] While some determinants of quality of life have been assessed in previous Indian studies, the majority have relied on small sample sizes, single-domain assessments, or limited nutritional markers, which has left the wider relationship between nutrition, comorbidity, and well-being understudied. Reduced muscle function and nutritional abnormalities, especially malnutrition and protein-energy wasting (PEW), are prevalent in dialysis populations and are associated with worse HRQoL as well as unfavorable clinical outcomes, such as increased hospitalization and mortality.[17-19]

Hand-grip strength (HGS) is a simple, reliable, and cost-effective measure of muscle function and prognostic status in patients with chronic kidney disease (CKD).[20] Beyond assessing muscle strength alone, HGS reflects overall functional status and is sensitive to the combined effects of inflammation, physical inactivity, and nutritional deficiencies.[21] Reduced HGS has been associated with poorer global HRQoL, impaired physical functioning, and diminished ability to perform activities of daily living. Furthermore, lower HGS has been shown to predict increased all-cause mortality among maintenance dialysis patients.[22-23] Despite this evidence, the use of HGS in HRQoL research involving Indian dialysis populations remains limited.[24]

Impaired health-related quality of life (HRQoL) is a common experience for patients undergoing maintenance hemodialysis. This is caused by a number of interconnected variables, such as comorbidity, poor nutritional condition, and decreased functional capacity. Among them, comorbidity has repeatedly been found to be a significant factor in worse HRQoL ratings in people with end-stage renal illness.[25-26] Reduced physical function and limited exercise capacity further compound the effects of comorbidity and nutritional impairment, collectively contributing to diminished well-being in hemodialysis patients.[27]

These results together highlight the multifaceted nature of decreased HRQoL in hemodialysis patients.

Nutritional screening tools such as the Short Nutritional Assessment Questionnaire (SNAQ) facilitate the early identification of malnutrition by providing valuable information on appetite loss and unintentional weight loss.[28] In patients with chronic kidney disease (CKD), poor nutritional status, including protein-energy wasting, is strongly associated with increased rates of hospitalization and mortality. Appetite loss is considered one of the major contributors to inadequate dietary intake in this population.[29] Although anthropometric measures like body mass index (BMI), mid-upper arm circumference (MUAC), mid-arm muscle circumference (MAMC), and triceps skinfold thickness (TSF) are frequently used to evaluate nutritional status however, they frequently miss functional decline or inflammatory burden.[30] The complex relationship between body composition, inflammation, and functional status in dialysis patients cannot be fully captured by a single nutritional assessment tool.[31] The Malnutrition-Inflammation Score (MIS) and other inflammation-based scoring tools have been found to correlate with both anthropometric measures and inflammatory markers (e.g., IL-6). This suggests that combining anthropometric assessments with markers related to inflammation or function offers a more thorough assessment of nutritional health in patients with chronic kidney disease.[32]

From an analytical perspective, HRQoL outcomes present unique methodological challenges. The EQ-VAS is a bounded continuous variable that is commonly analyzed using ordinary least squares (OLS) regression, whereas the EQ-Index is restricted to the 0–1 interval and often violates the assumptions of linear regression due to skewness and heteroscedasticity. Despite these differences, most HRQoL studies have applied linear models uniformly to both outcomes, potentially leading to biased estimates of utility-based measures.[33-34] Beta regression offers a statistically appropriate framework for modelling bounded utility outcomes such as the EQ-Index; however, its use remains limited in dialysis research in India.

Given these gaps, there is a clear need for comprehensive and methodologically robust studies evaluating the clinical, nutritional, functional, and demographic determinants of HRQoL among Indian hemodialysis patients. Therefore, the present analytical cross-sectional study aimed to investigate the determinants of HRQoL in an Indian maintenance hemodialysis (MHD) cohort using both EQ-VAS and EQ-Index measures, along with comprehensive nutritional and functional assessments, including hand-grip strength (HGS), and appropriate regression models. By identifying modifiable factors associated with impaired HRQoL, this study seeks to support more patient-centered care strategies and inform targeted nutritional and functional interventions in resource-limited dialysis settings.

Materials and Methods

A) Study Design and Setting

This was a single-center, cross-sectional observational study conducted over a six-month period (November 2024 to April 2025) at a tertiary care hospital, Ruby Hall Clinic, Hinjewadi, Pune, India.

B) Participants

A total of 190 adult patients (≥18 years) undergoing maintenance hemodialysis (MHD) were recruited for the study. Eligible participants were required to be on MHD for a minimum duration of three months, attending regular dialysis sessions, and willing to provide written informed consent. Patients with acute kidney injury, those on peritoneal dialysis, individuals with cognitive impairment precluding questionnaire administration, and patients with incomplete anthropometric or health-related quality-of-life data were excluded from the study.

C) Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of Ruby Hall Clinic, Hinjewadi, Pune, India (IRB/IEC approval number: RHC/BIOPMRFIEC/2025/561; reference number: Bio IEC/377; approval date: March 19, 2025). The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrolment.

D) Data Collection and Measurements

Anthropometric measurements, including height, weight, body mass index (BMI), triceps skinfold thickness (TSF), mid-upper arm circumference (MUAC), and mid-arm muscle circumference (MAMC), were obtained using standardised measurement techniques. Hand-grip strength (HGS) was assessed using a calibrated handheld dynamometer, with participants in a seated position. Measurements were performed using the non-fistula arm, and the highest value from three consecutive attempts was recorded for analysis.

Nutritional status was evaluated using the Short Nutritional Assessment Questionnaire (SNAQ). Health-related quality of life (HRQoL) was assessed using the EQ-5D-5L questionnaire and the EQ-VAS. The EQ-5D-5L questionnaire was administered using validated language versions appropriate for the study population. EQ-5D-5L health states were converted into utility index values using the Indian population-specific value set.

All anthropometric, functional, nutritional, and HRQoL assessments were conducted prior to initiation of the dialysis session, and this standardized pre-

dialysis assessment protocol was applied uniformly across all participants to minimize the acute physiological effects of hemodialysis. This approach ensured greater consistency and comparability of measurements across the study population. Furthermore, conducting assessments before dialysis helped reduce variability arising from fluid shifts. A schematic overview of participant recruitment and data collection procedures is presented in Figure 1.

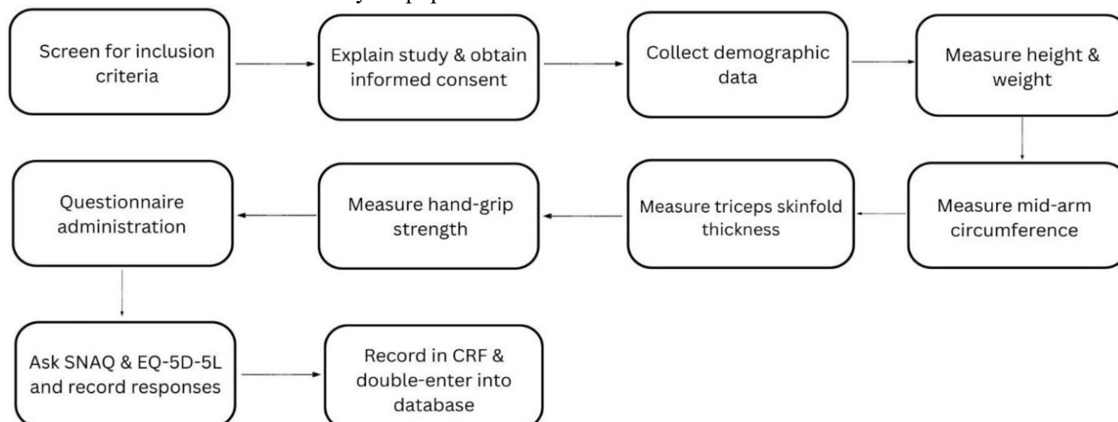

Figure 1: Schematic representation of the study workflow and data collection process.

E) Data Management

Data were recorded in electronic case record forms (CRFs) with double-entry verification to ensure accuracy. Participant confidentiality was maintained throughout the study by restricting access to anonymized data.

F) Statistical Analysis

Statistical analyses were conducted using Python (version 3.12) and R (RStudio Cloud). Continuous variables were summarized as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. The Shapiro–Wilk test assessed normality of continuous variables. Associations between EQ-VAS, EQ-Index, and potential predictors were evaluated using Spearman's rank correlation, and Mann–Whitney U tests were used for group comparisons by gender, diabetes mellitus, and hypertension. Partial correlations were performed controlling for age and gender.

Multivariable ordinary least squares (OLS) regression was used to identify predictors of EQ-VAS, while beta regression (using the *betareg* package in R) was applied for EQ-Index due to its bounded distribution. Model diagnostics included residual and Q–Q plots, Cook's distance, variance inflation factors (VIF) for multicollinearity, and the Breusch–Pagan test for heteroscedasticity. A two-sided p-value < 0.05 was considered statistically significant.

Results

1) Participant Characteristics

A total of 190 maintenance hemodialysis patients were included in the analysis. The cohort was predominantly middle-aged with a wide age range, reflecting a heterogeneous adult dialysis population. Nutritional and functional indicators showed substantial variability, indicating differing degrees of muscle mass and functional impairment. Overall HRQoL scores reflected moderate self-perceived health, with EQ-Index values clustering toward the upper bound, suggestive of a ceiling effect (Table 1).

Table 1. Baseline characteristics of the study population

Variable	Mean ± SD / %	Range / Category
Age (years)	53.5 ± 14.0	21 – 81
Gender	Male 76%, Female 24%	—
BMI (kg/m²)	22.4 ± 3.7	15.5 – 34.4
TSF (mm)	13.5 ± 4.6	2 – 30
MUAC (cm)	25.8 ± 3.3	12 – 40
MAMC (cm)	21.6 ± 2.8	8.2 – 34.9
HGS (kg)	15.5 ± 7.0	2.8 – 38.7
EQ-VAS	70.5 ± 12.5	35 – 95
EQ-Index	0.86 ± 0.17	0.02 – 1.00

2) Distributional Properties of Study Variables

Shapiro–Wilk testing demonstrated that all continuous variables deviated significantly from normality. Non-normality was particularly pronounced for EQ-Index

scores, consistent with their bounded nature and clustering near 1.0. These findings justified the use of non-parametric correlation analyses and beta regression for EQ-Index outcomes.

3) Bivariate Associations with HRQoL

Spearman correlation analysis revealed that hand-grip strength (HGS) showed the strongest and most consistent association with HRQoL. Higher HGS was significantly correlated with both EQ-VAS and EQ-Index scores (Table 2).

Table 2. Bivariate correlations between HRQoL outcomes and predictors.

Dependent	Variable	r	p-value	Method
EQ-VAS	Age	-0.200	0.006	Spearman
EQ-VAS	HGS	0.269	<0.001	Spearman
EQ-VAS	MAMC	0.175	0.016	Spearman
EQ-Index	HGS	0.217	0.003	Spearman
EQ-Index	SNAQ	-0.195	0.007	Spearman

Age demonstrated a modest but statistically significant negative association with EQ-VAS, whereas no significant association was observed with EQ-Index.. Anthropometric indicators of muscle mass, particularly MAMC, showed weaker but significant correlations with EQ-VAS. SNAQ scores were inversely associated with EQ-Index but not with EQ-VAS, suggesting that malnutrition risk may be more closely reflected in utility-based HRQoL than in subjective health ratings.

4) Group Comparisons

Group comparisons indicated that diabetes mellitus was the only comorbidity significantly associated with poorer HRQoL. Patients with diabetes reported significantly lower EQ-VAS scores and modestly lower EQ-Index values. No significant differences in HRQoL were observed by gender or hypertension status (Table 3).

Table 3. Group comparisons for HRQoL by comorbid conditions.

Group Variable	Dependent	Test	Statistic	p-value
Diabetes	EQ-VAS	Mann–Whitney	5530.5	0.0007
Diabetes	EQ-Index	Mann–Whitney	5078.0	0.033
Gender	EQ-VAS	Mann–Whitney	3149.0	0.724
Hypertension	EQ-Index	Mann–Whitney	3008.5	0.979

5) Partial Correlation Analysis

After adjustment for age and gender, HGS remained independently associated with EQ-VAS, confirming that functional strength contributes to perceived health beyond demographic influences (Table 4). Measures of upper-arm muscle mass (MAMC and MUAC) also retained weaker but significant associations with EQ-VAS. In contrast, BMI and SNAQ were no longer significant after adjustment, suggesting confounding effects in unadjusted analyses.

Table 4. Partial correlations between EQ-VAS and nutritional indicators (controlled for age & gender).

Variable	Partial r	p-value	Interpretation
BMI clean	0.104	0.156	Weak, non-significant positive link
HGS	0.252	0.0005	Significant positive correlation
MAMC	0.180	0.0138	Moderate positive association
MUAC	0.170	0.020	Moderate positive link
SNAQ	-0.096	0.192	Weak, non-significant negative link

6) Multivariable OLS Regression For EQ-VAS

In the multivariable OLS model, HGS and age emerged as independent predictors of EQ-VAS (Table 5). Greater grip strength was associated with higher self-rated health, while increasing age was associated with lower EQ-VAS scores. Other nutritional indicators did not contribute significantly once functional strength and age were included.

Table 5. OLS Regression Predicting EQ-VAS

Predictor	Coefficient (β)	SE	t	p	95% CI
Constant	61.75	8.09	7.64	<0.001	45.8–77.7
Age	-0.14	0.07	-2.01	0.046	−0.28–−0.00
HGS	0.32	0.14	2.33	0.021	0.05–0.60
BMI	-0.01	0.33	-0.02	0.988	−0.66–0.65

MAMC	0.38	0.74	0.51	0.609	−1.07–1.83
MUAC	0.15	0.71	0.21	0.838	−1.26–1.55
SNAQ	-0.47	0.42	-1.11	0.269	−1.30–0.36

The model demonstrated acceptable fit with modest explanatory power (adjusted $R^2 = 0.09$). Diagnostic evaluation supported the adequacy of the linear regression assumptions. Visual inspection of the residuals versus fitted values plot showed a random scatter of residuals around zero with no evidence of heteroscedasticity or systematic model misspecification (Figure 2).

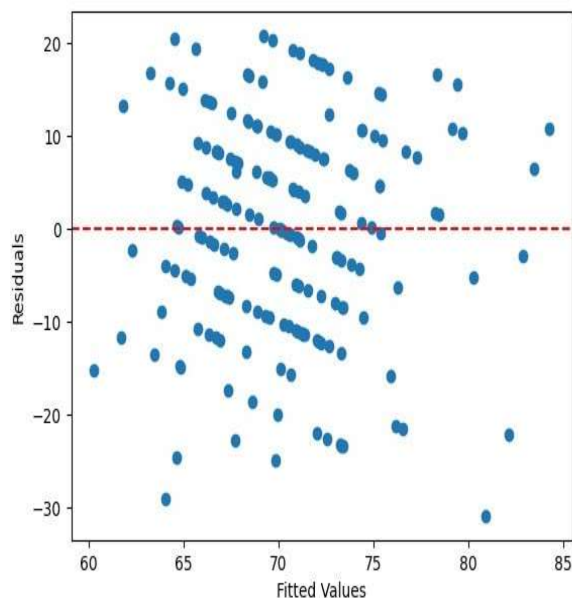

Figure 2. Residuals vs fitted values (OLS model)

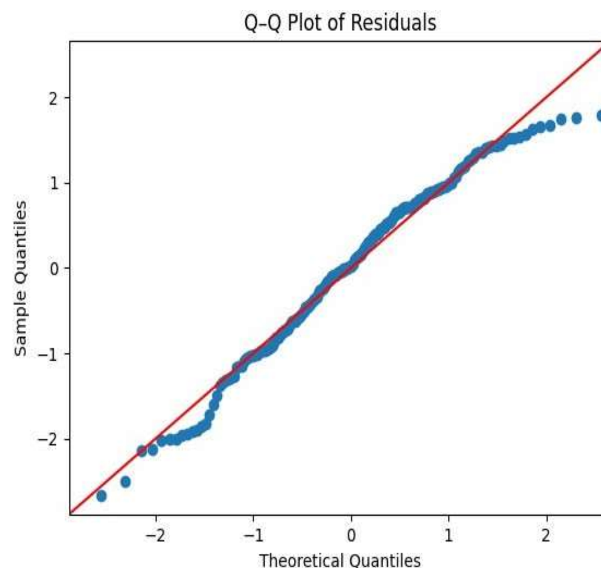

Figure 3. Q–Q plot of Standardized residuals(OLS model)

In addition, the Q–Q plot of standardized residuals demonstrated approximate normality, with only minor deviations at the distributional tails (Figure 3). These findings were consistent with formal diagnostic testing and indicated acceptable model fit.

7) Beta Regression Predicting EQ-Index

In the beta regression model, HGS was the only significant predictor of EQ-Index, indicating that functional strength also influences preference-based utility scores (Table 6). SNAQ showed a trend toward association but did not reach statistical significance. Age, gender, diabetes, and hypertension were not independently associated with EQ-Index values.

Model diagnostics indicated an adequate fit. The Q–Q plot of quantile residuals showed close alignment with the theoretical distribution, with no marked deviations suggestive of misspecification or influential observations (Figure 4). The estimated precision parameter suggested moderate dispersion of EQ-Index values, consistent with the observed variability in health utility within the cohort.

Table 6. Beta Regression Predicting EQ-Index

Predictor	**Estimate**	**Std. Error**	**z**	**p**
(Intercept)	1.505	0.433	3.48	0.0005
Gender (Male)	-0.013	0.182	-0.07	0.941
Age	-0.004	0.006	-0.64	0.522
HGS	0.026	0.012	2.13	0.033
Diabetes	-0.081	0.159	-0.51	0.609
Hypertension	0.091	0.177	0.52	0.607
SNAQ	-0.055	0.034	-1.62	0.105
φ (Precision)	4.127	0.439	9.39	<0.001

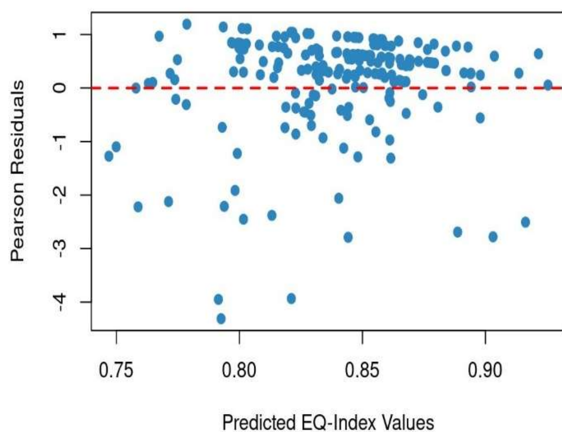

Figure 4. Residuals vs predicted EQ-Index values (Beta regression)

Discussion

According to both global self-rated health (EQ-VAS) and health utility scores (EQ-5D-Index), the current cross-sectional analytical study suggests that hand-grip strength (HGS) is the most reliable and clinically significant predictor of health-related quality of life (HRQoL) among Indian patients receiving maintenance hemodialysis (MHD).

1) Hand-Grip Strength as a Determinant of HRQoL

HGS was the only predictor that maintained statistical significance across both multivariable models among a wide range of demographic, nutritional, anthropometric, and clinical variables, showing the vital part that functional capacity has in influencing perceived health and utility-based quality of life in this population.

Based on the multivariable OLS regression model, there was also a significant positive correlation between HGS and EQ-VAS (β = 0.32, p = 0.021). Similarly, HGS was the only variable that independently predicted health utility in the Beta regression model, which was specifically selected to account for the skewed and bounded nature of EQ-Index data (β = 0.026, p = 0.033). The robustness of the result is further demonstrated by the consistency of this association across two different HRQoL constructs.

These findings are consistent with earlier studies demonstrating the fact that lower health-related quality of life in hemodialysis patients is independently linked to decreased muscle strength.[35] Additionally, Isoyama et al. found that even after adjusting for multiple confounders and maintaining muscle mass, dialysis patients with lower muscle strength had a higher risk of all-cause mortality.[36]

2) Nutritional Indicators and HRQoL

Anthropometric measures in this current study, including triceps skinfold thickness (TSF), mid-arm muscle circumference (MAMC), and mid-upper arm circumference (MUAC), displayed significant correlations with EQ-VAS in bivariate and partial correlation analyses. These trends, however, lost statistical significance in multivariable models, indicating that functional performance may act as a mediating factor in their impact on HRQoL. Similar conclusions were reported by Feroze et al., who discovered that, Although nutritional markers are associated with hemodialysis patient outcomes, their relationship with quality of life is less strong than that of functional and inflammatory parameters.[37] This is consistent with the more general idea that muscle strength is a more complete measure of a patient's health since it reflects both neuromuscular function and nutritional reserve.

SNAQ scores demonstrated an inverse association with EQ-Index in bivariate analysis and a non-significant trend in the beta regression model. This finding suggests that nutritional risk may influence HRQoL indirectly, potentially through its impact on muscle strength and physical functioning. These results are consistent with prior literature indicating that screening tools for malnutrition often correlate with HRQoL but may not independently predict outcomes once functional parameters are considered.[38-40]

3) Age and Divergence Between EQ-VAS and EQ-Index

In the OLS model, age showed a slight but significant negative correlation with EQ-VAS (β = −0.14, p = 0.046), but there was also no significant correlation with EQ-Index. While there was no apparent association for the EQ-Index, growing older was independently linked to lower EQ-VAS scores in the current study. This variation implies that preference-based utility measures and subjective self-rated health may capture distinct facets of maintenance hemodialysis patients' perceptions of their health.

Although the strength and consistency of these associations vary across cohorts, studies conducted in dialysis populations outside India have consistently reported a decline in health-related quality of life with advancing age, affecting both EQ-VAS and EQ-5D utility scores.[41] Population-based EQ-5D normative studies have also demonstrated an age-related decline

8) Model Diagnostics

Diagnostic evaluation confirmed that both regression models met underlying assumptions . Residuals were centered around zero, variance patterns were stable,

and no problematic multicollinearity or influential observations were identified. Visual inspection of diagnostic plots (Figures 2–4) supported overall model adequacy.

in EQ-VAS scores, whereas changes in utility scores are often smaller, less linear, or attenuated, possibly reflecting adaptation to chronic health states.[42]

However, data examining these age-related variations among Indian hemodialysis patients remain limited. The present findings therefore suggest that, within this study population, EQ-VAS may be more sensitive than EQ-Index in capturing subjective age-related declines in perceived health status.[43] From a public health perspective, these findings are particularly relevant in low- and middle-income countries such as India, where the burden of CKD continues to increase despite limited healthcare resources.[44-45]
Overall, as evidenced by its consistent correlation with both EQ-VAS and EQ-Index, the study supports growing evidence that functional performance measures particularly handgrip strength may be a better predictor of HRQoL among dialysis patients than traditional anthropometric indicators.

Clinical Implications
Given these finding, routine evaluation of hand-grip strength in hemodialysis unit may be used as an inexpensive, straight forward functional screening method to identify patients who may be at risk for lower HRQoL. Even if conventional anthropometry stays unchanged, interventions targeted at increasing muscle strength through physical activity, intradialytic exercise, resistance training, and nutritional optimization , may result in significant improvements in quality of life. Additionally, these functional test may also be used in conjunction with nutritional screening instrument like SNAQ and body-composition indices to give a more comprehensive assessment.

Future Direction
Longitudinal studies are needed to monitor changes in HGS, nutritional status, and HRQoL over time, as well as to evaluate interventions designed to improve nutrition and muscle strength. Multicenter studies conducted across diverse dialysis settings in India would improve the generalizability and predictive accuracy of HRQoL models. Furthermore, the inclusion of psychosocial, access-related, and dialysis-specific variables may enhance the explanatory power of future models.

Strength and Limitation
The strengths of this study include the comprehensive evaluation of nutritional, functional, anthropometric, and clinical variables; the use of both EQ-VAS and EQ-5D utility outcomes; and the rigorous diagnostic assessment of regression models. However, the cross-sectional study design limits the ability to establish causality or assess temporal changes. In addition, recruitment from single center may limit the generalizability of the findings to other dialysis settings in India. Furthermore, psychosocial factors, dialysis adequacy parameters, and inflammatory markers were not included and may have confounded the observed associations. Lastly, the comparatively low explanatory power (pseudo-R^2) suggests that additional unmeasured factors such as depression, dialysis access complications, and social determinants of health may further contribute to variations in HRQoL.

Conclusion
In this single-center study of maintenance hemodialysis patients in India, hand-grip strength (HGS) emerged as the most reliable and clinically significant predictor of health-related quality of life (HRQoL). Although anthropometric measures and nutritional screening parameters demonstrated significant bivariate associations with HRQoL, these relationships were substantially attenuated after adjustment for functional capacity and demographic factors. In multivariable analyses, HGS remained the only variable significantly associated with both EQ-VAS and EQ-5D-5L utility scores, while older age was independently associated with lower self-rated health as measured by EQ-VAS.

These findings support the inclusion of routine HGS assessment in dialysis unit evaluations as a simple and low-cost screening method for identifying patients at risk of impaired quality of life. Interventions aimed at preserving or improving muscle strength such as intradialytic exercise, home-based resistance training programs, and nutritional optimization should be prioritized and further evaluated for their potential impact on HRQoL and related clinical outcomes.

Several limitations should be considered when interpreting these findings. The cross-sectional design captures associations at a single point in time and does not permit causal inference. In addition, psychosocial factors, dialysis adequacy parameters, and inflammatory biomarkers were not assessed and may account for additional variability in HRQoL outcomes. Nevertheless, the present findings provide a strong foundation for future research, including longitudinal studies evaluating changes in HGS and HRQoL over time, multicenter investigations across diverse dialysis settings in India to improve the generalizability of predictive models, and randomized or quasi-experimental studies assessing the effectiveness of strength-preserving interventions.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this study.

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