Review article

Estimates of malnutrition associated with chronic kidney disease patients globally and its contrast with India: An evidence based systematic review and meta-analysis

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ABSTRACT

Background: Malnutrition is one of the most serious complications of chronic kidney disease due to its devastating consequences in terms of quality of life, morbidity, hospitalization and mortality. This study aims to evaluate the prevalence of malnutrition among chronic kidney disease patients globally and its contrast with India.

Methods: Articles reporting the prevalence of malnutrition associated with CKD patients were retrieved from PubMed/Medline, ScienceDirect, Cochrane library & Google scholar. The quality assessment of studies was performed by using Newcastle-Ottawa scale. The pooled prevalence was reported with effect size considering the random effect model using comprehensive meta-analysis version 2.0.

Results: The results from 61 observational studies containing 21119 patients are presented. The global prevalence of malnutrition associated with CKD was found to be 42.7%. The prevalence of malnutrition in peritoneal dialysis group was found to be (45.3%, 95%CI; 29.5–62.1) higher as compared to hemodialysis group (43.1%, 95% CI; 32.2–54.7) followed by non-dialysis group (38.5%, 95% CI; 24.0–55.3). The prevalence of malnutrition in India was found to be 56.7% (95% CI: 42.4–70.0%). Males were predominantly affected with malnutrition as compared to females. The prevalence in India was reported to be higher as compared to all the included countries, except Mexico and Jordan.

Conclusions: Globally, India occupies the highest share of prevalence studies followed by Brazil. The geographical stratification of results revealed that the highest prevalence of malnutrition was observed in India except Mexico and Jordan. Given the high prevalence of malnutrition among CKD patients, evaluation of interventions for malnutrition with patient centered outcomes are warranted.

1. Introduction

Chronic kidney disease is a global public health problem. Patients suffering from chronic kidney disease have various comorbidities such as hypertension, diabetes, inflammation etc. It is also reported that chronic kidney disease is associated with a high economic cost to health systems and is an independent risk factor for cardiovascular disease.

Nutrition is profoundly found to be altered in chronic kidney disease as the result of deranged renal regulation of systemic homeostasis.¹ Malnutrition is one of the most serious complications of chronic kidney disease. Its consequences, particularly for patients on hemodialysis as well as on continuous ambulatory peritoneal dialysis, are devastating in

terms of quality of life, morbidity, hospitalization and mortality.^{2,3}

Earlier, nutritional status was usually assessed by measuring anthropometric variables. These anthropometric variables were measured by different methods including dual-energy X-ray absorptiometry or bioelectrical impedance analysis, and total body nitrogen. Total body nitrogen quantifies the body's protein content and is considered the gold standard for assessing the nutritional status of patients with end stage renal disease.

Currently, nutritional status is assessed by employing noninvasive techniques which involve using validated tools or questionnaire. Different tools available in the open domain are; subjective global assessment tool (SGA), malnutrition inflammation score (MIS), mini nutritional assessment tool (MNA), and subjective global nutritional

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Abbreviations

CMA	Comprehensive Meta-Analysis
CKD	Chronic Kidney Disease
ESRD	End Stage Renal Disease
MIS	Malnutrition Inflammation Score
MNA	Mini Nutritional Assessment tool
NOS	Newcastle Ottawa Scale
RevMan	Review Manager
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	The International Prospective Register of Systematic Reviews
SGA	Subjective Global Assessment tool
SGNA	Subjective Global Nutritional Assessment

assessment (SGNA). The best method to evaluate nutritional status includes a composite approach using both anthropometric measurements and nutritional assessment tools.

The management of chronic kidney disease complications are more challenging as it goes unnoticed. Early screening and identification is an important determinant for the timely management of complications like malnutrition associated with chronic kidney disease.

This work is an attempt to evaluate the pooled prevalence of malnutrition among chronic kidney disease patients globally and its contrast with India. Pooled prevalence was also estimated with respect to patient type (hemodialysis, peritoneal-dialysis and non-dialysis), region (country-wise breakup), assessment tool and gender.

2. Methods

2.1. Search strategy and selection criteria

This systematic review and meta-analysis was conducted in accordance with the Meta-Analysis of Observational Studies in Epidemiology guidelines⁴ and the protocol has been published (PROSPERO: CRD42021226344) in Prospero registry for systematic review and Meta-analysis. The search strategy was discussed with an expert for optimum inclusion sensitivity. A systematic literature search was conducted by using following repositories: PubMed, Cochrane library, Google scholar, science direct databases to identify the articles published during last 30 years (1990–2020). The manual search was also performed to find out the relevant articles.

The electronic search on PubMed/Medline database was performed using advanced filters and Medical Science Heading (MeSH) terms: ("Prevalence" [MeSH Terms] OR "Prevalence studies" [Title/Abstract] OR "Prevalence Study" [Title/Abstract] OR "studies prevalence" [Title/Abstract] OR "study prevalence" [Title/Abstract]) AND ("Malnutrition" [MeSH Terms] OR "undernutrition" [Title/Abstract] OR "Malnourishment" [Title/Abstract] OR "overnutrition" [MeSH Terms]) AND ("renal insufficiency, chronic" [MeSH Terms] OR "Chronic Renal Insufficiencies" [Title/Abstract] OR "Chronic Kidney Diseases" [Title/Abstract] OR "Chronic Kidney Insufficiency" [Title/Abstract] OR "renal disease chronic" [Title/Abstract] OR "disease chronic renal" [Title/Abstract]). [Supplementary file A]

The relevant articles were screened in full text to check for eligibility criteria. Cross-referencing from all the selected articles were done to check for other similar articles.

2.2. Inclusion and exclusion criteria

All the observational studies published between 1990 and 2020 from any study setting population, with the age group of 18 years or more

having chronic kidney disease associated malnutrition reported by using any nutritional assessment tool and/or anthropometric measurements were included. The studies with unresolved discrepancies in data or the date repeated in different studies or the nutritional status were not reported or having language barrier were excluded from the study.

2.3. Study outcome

The study outcomes were reported as effect size, which is the pooled prevalence of malnutrition among chronic kidney disease patients globally along with India based on patient type (non-dialysis, hemodialysis, peritoneal-dialysis, & unspecified dialysis), region (country wise break-up), assessment tool and gender.

2.4. Data extraction and quality assessment

Initially, the articles were screened for eligibility and the data extraction based on journal, title, abstract, and publication year was done by two authors [IR and AB] independently. The authors [PT, SD & SJ] were engaged in resolving the discrepancies in the study and data (if any). The articles were then reviewed for the full text based on study population, outcome variable, study location etc. by the authors [IR and AB]. The articles with incomplete data were excluded. Incomplete data covered poorly written results, and absence of desired variables.

The extracted data was maintained in Microsoft excel spreadsheet under column headings: title of the study, journal name, year of study, study design, 1st author's name, study location, nutritional assessment tool used, sample size, numbers in normal nutritional status category, number of malnourished cases (mild/moderate and severe malnutrition).

In this review, the quality of studies was evaluated by using the Newcastle-Ottawa quality assessment form.⁵ This scale is golden standard for the prevalence based meta-analysis. Only studies with quality score greater than 50% were included in the analysis. The disagreement between the authors with respect to quality control was resolved by formal consensus from all the authors.

2.5. Statistical analysis

The software package Comprehensive Meta-analysis version 2.0 and Review Manager (RevMan Cochrane Collaboration 5.4) was used to perform the statistical analysis. The random effect (RE) model⁶ was used to determine the pooled estimate and subgroup analysis at 95% confidence interval. The 95% confidence intervals are reflected in brackets, as applicable, in the results section.

The value of I squared statistic (I^2 greater than 50% & Q test ($p < 0.10$) was determined to assess the variability due to heterogeneity. The publication bias was evaluated utilizing the funnel plot and eggers regression intercept. The presence of asymmetry reflects publication bias, whereas symmetry reflects absence of publication bias.

The pooled prevalence was reported in "effect size". Subgroup analysis for gender (male and female), patient type (hemodialysis, peritoneal dialysis, non-dialysis & unspecified dialysis), region (comparison within India), assessment tool used (SGA, MIS, Anthropometry) and geography (comparison of prevalence in India with other countries) were performed

Meta-regression analysis was performed in comprehensive meta-analysis to assess the effect of different covariates (gender, patient type, mean age and geography) in predicting the prevalence of malnutrition at 95% confidence interval ($p < 0.05$).

3. Results

The electronic search yielded 429 articles from MEDLINE/PubMed and 46 articles from other data sources after finalizing the search strategy [Fig. 1]. A total of 475 articles were screened for the title and

Fig. 1. Systematic review PRISMA flowchart of research articles screened, excluded and included in meta-analysis.

Source: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7):e1000097.

abstract, 380 articles were excluded based on incomplete data, language other than English, children age group, duplicates and less quality. The remaining 95 articles were screened for full text, out of these 34 articles were again left out due to insufficient data, language barrier, duplicates and children age group. A total of 21119 samples from 61 studies were potentially eligible for quantitative analysis. The **Supplementary File A** represents the relevant details of all studies.

The patients who suffered with chronic kidney disease were evaluated for malnutrition. The study outcomes were reported as effect size, which is the pooled prevalence of malnutrition among chronic kidney disease patients globally along with India based on patient type (non-dialysis, hemodialysis, peritoneal-dialysis, & unspecified dialysis), region (country wise break-up), assessment tool and gender.

3.1. Global scenario

The pooled estimate of prevalence was found to be 0.427 with 95% CI, which means that the mean global prevalence of malnutrition among CKD patients is 42.7%. These studies were sampled from a universe of possible studies defined by certain inclusion/exclusion criteria as outlined in the methodology.^{7-15, 16-24, 25-36, 37-49, 50-67} The confidence interval for the prevalence was found to be 0.352–0.506, which indicates that the mean prevalence in the universe of studies could fall anywhere

in the range 35.2%–50.6%. The I^2 value was found to be 98.58 which shows that 98% of the variance in observed rates reflect variance in true rates rather than sampling error. The heterogeneity was decreased when sub-group analysis was performed. For the studies reported from India, I^2 was found to be 95%. **Fig. 2** represents the pooled prevalence of malnutrition among chronic kidney disease patients globally.

3.2. Subgroup analysis

Subgroup analysis was performed for multiple covariates [Table 1]. The prevalence breakdown was provided in all sixty-one studies based on patient type. The prevalence of malnutrition in peritoneal dialysis group (thirteen studies) was 45.3% (95% CI; 29.5–62.1) higher as compared to hemodialysis group (twenty-nine studies) 43.1% (95% CI; 32.2–54.7) followed by non-dialysis group (thirteen studies) 38.5% (95% CI; 24.0–55.3). The pooled prevalence of malnutrition in non-specified dialysis group was found to be 44.8% (95% CI; 23.0–68.8).

The geography specific prevalence was examined in fourteen countries with most of the studies reported from India, Brazil, Nigeria, Iran and China etc. [Table 2]. Geographical areas with more than one report were pooled using random effects models. In India, the pooled prevalence of malnutrition among chronic kidney disease patients was found to be 56.7% (95% CI; 42.3–70.1) for the nine studies.⁷⁻¹⁵ In

Fig. 2. Global prevalence of malnutrition among chronic kidney disease patients.

(Quality is described by Newcastle Ottawa Scale [NOS] Score, Event rate describes the pooled prevalence, CI as confidence interval, Red box at the bottom indicates total pooled prevalence).

Brazil,^{39,40,17,41,18} it was found to be 26.7% (95% CI; 13.8–45.3) and in China,^{42,43,19} it was found to be 37.9% (95% CI; 18.5–62.2).

The gender specific prevalence of malnutrition among chronic kidney disease patients was examined in twenty-five studies.^{16,24,8,11,12,15,25,36} The overall gender-specific prevalence was found to be 40.1% (28.7–52.7%). In case of male patients, the pooled prevalence of malnutrition was found to be higher 20.7% (95% CI; 14.2–29.3) than female patients 16.4% (95% CI; 11.6–22.6%).

The breakdown of prevalence analyzed on the basis of “assessment tool” used. The prevalence reported by using subjective global assessment tool^{36,38,40,43,17,18,45,46,21,25,48,28,11,7,15,9,14,50,51,53,27,28,55,57,30,38,59,33,60,34,35,63,66,67} was found to be 42.0%, while using Anthropometric measurements^{20,24,49,10,26,56,29,31,32,62,65,36} and Malnutrition inflammation^{39,47,12,13,52,54,61} score the prevalence was found to be 45.8%, and 40.6%.

The univariate and multivariate meta-regression of prevalence and covariates (mean age, patient type, assessment tool used, gender, geography) was performed to find out the effect of covariates on prevalence. The mean population age, & geography were found to be statistically significantly associated with the prevalence of malnutrition among chronic kidney disease patients ($p < 0.032$, $R^2 = 0.21$ & $p = 0.004$, $R^2 = 0.55$).

3.3. Indian scenario

India comprises highest number of the studies (9) on malnutrition associated with chronic kidney disease across the globe [Fig. 3]. The pooled estimate of prevalence in India was found to be 56.7% with 95% CI ranging between 42.4% and 70.0%.⁷⁻¹⁵

3.4. Subgroup analysis

Subgroup analysis was performed for different patient groups (hemodialysis, peritoneal-dialysis, non-dialysis & non-specified dialysis) [Table 2]. The pooled prevalence in peritoneal-dialysis group⁷⁻⁹ {69.2% ranging from 42.7% to 87.2%} was found to be higher than the hemodialysis group^{13,14} {56.8% ranging from 25.3% to 83.6%}, followed by non-dialysis group¹⁰⁻¹² {44.2% ranging from 20.7% to 70.6%}. The non-specified dialysis group¹⁵ had a mean prevalence of 53.1% ranging from 14.1% to 88.6%.

The sex specific prevalence of malnutrition among chronic kidney disease patients was reported in only four studies. The overall pooled prevalence was found to be 50.8% with a range of 26.9%–74.3%. The male patients with chronic kidney disease were (32.7%) considerably higher affected with malnutrition than female patients (16.3%).^{7,8,12,15}

Table 1

Subgroups analysis based on gender, patient type, geography and assessment tool according to random effect model - a global scenario.

Sub-groups	N	Pooled Prevalence [R]	Sample Size	Normal (N)	Mild-Moderate (N)	Severe (N)	Malnutrition (N)
Gender							
M	25	20.7% (14.2–29.3%)	14401	11608	986	1807	1539
F	25	16.4% (11.6–22.6%)	14401	11608	986	1807	1244
Patient Type							
HD	29	43.1% (32.2–54.7%)	13581	10880	1071	1630	2701
PD	13	45.3% (29.5–62.1%)	2135	1034	662	372	1034
ND	13	38.5% (24.0–55.3%)	2553	1730	250	573	823
NSD	6	44.8% (23.0–68.8%)	2850	1951	193	706	899
Geography							
India	9	56.7% (42.3–70.1%)	1443	239	480	424	904
Brazil	5	26.7% (13.8–45.3%)	1686	1378	153	155	308
Nigeria	4	35.0% (18.0–56.8%)	347	222	30	95	125
Iran	4	28.3% (14.2–48.6%)	1056	715	86	255	341
China	3	37.9% (18.5–62.2%)	690	422	200	68	268
Italy	3	38.1% (18.5–62.5%)	783	482	28	273	301
Jordan	3	61.7% (37.4–81.3%)	575	220	323	32	355
Mexico	3	73.7% (50.4–88.6%)	318	94	106	118	224
Australia	3	19.7% (7.8–41.6%)	488	117	77	60	137
South Korea	3	31.2% (14.3–55.2%)	1135	935	156	44	200
Romania	2	19.7% (6.5–46.1%)	230	179	40	11	51
Sweden	2	54.2% (25.8–80.2%)	237	107	17	113	130
Morocco	2	48.2% (20.7–76.9%)	166	64	26	76	102
Europe	2	18.2% (6.2–42.7%)	8534	3835	18	646	664
Assessment Tool							
SGA	40	42.0% (33.9–50.7%)	9256	5852	1723	1681	3404
ANP	12	45.8% (30.7–67.8%)	10465	9138	162	1165	1327
MIS	7	40.6% (22.4–61.7%)	1046	481	150	415	565

M: Male, F: Female. HD: Hemodialysis, PD: Peritoneal Dialysis, ND: Non Dialysis, NSD, Non Specified Dialysis. ANP: Anthropometry, SGA: Subjective Global Assessment, MIS: malnutrition Inflammation Score. Column 3 (): Prevalence range - lower and upper limit.

Table 2

Subgroups analysis based on gender, patient type, geography and assessment tool according to random effect model – an Indian scenario.

Sub-groups	N	Pooled Prevalence [R]	Sample Size (N)	Normal (N)	Mild-Moderate (N)	Severe (N)	Malnutrition (N)
Gender							
M	4	32.7% (18.5–51.0)	696	291	170	235	280
F	4	16.3% (10.8–23.9)	696	291	170	235	125
Patient Type							
HD	2	56.8% (25.3–83.6)	308	112	51	145	196
PD	3	69.2% (42.7–87.2)	622	167	384	71	455
ND	2	44.2% (20.7–70.6)	432	222	2	208	210
Geography							
UP	3	65.6% (38.6–85.2)	542	168	192	182	374
AP	2	30.8% (10.2–63.6)	308	112	51	145	196
TN	2	56.8% (25.3–83.6)	210	148	43	19	62
Assessment Tool							
SGA	6	59.6% (40.0–76.5)	1006	347	454	205	659
ANP	2	60.0% (17.6–91.3)	337	152	24	161	185

M: Male, F: Female. HD: Hemodialysis, PD: Peritoneal Dialysis, ND: Non Dialysis. ANP: Anthropometry, SGA: Subjective Global Assessment. UP: Uttar Pradesh, AP: Andhra Pradesh, TN: Tamil Nadu.

Column 3 (): Prevalence range - lower and upper limit.

The breakdown of prevalence was also provided in all the regions where the studies have been conducted. The Uttar Pradesh^{7,8} 65.6% (38.6–85.2%) region had a higher pooled prevalence of malnutrition as compared to Chennai^{13,14} 56.8% (25.3–83.6%) followed by Andhra Pradesh^{12,15} 30.8% (10.2–63.6%). The comparison was possible for only regions who have reported more than two studies. The mean prevalence in Rohtak, Haryana¹⁰ was found to be 60.0% (18.0–91.1%) and 74.9% in Mumbai, Maharashtra⁹ (30.9–95.2%).

This was further analyzed on the basis of “assessment tool” used. The pooled prevalence reported by using subjective global assessment tool^{7–12} and anthropometric measurements¹⁵ was found to be 59.6% and 60.0%. Based on malnutrition inflammation score^{13,14} the prevalence was found to be 45.9%.

3.5. Quality assessment

The methodological quality of studies was assessed by Newcastle Ottawa Scale.⁶ All the 61 studies were found to be of good quality ranging from 6 stars to 10 stars (Fig. 2). Sixteen studies scored 7 stars, twenty-seven studies scored 8 stars, nine studies scored 9 stars, eight studies scored 6 stars and only one study scored 10 stars.

3.6. Heterogeneity and publication bias

The included sixty-one studies were assessed for heterogeneity and publication bias. Accordingly, the analysis showed a substantial heterogeneity of Q test ($p < 0.001$) and I^2 statistic ($I^2 = 98.5\%$). The funnel plot for publication bias showed no symmetry while the Egger's test for a

Fig. 3. Prevalence of malnutrition among chronic kidney disease patients in India.

Quality is described by Newcastle Ottawa Scale Score, Event rate describes the pooled prevalence, CI as confidence interval, Red box at the bottom indicates total pooled prevalence).

regression intercept gave a p-value of less than 0.001 verifying the presence of bias. There was no change in heterogeneity while assessing for the subgroups like gender ($I^2 = 99.0\%$), and geography ($I^2 = 98.6\%$), though it has been found to be slightly increased.

3.7. Sensitivity analysis

Sensitivity analysis of the sixty-one studies was done to test the effect of each study on the pooled result by excluding each study step by step (i.e based on sixty studies) and the results showed that one study (Marjike et al., 2018) was relatively the prime determinants higher heterogeneity. The I^2 statistic changes from $I^2 = 98.5\%$ to $I^2 = 97.2\%$ after removing Marjike et al. study. There was no change in heterogeneity while performing sensitivity analysis for other studies.

3.8. Meta regression

The Univariate meta-regressions of malnutrition prevalence and covariates (mean age, & geography) was undertaken to determine the effect of covariates on prevalence. The mean population age, given in 57 of 61 populations was significantly associated ($p = 0.03$, $R^2 = 0.21$) as was geography ($p < 0.001$, $R^2 = 0.55$), with the prevalence of malnutrition among chronic kidney disease patients. No significant association was observed for gender and patient type. Here R^2 is used to quantify the proportion of variance likely to be explained by different kinds of covariates or interventions. This index (R^2) is intuitive as it can be interpreted as a ratio, with a range of 0–1, or of 0%–100%.

4. Discussion

This meta-analysis comprises 61 observational studies and provides estimated pooled prevalence of malnutrition associated with chronic kidney disease in India and other countries. Globally, India occupies the highest share of prevalence studies 14.75% followed by Brazil 8.19%. The geographical stratification of results revealed that developing areas where economies are growing such as Mexico (73.7%), Jordan (61.7%), and India (56.7%) had higher rates of CKD associated malnutrition prevalence in comparison to areas which are developed such as Australia (19.7%), Europe (18.2%) etc. In India, the prevalence of malnutrition was also higher as compared to its neighboring countries like China (37.9%), & Iran (28.3%), even it was higher all across Asia. The cultural, religious and ecological diversity of India poses a challenge to evaluate nutritional status among different patient populations. This wide variation may be due to varying number of studies conducted and reported.

Also, the existing literature stated that the different socio-economic status, level of education and poor approach to medical facility may be the possible reason. However, the exact cause of malnutrition associated with chronic kidney disease are complex and multifactorial.

This review also reflects that a significant variation of prevalence exists on the basis of patient type such as patients on hemodialysis, peritoneal dialysis and non-dialysis. In case of non-dialysis chronic kidney patients, Prasad et al. from India have reported that the high prevalence could be due to late medical attention, severe uremic symptoms with poor appetite and decrease in dietary food intake.¹¹ Prakash et al. had reported elevated serum total iron binding capacity (due to iron deficiency & low serum transferrin level) in patients with malnutrition but without appearance of signs and symptoms. They have also reported increase in serum triglyceride levels in chronic kidney disease patients with malnutrition, which can further heighten the already increase cardiovascular risk in chronic kidney disease patients.³² The findings related to causes of malnutrition associated with chronic kidney disease reported by Agaba et al. from Nigeria were in consonance with the findings of Prakash et al.

In case of hemodialysis patients, Anupama et al. (after stratifying the severity of malnutrition according to the stages of chronic kidney disease) have found that malnutrition is higher in progressive stages along with patients having low-socio economic status. Ramalakshmi et al. reported carnitine deficiency among 64.3% dialysis population in India.⁶⁸

The peritoneal dialysis patients are known to have decreased appetite and early satiety. The findings of Oreopoulos et al. and Von Baeyer et al. confirm that uremia, absorption of glucose and abdominal distension by the dialysate fluid are the possible causes for the loss of appetite.⁶⁹

Around 40% of the studies reported gender specific prevalence of malnutrition among CKD patients and the results highlighted considerably higher prevalence among male patients. However, these findings can't answer why this may occur. We can only speculate that these findings may be partially explained by selection bias inherent within the studies due to a different age demographic for the two sexes. Alternatively, it may be due to complex factors in the disease pathology that are not captured within the studies.

This meta-analysis also provided the prevalence of malnutrition associated with CKD on the basis of different assessment tool available. Globally, the pooled estimate of malnutrition prevalence was found to be almost in the same range such as 42.0% (SGA), 45.8 (ANP) and 40.6% (MIS). However, in Indian scenario the subgroup analysis based on assessment tools was not possible for all the tools reported in this study.

The pooled estimate of prevalence was only possible for SGA (59.6%) and ANP (60.0%) which has been found to be quite similar. Only one study has reported prevalence by using malnutrition inflammation score (MIS).

Our principal finding is that the overall pooled prevalence of malnutrition associated with chronic kidney disease globally falls anywhere in between 35.2 and 50.6%. As chronic kidney disease progresses to higher stages the patient needs to titrate the diet and daily food intake because of compromised kidney's filtration ability. So it is quite apparent, malnutrition among chronic kidney disease patients is mostly because of treatment forced restrictions in the diet and insufficient food intake (due to poor appetite).

This meta-analysis of malnutrition prevalence in patients with chronic kidney disease provides more precise evidence-based estimates than previously reported, which credibly illustrate the commonness of this complication in patients with hemodialysis, peritoneal dialysis and non-dialysis. Our results also explored that the prevalence of malnutrition is insufficiently studied in some scenarios, such as CKD stages, pediatric CKD population, & kidney transplant recipients.

4.1. Strength & limitations

The consideration of validated tools like subjective global assessment tool and malnutrition inflammation score could preserve the appropriateness of this review. This is the first country wide estimate of the prevalence of malnutrition among chronic kidney disease patients in India. The subgroup analysis shows differential prevalence based on gender, patient type, and geography.

The pooled prevalence was estimated from cross sectional, cohort and case control studies. The variation in the study design is a limitation beyond the control of the researchers. The random effect model prevalence estimates and New-castle Ottawa scale for quality assessment can be used with caution.

5. Conclusions

In conclusion, the study findings confirms that India occupies the highest share of prevalence studies, globally. In India, the pooled prevalence of malnutrition among chronic kidney disease patients was lower as compared to Mexico and Jordan; while it was considerably high as compared to Brazil, China, Iran etc. The male patients were considerably higher affected with malnutrition than the female patients.

Given the high prevalence of malnutrition among CKD patients, evaluation of interventions for malnutrition with patient centered outcomes are warranted.

Future research

The existing literature suggests that, malnutrition is poorly characterized among CKD stages, which offers a window for further research in this domain. Also large-scale interventional studies using validated tools should be performed to assess the effect of nutritional uptake programs on chronic kidney disease patient's nutritional status. Additionally, to further address the underlying mechanisms of malnutrition, there is an urgent need to map its risk factors.

Declaration of competing interest

The authors declare no conflict of interest exists.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cegh.2021.100855>.

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