Global Prevalence of Protein-Energy Wasting in Kidney Disease: A Meta-analysis of Contemporary Observational Studies From the International Society of Renal Nutrition and Metabolism

Global prevalence of protein-energy wasting (PEW) in kidney disease: a meta-analysis of contemporary cohort studies from the International Society of Renal Nutrition and Metabolism (ISRNM).

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ABSTRACT

The prevalence of protein-energy wasting (PEW) in kidney disease is poorly defined. We performed a meta-analysis of PEW prevalence from contemporary studies including more than 50 patients with kidney disease, published during 2000-2014 and reporting on PEW prevalence by subjective global assessment (SGA) or malnutrition-inflammation score (MIS). Data were reviewed throughout different strata: acute kidney injury (AKI), pediatric chronic kidney disease (CKD), non-dialyzed CKD 3-5, maintenance dialysis and kidney transplant (Tx). Sample size, period of publication, reporting quality, methods, dialysis technique, country, geographical region and gross national income were *a priori* considered factors influencing between-study variability. Two studies including 189 AKI patients reported a PEW prevalence of 60 and 82%. Two studies including 1067 Tx patients reported a PEW prevalence of 28 and 52%. Five studies including 1776 patients with CKD stages 3-5 reported PEW prevalence ranging from 11 to 54%. Finally, ninety studies from 34 countries including 16,434 patients on maintenance dialysis were identified. In studies on dialysis patients, the 25th-75th percentiles range in PEW prevalence was 28-54%. Large variation in PEW prevalence across studies remained even when accounting for moderators. Mixed-effects meta-regression identified geographical region as the only significant moderator explaining 23% of the observed data heterogeneity. No studies containing pediatric CKD patients were identified. We thus provide evidence-based ranges of PEW and conclude that PEW is a common phenomenon across the spectrum of acute and CKD. This, together with its well-documented impact on patient outcomes, deserves increased medical attention.

INTRODUCTION

The syndrome of protein-energy wasting (PEW) encompasses a number of nutritional and metabolic alterations that often coexists in patients with chronic kidney disease (CKD) and that result, collectively, in a progressive loss of body stores of protein and energy fuels (i.e. body muscle and fat mass)[1-3]. The consequences of PEW are many and important, with a negative impact on not only patients' prognosis, complications, management and quality of life, but on health economics. Despite this evidence, PEW is often undetected and untreated, not being considered a clinical priority. Lack of awareness as well as insufficient knowledge and training are possibly major obstacles. Increased awareness of PEW in kidney disease starts by recognizing its prevalence along the CKD spectrum

PEW prevalence in kidney disease patients is, to date, poorly defined. Reports often state wide and non-informative wide ranges such as 18-75%. The evaluation of PEW prevalence from existing CKD literature is hampered by multiple factors, including lack of standardized PEW definitions, variability of existing assessment tools, studies with small sample size and differences in the socioeconomic realities of the countries in which the studies took place. An evidence-based and more objective determination of PEW prevalence is necessary in order to weigh the magnitude of the problem, evaluate the need for increased medical attention and allocation of clinical resources/manpower, and allow assessment of expected PEW prevalence for study planning. The latter is important for both sample size determination for randomized controlled trials (RCTs) and for detectable effect sizes when utilizing existing records. For these purposes, we present, on behalf of the International Society of Renal Nutrition and Metabolism (ISRNM), a meta-analysis of the prevalence of PEW in contemporary cohort studies of patients with kidney disease. Such information may raise awareness and enhance the implementation of effective clinical service programs that address PEW in kidney disease at all levels of decision-making.

RESULTS

We identified 193 eligible original articles (see **Figure 1**). Upon consultation of their full-text, 92 studies were excluded due to: not fulfilling inclusion criteria (n=23), incorrect use of methods or no response to our email requests (n=20), different exposure definitions or PEW prevalence not possible to calculate from presented data (n=18), articles derived or presumably derived from the same patient material (n=16), data collection prior to year 2000 (n=7), report of mixed CKD populations (n=5) and inclusion criteria biasing estimates (n=3). The remaining 101 studies were included in a qualitative synthesis analysis and scored individually. In this step, we modified our initial protocol and decided to exclude 6 studies that used a semi-quantitative SGA scale. After completed study identification and selection, 95 studies were analyzed, including 2 studies of AKI patients, 2 studies of Tx patients, 5 studies of non-dialysis CKD patients, and 84 studies including maintenance dialysis patients (formally resulting in 90 separate estimates given that two studies[4, 5] included combined cohorts of HD and PD patients and a multi-national analysis[6] reported PEW prevalence in cohort from 5 different countries). No eligible study of pediatric CKD patients was identified. The complete dataset for analysis can be accessed along with the supplementary information to this study.

Studies including patients with acute kidney injury (AKI), kidney transplantation (Tx) and non-dialysis CKD patients stages 3-5 are described in **Tables 1 and 2, Parts A-C**, and their respective PEW prevalence data are depicted in **Figure 2.** The two studies including Tx patients[7, 8] (n=1067 patients) reported wide difference in PEW prevalence (28 and 52%, respectively). The prevalence of PEW among AKI studies[9, 10](n=189 patients) was higher, but again with broad variability between studies (60 and 82%, respectively).

Five studies included non-dialysis dependent CKD patients stages 3-5[11-15] (n=1776 patients). Four of those studies [11-14] used subjective global assessment (SGA) and reported PEW prevalence that ranged from 11 to 18%. One additional study[15] that used the malnutrition-inflammation score (MIS) reported a PEW prevalence of 54% for a combined estimate of 22.5% (95% C.I. 6.9-38%). However, the high ratio of true heterogeneity to total observed variation of I^2=98.5% (test for heterogeneity p<0.001) strongly suggests that more than random fluctuation is needed to explain this variability of PEW prevalence.

The remaining 90 studies/estimates included maintenance dialysis patients (including collectively 16434 patients) from 10 geographical regions (**Tables 1 and 2, Part D**), and this larger number of studies allowed further meta-analysis. The 34 countries that are represented by at least one study represent most but not all parts of the world, see **Figure 3**: 47(52%) studies come from Asia, followed by 20(22%) from Europe, 16(18%) from the Americas, 4(4.4%) from Oceania (Australia), and 3(3.3%) from Africa. Most studies, (n=65, 72%) included hemodialysis (HD)-patients and the remaining (n=25, 28%) included peritoneal dialysis (PD)-patients. Thirty-nine studies (43%) reported fewer than 100 patients, 36(40%) between 100 and 250 patients, and 15(17%) more than 250 patients. In 10 studies (11%), PEW was determined by MIS, and in 80(89%) studies by SGA. About half of the studies, 47(52%), came from high-income countries, 39(43%) from middle-income countries, and only 4(4.4%) from low-income countries. Most studies were reported/published between 2010 and 2014 (52 studies, 58%), followed by 28(31%) studies published between 2005 and 2009, and only 10 studies (11%) published between 2000 and 2004. The assigned quality index score was less than 5/8 for 52(58%) of the studies and greater than or equal to 5/8 for 38(42%) studies.

Studies of maintenance dialysis patients showed a large variation in PEW prevalence across countries and regions, and excess heterogeneity (I^2=97%, p <0.001) strongly indicating that simple pooled estimates would be inappropriate. The observed average PEW prevalence was 42% (raw prevalence across all studies irrespective of study size). Individual studies reported prevalence ranging from 9 to 98%, with half of the studies reporting a prevalence above 40% (median PEW prevalence 40%). The 25^{th}-75^{th} percentile range was 28-54% (**Figure 4**). This was similar in HD (range 9.2-81%; 25^{th}-75^{th} percentiles 28-56%; median 43%) and PD (range 16-98%; 25^{th}-75^{th} percentiles 32-49%; median 36%) studies, and dialysis modality was not a statistically significant factor for PEW prevalence (p = 0.915; see also **Supplemental information 3.1**).

Differences in PEW prevalence were not due to random fluctuation attributable to study size (p = 0.1; **Supplemental information 3.2**), method used (p = 0.2; **Supplemental information 3.3**), or the Gross National Income (GNI) of the associated country (p=0.4; **Supplemental information 3.4**) that might reflect on overall patient populations. Nor can the differences be "explained" by the quality of the study as described by our quality index score (p=0.9; **Supplemental information 3.5**) or the year of publication. Specifically, we did not see evidence for that more recent studies would start to agree more on overall PEW prevalence (p=0.3; **Supplemental information 3.6**). Visual inspection of an ordering of studies according to PEW prevalence did not suggest any noteworthy patterns as well (**Supplemental information 3.7**). In these analyses, no systematic variation of PEW prevalence emerged when studies were ordered by any of such variables, and not much light was shed on possible origins of these diverse PEW prevalence estimates. This was verified by our mixed-effects meta-regression analysis, where the only statistically significant fixed-effect was geographical region (p<0.001), which explained about 23% of the observed heterogeneity between the studies (**Supplemental information 4**). The residual heterogeneity remained very high in that model (I^2=96%, p<0.001), and these model-based best estimates are presented in **Supplemental information 4** together with the raw prevalence proportions for various grouping summaries in **Supplemental information 5.1-5.4**. We anticipate that these numbers might be helpful for planning of future studies in the respective areas.

DISCUSSION

This meta-analysis of PEW prevalence in patients with kidney disease provides more precise evidence-based estimates than previously reported, and which credibly illustrate the commonness of this syndrome in patients at all stages of kidney disease. We also found out that the prevalence of PEW is insufficiently studied in some scenarios, such as pediatric CKD or Tx. Finally, we found wide variability in the reported PEW estimates, which has implications in the design of future studies.

We identified five studies performed in patients with CKD stages 3-5[11-15] with a PEW prevalence range of 11-54%. This range, albeit broad, is in line with studies that described PEW by other definitions[16] and consistent with the observed gradually increasing prevalence in PEW as the severity of CKD worsens[16]. Most studies used SGA[11-14], and their reported PEW prevalences were lower than that reported by the only study using MIS[15]. Reasons for this discrepancy could lie in the between-study variability, but also in the fact that typically, MIS tends to report a larger proportion of PEW by considering hypoalbuminemia -which is almost ubiquitous in these patients- in its scoring. Further, we used a score cutoff based on mortality prediction, which is not necessarily the cutoff for best PEW diagnostic performance. The lack of a gold-standard for measuring PEW makes the determinations for such diagnostic cutoff difficult at present[17].

It has been noted that the burden of PEW features in Tx patients is similar to that of non-dialysis CKD patients with similar eGFR[18]. PEW may have not received sufficient attention in the scientific literature, as only two eligible studies were identified in our searches[7, 8]. The estimates of these two studies are rather different (28 and 52%), which suggests the need of further characterization of the PEW status in this population. It is possible that differences in health systems or clinical approaches to transplant recipients, and other factors such as racial or cultural differences may impact at this level. However, PEW features alike in other CKD patient populations, also impact on the outcome of kidney transplant recipients, such as mortality risk and allograft rejection[19], presence of anemia[20], risk of depression[21] and poor quality of life[22].

The main results of our work involve an abundance of studies including maintenance dialysis patients, which allowed further exploration and stratification. Our principal finding is that 28-54% of maintenance dialysis patients present with PEW. This estimate is based on the interquartile range of distribution of 90 studies and is the first evidence-based prevalence range of PEW reported for this patient population, offering more precision and emphasizing the burden of wasting alterations in these patients. Another important finding is our inability to provide moderators for PEW prevalence estimates in this patient population due to remaining high residual heterogeneity and diversity between the studies. We feel that our meta-analysis is large enough to conclude that neither the type of dialysis, nor PEW determination, a country's GNI, or an overall quality of the reported study "explains" the observed PEW prevalence variability. The only identified major contributor to the diverse PEW prevalence rates is geographical region, but this only explained about 23% of the observed heterogeneity between the studies.

Explanations for the high heterogeneity observed may lie in the subjectivity of the exposure, naturally affected by inter and intra-observed variability[23]. In addition, it may be affected by the individual healthcare professional's education, knowledge and experience, as well as on the approach used to define patients with PEW (that is, reporting of PEW by methods other than

SGA/MIS). We acknowledge that other potential modifiers such as dialysis vintage, access to a renal dietitian were not available in the majority of studies identified and could not be accounted for. Contrary to our expectations, GNI of the countries represented in our study did not differentiate studies with different PEW prevalence. A plausible explanation could be that studies identified in our searches are not representative of the reality of their respective countries. For instance, studies addressing PEW prevalence and outcomes may come from hospitals/centers with interest/awareness of this problem, and be taking more actions to detect/combat PEW than other centers in the same country. Studies deriving from developing countries and emerging economies may come from selected hospitals with the resources to perform these determinations, or that receive insured or financially affluent individuals not representative of the majority of the population in that country. We are not able to address this possible "representation bias", which in our analysis is simply absorbed into the remaining variability in the observed PEW prevalence. Similarly, we were not able to systematically assess specific enrollment criteria for published studies that may or may not explain some of the variability in the empirically observed PEW prevalence. A final consideration is that because most if not all CKD studies included clinically stable patients, the reported ranges would be, if anything, an underestimation of the true PEW prevalence.

Although several lines of evidence suggest that features of PEW exist in the pediatric CKD population, this syndrome seems to be less well characterized in children, as our study could not identify any eligible reports. As discussed elsewhere[24], characterizing PEW in children is challenging, and existing studies are biased by their small-sample size as well as inclusion of patients with generally early forms of CKD (where PEW is seldom encountered)[25]. Nonetheless, indicators of PEW tend to increase with decreasing GFR in CKD children, such as hypoalbuminemia and poor appetite[26]. It is possible that factors such as short stature and poor growth may be more relevant manifestations of PEW in children with CKD[26]. As in adults, PEW surrogates are important outcome predictors in CKD children, such as low serum albumin[27], low body mass index[28, 29] or growth failure[30].

Evaluating nutritional status is particularly difficult in AKI patients, with no single nutritional tool credited with enough sensitivity and specificity in this clinical context, similar to critically ill patients in general. Studies identified in our search used SGA, which, as an intrinsic limitation, cannot be used for repeated evaluations at short intervals of time; thus, its use is not to be recommended for monitoring short-term changes in nutritional status or to evaluate the immediate effects of nutritional support. Based on currently available evidence, PEW seems to be a frequent problem in AKI (60-82% PEW prevalence observed[9, 10]). Complementing these estimates, additional reports were excluded from our analysis but ought to be mentioned for contextualization: an Italian study reported severe malnutrition (SGA score C), in 36.8% of AKI in patients not requiring renal replacement therapy (RRT) and in 47.4% in AKI requiring RRT[31]. Further, 32.2% of consecutive cases of mechanically ventilated patients with AKI were severely malnourished[32]. PEW has adverse consequences in these patients, as the length of hospital stay, the risk of complications (sepsis, bleeding, arrhythmia, respiratory failure, etc.) and in-hospital mortality risk is significantly increased in AKI patients with PEW compared to AKI patients without PEW[33].

Our study has other limitations that need consideration, starting with the fact that the quality of our estimates depends on the evidence available to analyze. The study searches were not entirely

systematic, but instead initiated from the concerted effort of global experts in the topic. Nonetheless, we find it unlikely that we have missed studies so different from the included ones that would alter our conclusions. We recognize that both SGA and MIS are imperfect measures of PEW, and more so in children and AKI. The lack of gold-standard methods to diagnose a complex syndrome such as PEW precludes making definitive conclusions on this issue. We restricted our search to these two methods of nutritional assessment to allow comparison across studies; otherwise, PEW prevalence varies considerably depending on the assessment tools and cutoffs employed[34].

Clinically, we believe that our results are relevant to raise awareness on the importance of PEW for CKD patients, relatives and healthcare professionals; motivate the development of effective programs to implement PEW screening, planning and monitoring in healthcare centers; and justify the prioritization of this common complication in terms of resource allocation and utilization. From a research point of view, our findings also have implications with regard to required sample sizes in prospective studies or detectable effect sizes in retrospective studies or for secondary analyses of existing data. With the exception of Australia, no geographic region has a narrow range of plausible PEW prevalence conditional on the characteristics explored in our meta-regression analysis. Therefore, the entire range of historically observed and reported prevalence rates for a specific region/country should be considered when planning for a study in any of the included regions.

By providing reliable evidence-based estimates from contemporary studies, we conclude that PEW is an unacceptably prevalent complication across the spectrum of acute as well as chronic kidney diseases. This commonness of PEW deserves increased medical attention. Establishing proper PEW screening tools is an important starting point for improving PEW care. Nutritional assessment, by means of widely available questionnaires, SGA or MIS requires minimal resources. However, strategies to tackle PEW and subsequently integrating them into daily clinical routines demand organizational issues that need to be ranked higher in the list of clinical priorities for these patients. Ultimately, these results also highlight the need for well-designed intervention studies targeting PEW for improving clinical outcomes of these patients.

METHODS

Data sources and searches

This is a collaborative initiative from the ISRNM. ISRNM members were invited to join and participate in the identification of studies eligible for meta-analysis of PEW prevalence. Selection of 25 study collaborators was based on their publication track-record on the topic of investigation and geographical location. We performed a wide search to identify studies reporting on the prevalence of PEW in kidney disease. We searched MEDLINE (PubMed), Embase, Cochrane, backward citation in Web of Science and language specific search engines (SCIELO for Spanish papers, CNKI for Chinese studies, and KoreaMed for Korean studies). The search string consisted of two parts: (i) the exposure (i.e., protein energy wasting, PEW, malnutrition, undernutrition, subjective global assessment, SGA, malnutrition inflammation score, MIS); and (ii) study population. For the latter, we used the recently published "High-Performance Information Search Filters for CKD Content" algorithm [35]. Different spelling was accounted for, and medical subheadings (MeSH) were incorporated in the PubMed search.

Study outcome

The outcome of this meta-analysis was the prevalence of PEW. Given the lack of gold-standard methods/definitions to diagnose PEW, we decided *a priori* to focus on prevalence estimates derived from either SGA or MIS. The rationale is that SGA is a validated and well-established nutritional assessment score widely used internationally in many disciplines beyond nephrology[36], and MIS is a SGA-based semi-quantified score specific to CKD[37]. Initially, we included all variations of the SGA score (ABC SGA, 7 points SGA, CANUSA SGA and semi quantitative SGA) used within the CKD literature (summarized in [38], and defined PEW as the combined proportion of patients having mild, moderate or severe malnutrition (any kind of malnutrition). During qualitative data analysis, we modified the initial protocol and excluded studies utilizing the semi-quantitative SGA score developed by Kalantar-Zadeh et al.[39] This was done because the original publication did not define a PEW cutoff, and subsequent papers applying this method used arbitrary definitions that hampered their comparison. Further, we found that there was no universally agreed upon cutoff for PEW in the MIS. To define a common cutoff, we contacted the primary investigators of the three largest studies to date using MIS[8, 15, 19, 40], and accessed original patient data to perform receiver operator characteristic (ROC) curve analyses for mortality prediction. We defined PEW by a MIS cutoff (MIS score equal or higher than 5) that resulted in equal sensitivity and specificity (symmetry point of ROC curve).

Study population, inclusion/exclusion criteria

The study population included the following groups of patients within the spectrum of kidney diseases that were analyzed separately: acute kidney injury (AKI), pediatric CKD patients, adult non-dialysis dependent patients with CKD stages 3-5, adult dialysis-dependent patients and kidney transplant patients (Tx). We also separated studies performed in patients undergoing hemodialysis (HD) and peritoneal dialysis (PD). We did not consider CKD stages 1-2.

Study selection

Studies eligible for meta-analysis were those with an observational design and including patients affected by kidney disease, published between January 2000 and December 2014 and recruiting a minimum of 50 patients. Abstracts or other materials in conference proceedings, case reports, case series, and review articles were excluded. Language selection was applied to English, Chinese, Spanish and Korean. A study protocol was developed and distributed to study collaborators. Collaborators were asked to perform study searchers in their assigned geographical areas or within their assigned subpopulations (**Supplemental information 1**).

We follow the United Nation's association of countries with geographical regions and refer to countries by their short forms, which may or may not coincide with the name used by that country in official documents (United Nations standard for statistical uses M49; https://unstats.un.org/unsd/methodology/m49/). For brevity in our tables and figures we make the following exceptions from the M49 Standard names: "Hong Kong" refers to China, Hong Kong Special Administrative Region; "Korea" to the Republic of Korea; "Taiwan" to the island of Taiwan; "UK" to the United Kingdom of Great Britain and Northern Ireland; "USA" to the United States of America; "Iran" to Iran (Islamic Republic of).

Studies identified during this first selection phase were imported to Microsoft Excel software. For each study, the PDF file was saved in an online repository. The following information was

abstracted from each study and entered into the MetaXL dataset: first author's name, PMID number, year of publication, country, geographical region, type of population (pediatric, AKI, Tx, CKD or dialysis), total number of patients, number of patients with PEW, and method of PEW definition (SGA or MIS). For studies with insufficient data, email requests were sent to the corresponding authors. If no response was received after three email reminders, the study was excluded for further analysis. Because PEW may reflect underlying country-specific malnutrition, studies including dialysis patients were in addition classified according to their countries' GNI. Using the 2014 classification by the World Bank Atlas (https://datahelpdesk.worldbank.org/knowledgebase/articles/378832-what-is-the-world-bank-atlas-method) countries were grouped into: high-income countries; upper-middle-income countries; and low-income countries (low income + lower middle-income countries). Finally, two investigators (MZM, KN) developed and applied a Quality Index assigning a quality score of 0–1 to each study. The quality score was calculated on the basis of five aspects of a study (**Supplemental Information 2)**. The maximum raw score was 8 points, representing the highest methodological quality. Disagreements in the scores were resolved by discussion and consensus. The quality index was then "normalized" to the range 0-1 by dividing the raw score by 8 (max. achievable). At this point, a second selection phase was performed by three investigators (JJC, MZM, KN) in order to verify that inclusion-exclusion criteria were met, and to exclude duplicates from the same cohort. In cases of (partially) duplicated reports we retained the more recent report or the report with the largest sample size.

Data Analysis and Synthesis

We first performed random-effect meta-analysis of the reported PEW prevalence and confirmed that the residual heterogeneity and unaccounted variability across these studies is very high (I^2=97%, p<0.001). This was expected as we were already aware of widely diverse proportions of study participants reported to have PEW and hypothesized that these differences might be explained by the type of dialysis patients were receiving (HD and PD), the way PEW was assessed (MIS, SGA 3 points or SGA 7 points), or the geographic region of the study population. Because we *a priori* did not assume functionally equivalent studies, we anticipated using meta-regression as our fundamental modeling approach that would allow investigating systematic effects on the proportion of participants with PEW by study traits that we could identify from the respective publications. Additional factors explored as sources of heterogeneity were the study sample size (<100, 100-250 and >250 patients), the year of publication (2010-2014, 2005-2009, 2000-2004) and the study quality (normalized quality index score <5/8 and ≥5/8). Our mixed-effects meta-regression [41] estimates the (expected) mean of PEW prevalence in the identifiable subgroups including a standard error of such a summary effect. Funnel plots were used to assess publication bias. All analyses were repeated with logit transformed PEW proportion without appreciably different findings (not shown).

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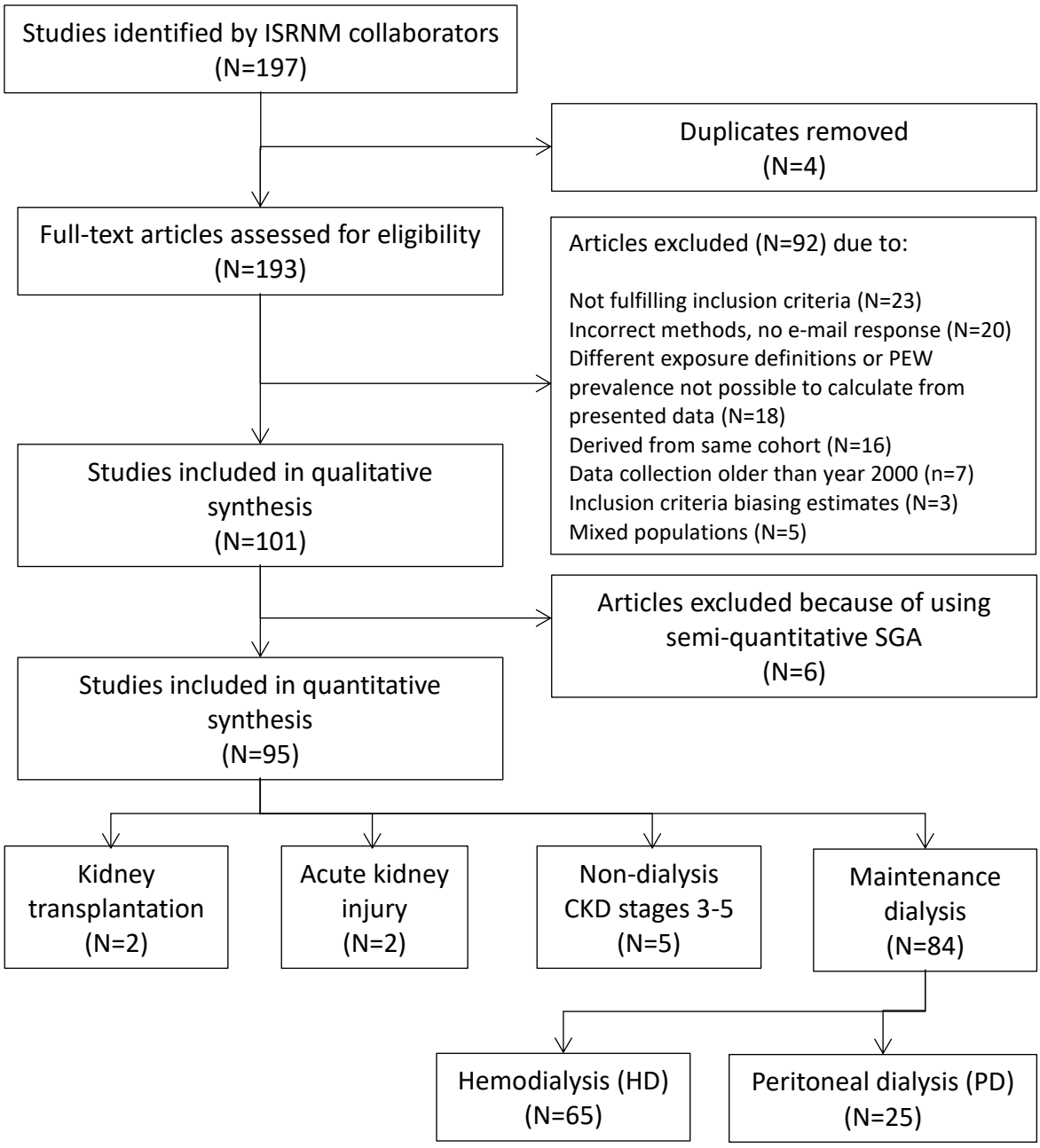
Supplemental information:
Available online at XXXX

Study dataset and R code:

Available online at XXX

Figure 1: Flow of studies through the different phases of the systematic review.



84 studies including maintenance dialysis patients resulted in 90 separate estimates given that two studies[4, 5] included combined cohorts of HD and PD patients and a multi-national study [6] reported PEW prevalence in 5 different countries.

Figure 2: PEW prevalence results reported from studies including kidney transplant (Tx), acute kidney injury (AKI), and non-dialysis chronic kidney disease (CKD) stages 3-5 patients.

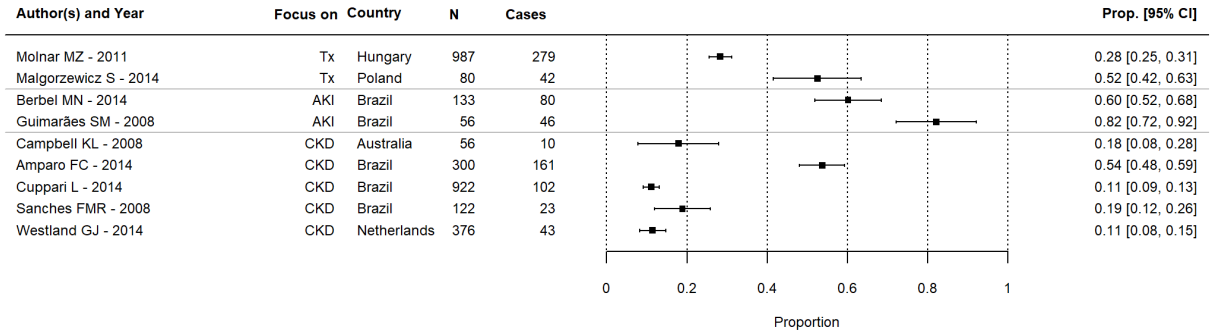


Figure 3: World map highlighting countries (in red) that contribute with at least one study to the meta-analysis of PEW prevalence in dialysis patients.

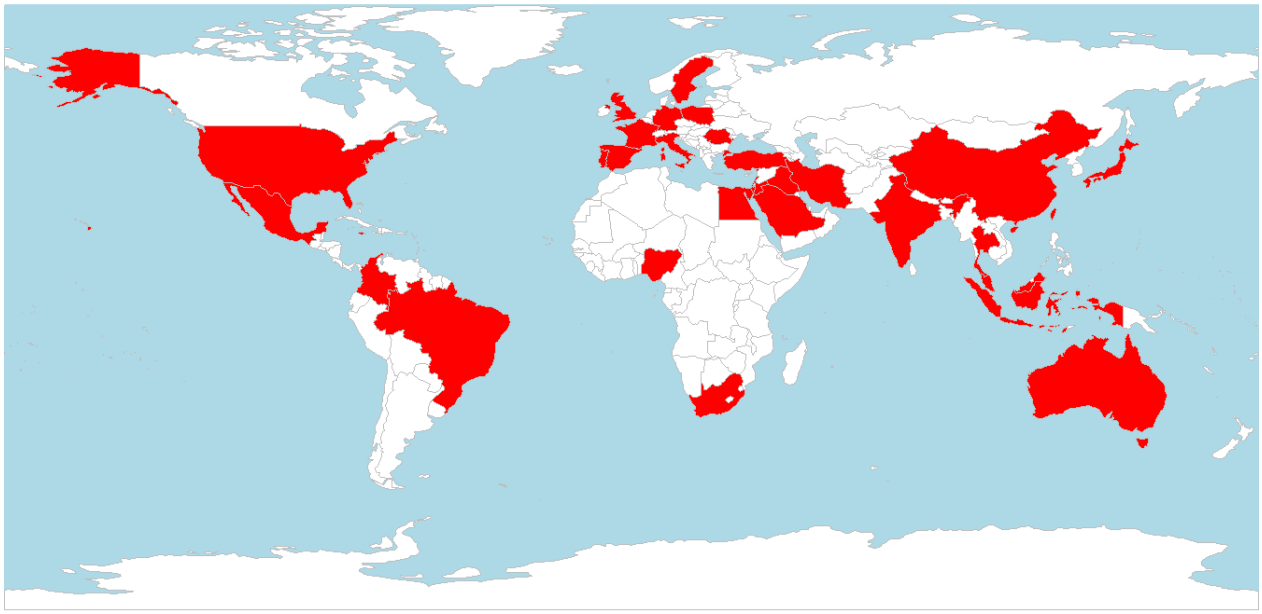


Figure 4: PEW prevalence results in studies including patients on maintenance dialysis, depicting reported prevalence of individual studies by country within region and marking in grey the interquartile range of unweighted PEW prevalence (that is, range where 50% of the results lie within). See supplemental figures for expanded versions including confidence intervals.

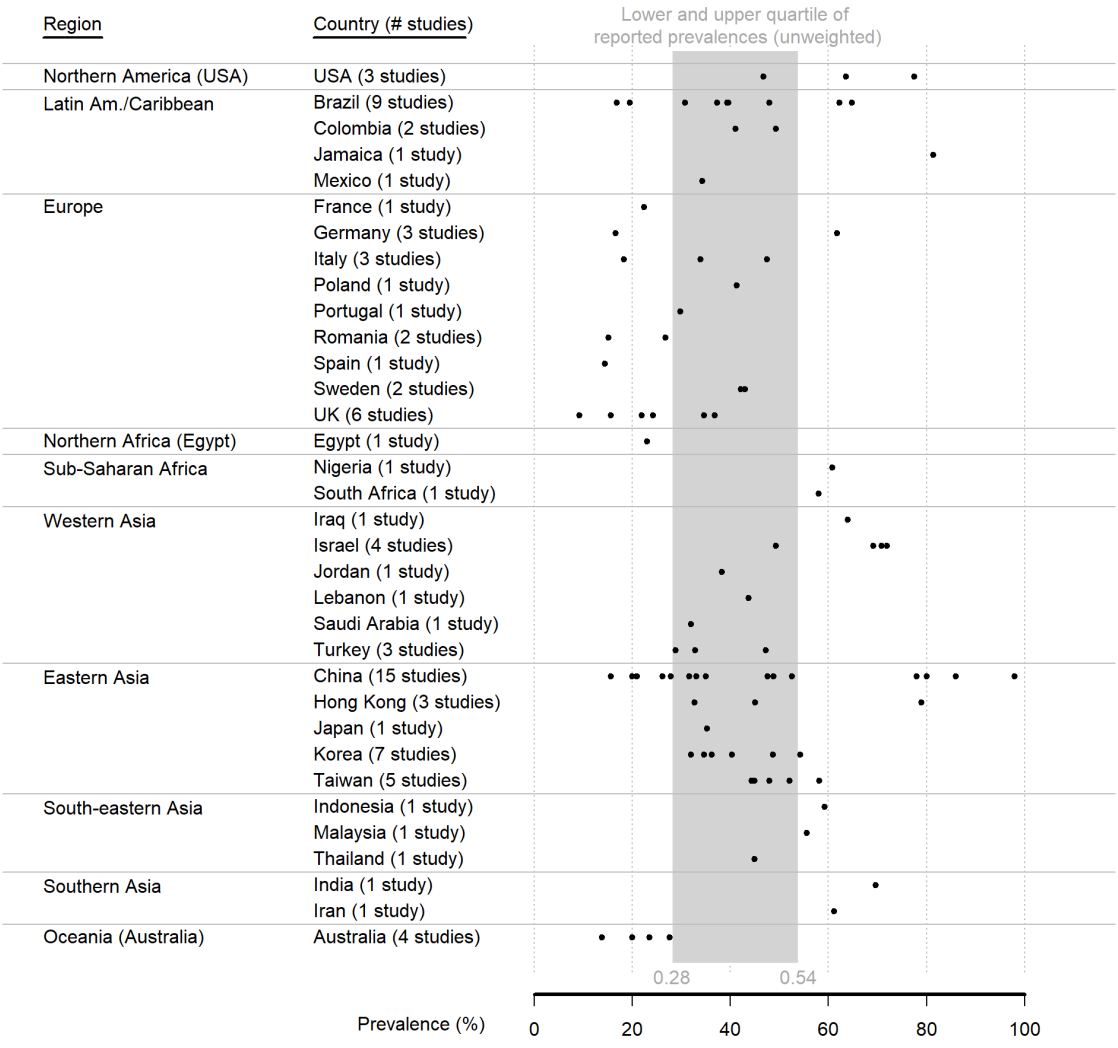


Table 1: Contributing studies by regions and type of patients (some studies are split-up due to reporting of several studies/patient groups, see the methods section for details).

Region	Countries	No. of studies	Combined Cases	Combined N	Raw % Cases
Part A: Kidney Transplant studies					
Europe	Hungary, Poland	2	321	1067	30.1
Part B: Acute Kidney Injury studies					
Latin Am./Caribbean	Brazil	2	126	189	66.7
Part C: Non-dialysis CKD stages 3-5 studies					
Oceania	Australia	1	10	56	17.9
Europe	Netherlands	1	43	376	11.4
Latin Am./Caribbean	Brazil	3	286	1344	21.3
	Total (Part C)	***5***	***339***	***1776***	***19.1***
Part D: Maintenance dialysis studies					
Oceania	Australia	4	92	414	22.2
Eastern Asia	China, Hong Kong, Japan, Korea, Taiwan	31	2197	4634	47.4
Western Asia	Iraq, Israel, Jordan, Lebanon, Saudi Arabia, Turkey	11	883	1866	47.3
South-eastern Asia	Indonesia, Malaysia, Thailand	3	143	271	52.8
Southern Asia	India, Iran	2	357	548	65.1
Northern Africa	Egypt	1	23	100	23.0
Sub-Saharan Africa	Nigeria, South Africa	2	60	101	59.4
Northern America	USA	3	510	995	51.3
Europe	France, Germany, Italy, Poland, Portugal, Romania, Spain, Sweden, UK	20	1100	4765	23.1
Latin Am./Caribbean	Brazil, Colombia, Jamaica, Mexico	13	1128	2740	41.2
	Total (Part D)		***6493***	***16434***	***39.5***

Table 2: References for included studies arranged by country.

Country	Reference
Part A: Kidney transplant studies	
Hungary	Molnar MZ-2011[8]
Poland	Malgorzewicz S-2014[7]
Part B: AKI studies	
Brazil	Berbel MN–2014[10], Guimarães SM–2008[9]
Part C: non-dialysis CKD stages 3-5 studies	
Australia	Campbell KL-2008[11]
Brazil	Amparo FC–2014[15], Cuppari L-2014[12], Sanches FMR-2008[13]
Netherlands	Westland GJ-2014[14]
Part D: Maintenance dialysis studies	
Australia	Campbell KL–2009[42], Campbell KL– 2013 [43], Desbrow–2005 [44], Todd A-2013[45]
Brazil	Barros A-2011[46], Leinig CE–2011[34], Nascimento M–2004[47], Nerbass F –2011[48], Oliveira CM–2010[49], Oliveira GT–2012[50], Pereira R –2013[51], Vannini F-2009[52], Vavruk MA-2012[53]
China (mainland)	Dong J–2006[54], Du–2012[55], Gu Y–2008[56], Gui–2010[57], He T–2013[56], Li Y–2009[58], Lu-2011[59], Shao Y–2013[60], Shi–2012[61], Wang–2008[62], Wang–2009[63], Wang–2012[64], Wu–2012[65], Ying–2013[66], Zou–2014[67]
China (Hong Kong)	Chan JY–2007[68], Chow VC–2007[69], Wang AY–2003[70]
Colombia	Sanabria M–2008a (HD estimate), Sanabria M–2008b (PD estimate)[4]
Egypt	Salwa I–2010[71]
France	Hecking E-2004[6]
Germany	Fiedler R–2009[72], Fiedler R-2011[73], Hecking E-2004b[6]
India	Sharma R–2013[74]
Indonesia	Suhardjono S–2006[75]
Iran	Ashabi A–2014[76]
Iraq	Al-Saedy AJ-2011[77]
Israel	Beberashvili I–2010[78], Beberashvili I–2013[79], Beberashvili I–2014[80], Blumberg S–2014[81]
Italy	Bossola–2009[82], Sclauzero P–2013[83], Hecking E-2004[6]
Jamaica	Dewar D-2012[84]
Japan	Honda H–2010[85]
Jordan	Reema F–2008[86]
Korea	Choi HY–2010[87], Choi MJ–2012[88], Chung SH-2010[89], Kim BS-2005[90], Koo HM–2011[91], Lee JE–2004[92], Lhee HY-2006[93]
Lebanon	Mirey K–2014[94]
Malaysia	Md Yusop NB-2013[95]
Mexico	Martín del Campo F–2012[96]
Nigeria	Liman HM–2012[97]
Poland	Malgorzewicz S–2004[98]
Portugal	Bernardo AP–2009[99]
Romania	Garneata L–2014[100], Segal L-2009[98]
Saudi Arabia	Al Saran K–2011[101]
South Africa	Abdu A-2011[102]
Spain	Hecking E-2004d[6]

Sweden	Carrero JJ–2007[103], Cobo-2014[104]
Taiwan	Hung CY–2005[105], Tsai HB–2012[105], Tsai HJ–2011[105], Wu TT–2011[105], Yang FL–2007[105]
Thailand	Pisetkul C–2010[106]
Turkey	Afsar B–2006[107], Arslan Y–2010[108], Sezer S–2012[109]
UK	Brown EA–2010a (HD estimate), Brown EA–2010b (PD estimate)[5], Gurreebun F–2007[110], Jones CH-2004[111], Hecking E-2004e[6], Elliott HA–2009[112]
USA	Han H–2013[113], Rambod M–2009[40], Wilson G–2006[114]

REFERENCES

1. Carrero JJ, Stenvinkel P, Cuppari L*, et al.* Etiology of the protein-energy wasting syndrome in chronic kidney disease: a consensus statement from the International Society of Renal Nutrition and Metabolism (ISRNM). *J Ren Nutr* 2013; **23:** 77-90.

2. Fouque D, Kalantar-Zadeh K, Kopple J*, et al.* A proposed nomenclature and diagnostic criteria for protein-energy wasting in acute and chronic kidney disease. *Kidney Int* 2008; **73:** 391-398.

3. Ikizler TA, Cano NJ, Franch H*, et al.* Prevention and treatment of protein energy wasting in chronic kidney disease patients: a consensus statement by the International Society of Renal Nutrition and Metabolism. *Kidney Int* 2013; **84:** 1096-1107.

4. Sanabria M, Munoz J, Trillos C*, et al.* Dialysis outcomes in Colombia (DOC) study: a comparison of patient survival on peritoneal dialysis vs hemodialysis in Colombia. *Kidney Int Suppl* 2008**:** S165-172.

5. Brown EA, Johansson L, Farrington K*, et al.* Broadening Options for Long-term Dialysis in the Elderly (BOLDE): differences in quality of life on peritoneal dialysis compared to haemodialysis for older patients. *Nephrol Dial Transplant* 2010; **25:** 3755-3763.

6. Hecking E, Bragg-Gresham JL, Rayner HC*, et al.* Haemodialysis prescription, adherence and nutritional indicators in five European countries: results from the Dialysis Outcomes and Practice Patterns Study (DOPPS). *Nephrol Dial Transplant* 2004; **19:** 100-107.

7. Malgorzewicz S, Debska-Slizien A, Czajka B*, et al.* Adipokines and nutritional status in kidney transplant recipients. *Transplant Proc* 2014; **46:** 2622-2626.

8. Molnar MZ, Keszei A, Czira ME*, et al.* Evaluation of the malnutrition-inflammation score in kidney transplant recipients. *Am J Kidney Dis* 2010; **56:** 102-111.

9. Guimaraes SM, Lima EQ, Cipullo JP*, et al.* Low insulin-like growth factor-1 and hypocholesterolemia as mortality predictors in acute kidney injury in the intensive care unit. *Crit Care Med* 2008; **36:** 3165-3170.

10. Berbel MN, Goes CR, Balbi AL*, et al.* Nutritional parameters are associated with mortality in acute kidney injury. *Clinics (Sao Paulo)* 2014; **69:** 476-482.

11. Campbell KL, Ash S, Davies PS*, et al.* Randomized controlled trial of nutritional counseling on body composition and dietary intake in severe CKD. *Am J Kidney Dis* 2008; **51:** 748-758.

12. Cuppari L, Meireles MS, Ramos CI*, et al.* Subjective global assessment for the diagnosis of protein-energy wasting in nondialysis-dependent chronic kidney disease patients. *J Ren Nutr* 2014; **24:** 385-389.

13. Sanches FM, Avesani CM, Kamimura MA*, et al.* Waist circumference and visceral fat in CKD: a cross-sectional study. *Am J Kidney Dis* 2008; **52:** 66-73.

14. Westland GJ, Grootendorst DC, Halbesma N*, et al.* The nutritional status of patients starting specialized predialysis care. *J Ren Nutr* 2015; **25:** 265-270.

15. Amparo FC, Kamimura MA, Molnar MZ*, et al.* Diagnostic validation and prognostic significance of the Malnutrition-Inflammation Score in nondialyzed chronic kidney disease patients. *Nephrol Dial Transplant* 2015; **30:** 821-828.

16. Kovesdy CP, George SM, Anderson JE*, et al.* Outcome predictability of biomarkers of protein-energy wasting and inflammation in moderate and advanced chronic kidney disease. *Am J Clin Nutr* 2009; **90:** 407-414.

17. Rambod M, Kovesdy CP, Kalantar-Zadeh K. Malnutrition-Inflammation Score for risk stratification of patients with CKD: is it the promised gold standard? *Nature clinical practice* 2008; **4:** 354-355.

18. Molnar MZ, Carrero JJ, Mucsi I*, et al.* Comparison of the malnutrition-inflammation score in chronic kidney disease patients and kidney transplant recipients. *Int Urol Nephrol* 2015; **47:** 1025-1033.

19. Molnar MZ, Czira ME, Rudas A*, et al.* Association of the malnutrition-inflammation score with clinical outcomes in kidney transplant recipients. *Am J Kidney Dis* 2011; **58:** 101-108.

20. Molnar MZ, Czira ME, Rudas A*, et al.* Association between the malnutrition-inflammation score and post-transplant anaemia. *Nephrol Dial Transplant* 2011; **26:** 2000-2006.

21. Czira ME, Lindner AV, Szeifert L*, et al.* Association between the Malnutrition-Inflammation Score and depressive symptoms in kidney transplanted patients. *Gen Hosp Psychiatry* 2011; **33:** 157-165.

22. Ujszaszi A, Czira ME, Fornadi K*, et al.* Quality of life and protein-energy wasting in kidney transplant recipients. *Int Urol Nephrol* 2012; **44:** 1257-1268.

23. Visser R, Dekker FW, Boeschoten EW*, et al.* Reliability of the 7-point subjective global assessment scale in assessing nutritional status of dialysis patients. *Advances in peritoneal dialysis* 1999; **15:** 222-225.

24. Mak RH. Cachexia in children with chronic kidney disease: challenges in diagnosis and treatment. *Curr Opin Support Palliat Care* 2016; **10:** 293-297.

25. Nourbakhsh N, Rhee CM, Kalantar-Zadeh K. Protein-energy wasting and uremic failure to thrive in children with chronic kidney disease: they are not small adults. *Pediatr Nephrol* 2014; **29:** 2249-2252.

26. Abraham AG, Mak RH, Mitsnefes M*, et al.* Protein energy wasting in children with chronic kidney disease. *Pediatr Nephrol* 2014; **29:** 1231-1238.

27. Wong CS, Hingorani S, Gillen DL*, et al.* Hypoalbuminemia and risk of death in pediatric patients with end-stage renal disease. *Kidney Int* 2002; **61:** 630-637.

28. Wong CS, Gipson DS, Gillen DL*, et al.* Anthropometric measures and risk of death in children with end-stage renal disease. *Am J Kidney Dis* 2000; **36:** 811-819.

29. Ku E, Glidden DV, Hsu CY*, et al.* Association of Body Mass Index with Patient-Centered Outcomes in Children with ESRD. *J Am Soc Nephrol* 2016; **27:** 551-558.

30. Furth SL, Hwang W, Yang C*, et al.* Growth failure, risk of hospitalization and death for children with end-stage renal disease. *Pediatr Nephrol* 2002; **17:** 450-455.

31. Fiaccadori E, Maggiore U, Giacosa R*, et al.* Enteral nutrition in patients with acute renal failure. *Kidney Int* 2004; **65:** 999-1008.

32. Fiaccadori E, Regolisti G, Cademartiri C*, et al.* Efficacy and safety of a citrate-based protocol for sustained low-efficiency dialysis in AKI using standard dialysis equipment. *Clin J Am Soc Nephrol* 2013; **8:** 1670-1678.

33. Fiaccadori E, Lombardi M, Leonardi S*, et al.* Prevalence and clinical outcome associated with preexisting malnutrition in acute renal failure: a prospective cohort study. *J Am Soc Nephrol* 1999; **10:** 581-593.

34. Leinig CE, Moraes T, Ribeiro S*, et al.* Predictive value of malnutrition markers for mortality in peritoneal dialysis patients. *J Ren Nutr* 2011; **21:** 176-183.

35. Iansavichus AV, Hildebrand AM, Haynes RB*, et al.* High-performance information search filters for CKD content in PubMed, Ovid MEDLINE, and EMBASE. *Am J Kidney Dis* 2015; **65:** 26-32.

36. Detsky AS, McLaughlin JR, Baker JP*, et al.* What is subjective global assessment of nutritional status? *JPEN J Parenter Enteral Nutr* 1987; **11:** 8-13.

37. Kalantar-Zadeh K, Kopple JD, Block G*, et al.* A malnutrition-inflammation score is correlated with morbidity and mortality in maintenance hemodialysis patients. *Am J Kidney Dis* 2001; **38:** 1251-1263.

38. Steiber AL, Kalantar-Zadeh K, Secker D*, et al.* Subjective Global Assessment in chronic kidney disease: a review. *J Ren Nutr* 2004; **14:** 191-200.

39. Kalantar-Zadeh K, Kleiner M, Dunne E*, et al.* A modified quantitative subjective global assessment of nutrition for dialysis patients. *Nephrol Dial Transplant* 1999; **14:** 1732-1738.

40. Rambod M, Bross R, Zitterkoph J*, et al.* Association of Malnutrition-Inflammation Score with quality of life and mortality in hemodialysis patients: a 5-year prospective cohort study. *Am J Kidney Dis* 2009; **53:** 298-309.

41. Borenstein M, Hedges LV, Higgins JPT*, et al. Introduction to Meta-Analysis. Chichester*. Wiley, 2009.

42. Campbell KL, Ash S, Zabel R*, et al.* Implementation of standardized nutrition guidelines by renal dietitians is associated with improved nutrition status. *J Ren Nutr* 2009; **19:** 136-144.

43. Campbell KL, Bauer JD, Ikehiro A*, et al.* Role of nutrition impact symptoms in predicting nutritional status and clinical outcome in hemodialysis patients: a potential screening tool. *J Ren Nutr* 2013; **23:** 302-307.

44. Desbrow B, Bauer J, Blum C*, et al.* Assessment of nutritional status in hemodialysis patients using patient-generated subjective global assessment. *J Ren Nutr* 2005; **15:** 211-216.

45. Todd A, Carroll R, Gallagher M*, et al.* Nutritional status of haemodialysis patients: comparison of Australian cohorts of Aboriginal and European descent. *Nephrology (Carlton, Vic* 2013; **18:** 790-797.

46. Barros A, da Costa BE, Poli-de-Figueiredo CE*, et al.* Nutritional status evaluated by multi-frequency bioimpedance is not associated with quality of life or depressive symptoms in hemodialysis patients. *Ther Apher Dial* 2011; **15:** 58-65.

47. Nascimento MM, Pecoits-Filho R, Qureshi AR*, et al.* The prognostic impact of fluctuating levels of C-reactive protein in Brazilian haemodialysis patients: a prospective study. *Nephrol Dial Transplant* 2004; **19:** 2803-2809.

48. Nerbass FB, Morais JG, Santos RG*, et al.* [Factors related to interdialytic weight gain in hemodialysis patients]. *J Bras Nefrol* 2011; **33:** 300-305.

49. Oliveira CM, Kubrusly M, Mota RS*, et al.* [Malnutrition in chronic kidney failure: what is the best diagnostic method to assess?]. *J Bras Nefrol* 2010; **32:** 55-68.

50. Oliveira GT, Andrade EI, Acurcio Fde A*, et al.* Nutritional assessment of patients undergoing hemodialysis at dialysis centers in Belo Horizonte, MG, Brazil. *Rev Assoc Med Bras (1992)* 2012; **58:** 240-247.

51. Pereira RA, Caetano AL, Cuppari L*, et al.* Adductor pollicis muscle thickness as a predictor of handgrip strength in hemodialysis patients. *J Bras Nefrol* 2013; **35:** 177-184.

52. Vannini FD, Antunes AA, Caramori JC*, et al.* Associations between nutritional markers and inflammation in hemodialysis patients. *Int Urol Nephrol* 2009; **41:** 1003-1009.

53. Vavruk AM, Martins C, Nascimento MM*, et al.* [Association between hypokalemia, malnutrition and mortality in peritoneal dialysis patients]. *J Bras Nefrol* 2012; **34:** 349-354.

54. Dong J, Wang T, Wang HY. The impact of new comorbidities on nutritional status in continuous ambulatory peritoneal dialysis patients. *Blood Purif* 2006; **24:** 517-523.

55. Du QN, Yan YC, Zhu ML*, et al.* Application of objective score of nutrition on dialysis for evaluating nutritional status in maintenance hemodialysis patients for 75 cases *Chinese Journal of Clinical Nutrition, 2012, August, Vol 20, No4; 222-228*.

56. Gu Y, Cheng LT, Chen HM*, et al.* Strong association between nutritional markers and arterial stiffness in continuous ambulatory peritoneal dialysis patients. *Blood Purif* 2008; **26:** 340-346.

57. Gui ZH, Wang HL, Zhang JY. Malnutrition inflammation score can evaluate malnutrition-inflammation status in Chinese peritoneal dialysis patients. *Chinese J of Blood Purification, 2010, October 12, Vol 9, No 10: 529-533*.

58. Li Y, Dong J, Zuo L. Is subjective global assessment a good index of nutrition in peritoneal dialysis patients with gastrointestinal symptoms? *Perit Dial Int* 2009; **29 Suppl 2:** S78-82.

59. Lu L, Chen Q, Wu J. Investigation and assessment of nutritional status in 147 maintained hemodialysis patients. *JiLin Medical J, 2011, Feb, Vol 32, No5: 910-912*.

60. Shao Y, Ma S, Tian X*, et al.* Dialysis adequacy in Chinese anuric peritoneal dialysis patients. *Int Urol Nephrol* 2013; **45:** 1429-1436.

61. Shi JB, Zhu N, Tian XK*, et al.* Impact of nutritional status on prognosis in Chinese hemodialysis patients. *Chinese J of Blood Purification, 2012, March, Vol 11, No 3: 124-127*.

62. Wang Y, Cheng MH. Analysis of nutritional status in continuous ambulatory peritoneal dialysis patients. *NingXia Medical J, 2008, May, Vol 30, No 5:420-422*.

63. Wang WL, Wang HL, Lu S*, et al.* Clinical observation of malnutrition and inflammation status in elderly patients on maintenance hemodialysis. *Chinese J of Integrated Traditional Chinese and Western Medicine of Nephrology, 2009, July, Vol 10, No 7: 599-603*.

64. Wang SP, Yang L, Zhao LN*, et al.* Nutritional Status of Elderly Maintenance Hemodialysis Patients and Its Influencing Factors. *Journal of Nursing (China), 2012, Oct, Vol19, No10B: 21-24*.

65. Wu Q. Multi-center investigation of nutrition conditions of patients with CAPD in Hunan province. *Thesis for master degree, 2012, The Third Affiliated Hospital of XiangYa Medical College*.

66. Ying XD, Sun LL. Analysis of incidence of malnutrition and evaluation index in hemodialysis patients. . *ACC J Chinese PLA Med SCh, 2013, Jun, 34(6):607-609*.

67. Zou F. Application of subjective global assessment in adequacy of peritoneal dialysis. *Chinese and Foreign Medical Research, 2014, Sep, Vol12, No27: 140-142*.

68. Chan JY, Che KI, Lam KM*, et al.* Comprehensive malnutrition inflammation score as a marker of nutritional status in Chinese peritoneal dialysis patients. *Nephrology (Carlton, Vic* 2007; **12:** 130-134.

69. Chow VC, Yong RM, Li AL*, et al.* Nutritional requirements and actual dietary intake of continuous ambulatory peritoneal dialysis patients. *Perit Dial Int* 2003; **23 Suppl 2:** S52-54.

70. Wang AY, Woo J, Lam CW*, et al.* Is a single time point C-reactive protein predictive of outcome in peritoneal dialysis patients? *J Am Soc Nephrol* 2003; **14:** 1871-1879.

71. Ibrahim S. Quality of care assessment and adherence to the international guidelines considering dialysis, water treatment, and protection against transmission of infections in university hospital-based dialysis units in Cairo, Egypt. *Hemodialysis international* 2010; **14:** 61-67.

72. Fiedler R, Jehle PM, Osten B*, et al.* Clinical nutrition scores are superior for the prognosis of haemodialysis patients compared to lab markers and bioelectrical impedance. *Nephrol Dial Transplant* 2009; **24:** 3812-3817.

73. Fiedler R, Dorligjav O, Seibert E*, et al.* Vitamin D deficiency, mortality, and hospitalization in hemodialysis patients with or without protein-energy wasting. *Nephron Clin Pract* 2011; **119:** c220-226.

74. Sharma R, Agrawal S, Saxena A*, et al.* Association of IL-6, IL-10, and TNF-alpha gene polymorphism with malnutrition inflammation syndrome and survival among end stage renal disease patients. *J Interferon Cytokine Res* 2013; **33:** 384-391.

75. Suhardjono. Malnutrition-inflammation syndrome in a hemodialysis population: the influence of polymorphic IL-6-174 and IL-10-1082 genes. *Acta Med Indones* 2006; **38:** 145-149.

76. As'habi A, Tabibi H, Nozary-Heshmati B*, et al.* Comparison of various scoring methods for the diagnosis of protein-energy wasting in hemodialysis patients. *Int Urol Nephrol* 2014; **46:** 999-1004.

77. Al-Saedy AJ, Al-Kahichy HR. The current status of hemodialysis in Baghdad. *Saudi J Kidney Dis Transpl* 2011; **22:** 362-367.

78. Beberashvili I, Azar A, Sinuani I*, et al.* Objective Score of Nutrition on Dialysis (OSND) as an alternative for the malnutrition-inflammation score in assessment of nutritional risk of haemodialysis patients. *Nephrol Dial Transplant* 2010; **25:** 2662-2671.

79. Beberashvili I, Azar A, Sinuani I*, et al.* Comparison analysis of nutritional scores for serial monitoring of nutritional status in hemodialysis patients. *Clin J Am Soc Nephrol* 2013; **8:** 443-451.

80. Beberashvili I, Azar A, Sinuani I*, et al.* Bioimpedance phase angle predicts muscle function, quality of life and clinical outcome in maintenance hemodialysis patients. *Eur J Clin Nutr* 2014; **68:** 683-689.

81. Blumberg Benyamini S, Katzir Z, Biro A*, et al.* Nutrition assessment and risk prediction in dialysis patients-a new integrative score. *J Ren Nutr* 2014; **24:** 401-410.

82. Bossola M, Scribano D, Colacicco L*, et al.* Anorexia and plasma levels of free tryptophan, branched chain amino acids, and ghrelin in hemodialysis patients. *J Ren Nutr* 2009; **19:** 248-255.

83. Sclauzero P, Galli G, Barbati G*, et al.* Role of components of frailty on quality of life in dialysis patients: a cross-sectional study. *J Ren Care* 2013; **39:** 96-102.

84. Dewar D, Soyibo AK, Barton EN. Nutritional markers in patients undergoing chronic haemodialysis in Jamaica. *West Indian Med J* 2012; **61:** 284-289.

85. Honda H, Ueda M, Kojima S*, et al.* Oxidized high-density lipoprotein is associated with protein-energy wasting in maintenance hemodialysis patients. *Clin J Am Soc Nephrol* 2010; **5:** 1021-1028.

86. Tayyem RF, Mrayyan MT, Heath DD*, et al.* Assessment of nutritional status among ESRD patients in Jordanian hospitals. *J Ren Nutr* 2008; **18:** 281-287.

87. Choi HY, Lee JE, Han SH*, et al.* Association of inflammation and protein-energy wasting with endothelial dysfunction in peritoneal dialysis patients. *Nephrol Dial Transplant* 2010; **25:** 1266-1271.

88. Choi MJ, Seo JW, Yoon JW*, et al.* The malnutrition-inflammation-depression-arteriosclerosis complex is associated with an increased risk of cardiovascular disease and all-cause death in chronic hemodialysis patients. *Nephron Clin Pract* 2012; **122:** 44-52.

89. Chung SH, Han DC, Noh H*, et al.* Risk factors for mortality in diabetic peritoneal dialysis patients. *Nephrol Dial Transplant* 2010; **25:** 3742-3748.

90. Kim BS, Kim JD, Shin MJ*, et al.* The Clinical Significance of Nutrition Assessed by DEXA in Hemodialysis Patients. . *Korean J Nephrol 2005;24(5): 789-796*.

91. Koo HM, Do HM, Kim EJ*, et al.* Elevated osteoprotegerin is associated with inflammation, malnutrition and new onset cardiovascular events in peritoneal dialysis patients. *Atherosclerosis* 2011; **219:** 925-930.

92. Lee JE, Chang T, Pak JT*, et al.* The Effect of Nutritional Status and Inflammation on the Endothelial Dysfunction in Continuous Ambulatory Peritoneal Dialysis Patients. *Korean J Nephrol 2004;23(6):907-919*.

93. Lhee HY, Lee KB, Kim H*, et al.* Relationship of malnutrition-inflammation score with atherosclerosis in maintenance hemodialysis patients. *Korean J Med 2006; 71:635-645*.

94. Karavetian M, Abboud S, Elzein H*, et al.* Nutritional education for management of osteodystrophy (NEMO) trial: Design and patient characteristics, Lebanon. *Nutr Res Pract* 2014; **8:** 103-111.

95. Md Yusop NB, Yoke Mun C, Shariff ZM*, et al.* Factors associated with quality of life among hemodialysis patients in Malaysia. *PLoS One* 2013; **8:** e84152.

96. Martin-del-Campo F, Batis-Ruvalcaba C, Gonzalez-Espinoza L*, et al.* Dietary micronutrient intake in peritoneal dialysis patients: relationship with nutrition and inflammation status. *Perit Dial Int* 2012; **32:** 183-191.

97. Liman HM, Anteyi EA, Oviasu E. Prevalence of malnutrition in chronic kidney disease: A study of patients in a tertiary Hospital in Nigeria. *Sahel Medical Journal* 2012; **15:** 97-100.

98. Segall L, Mardare NG, Ungureanu S*, et al.* Nutritional status evaluation and survival in haemodialysis patients in one centre from Romania. *Nephrol Dial Transplant* 2009; **24:** 2536-2540.

99. Bernardo AP, Fonseca I, Rodrigues A*, et al.* Overweight rather than malnutrition is widely prevalent in peritoneal dialysis patients. *Advances in peritoneal dialysis* 2009; **25:** 119-124.

100. Garneata L, Slusanschi O, Preoteasa E*, et al.* Periodontal status, inflammation, and malnutrition in hemodialysis patients - is there a link? *J Ren Nutr* 2015; **25:** 67-74.

101. Al Saran K, Elsayed S, Molhem A*, et al.* Nutritional assessment of patients on hemodialysis in a large dialysis center. *Saudi J Kidney Dis Transpl* 2011; **22:** 675-681.

102. Abdu A, Ladeira N, Naidoo S*, et al.* The nutritional status of continuous ambulatory peritoneal dialysis patients at a Johannesburg hospital. *S Afr J Clin Nutr* 2011; **24:** 150-153.

103. Carrero JJ, Qureshi AR, Axelsson J*, et al.* Comparison of nutritional and inflammatory markers in dialysis patients with reduced appetite. *Am J Clin Nutr* 2007; **85:** 695-701.

104. Cobo G, Gallar P, Gama-Axelsson T*, et al.* Clinical determinants of reduced physical activity in hemodialysis and peritoneal dialysis patients. *Journal of nephrology* 2015; **28:** 503-510.

105. Hung CY, Chen YA, Chou CC*, et al.* Nutritional and inflammatory markers in the prediction of mortality in Chinese hemodialysis patients. *Nephron Clin Pract* 2005; **100:** c20-26.

106. Pisetkul C, Chanchairujira K, Chotipanvittayakul N*, et al.* Malnutrition-inflammation score associated with atherosclerosis, inflammation and short-term outcome in hemodialysis patients. *J Med Assoc Thai* 2010; **93 Suppl 1:** S147-156.

107. Afsar B, Sezer S, Arat Z*, et al.* Reliability of mini nutritional assessment in hemodialysis compared with subjective global assessment. *J Ren Nutr* 2006; **16:** 277-282.

108. Arslan Y, Kiziltan G. Nutrition-related cardiovascular risk factors in hemodialysis patients. *J Ren Nutr* 2010; **20:** 185-192.

109. Sezer S, Bal Z, Tutal E*, et al.* Long-term oral nutrition supplementation improves outcomes in malnourished patients with chronic kidney disease on hemodialysis. *JPEN J Parenter Enteral Nutr* 2014; **38:** 960-965.

110. Gurreebun F, Hartley GH, Brown AL*, et al.* Nutritional screening in patients on hemodialysis: is subjective global assessment an appropriate tool? *J Ren Nutr* 2007; **17:** 114-117.

111. Jones CH, Newstead CG. The ratio of extracellular fluid to total body water and technique survival in peritoneal dialysis patients. *Perit Dial Int* 2004; **24:** 353-358.

112. Elliott HA, Robb L. Computer-Based Undernutrition Screening Tool for Hemodialysis Patients. *Dialysis & Transplantation* 2009**:** 1-6.

113. Han H, Burrowes JD, Houser R*, et al.* What is the impact of nutritional status on health-related quality of life in hemodialysis patients? *J Ren Nutr* 2012; **22:** 237-243.

114. Wilson G, Molaison EF, Pope J*, et al.* Nutritional status and food insecurity in hemodialysis patients. *J Ren Nutr* 2006; **16:** 54-58.