kidney and dialysis

MDPI

Review

Nutritional Recommendations for Pregnant Women Receiving Dialysis: A Scoping Review

Elyce Cutajar and Kelly Lambert *

School of Medical, Indigenous and Health Sciences, University of Wollongong, Wollongong, NSW 2522, Australia; ecuta7@hotmail.com
* Correspondence: klambert@uow.edu.au

Abstract: Pregnancy in the dialysing population is an infrequent but increasing event. There is a lack of contemporary guidance regarding the nutritional management of this complex patient group. The aim of this scoping review was to identify, evaluate and summarise the evidence base describing nutritional recommendations for pregnant women receiving dialysis. A systematic search strategy of four databases and the grey literature was conducted. Eligible publications contained reference to recommendations regarding nutrition, supplements, breastfeeding, dietary patterns, and/or weight recommendations for pregnant dialysing women. A total of 136 eligible records were included for synthesis including 66 case reports/case series, 46 reviews, 15 book chapters, 5 editorials, and 4 consensus guidelines/position papers. Recommendations regarding energy, protein, dietary patterns, weight, and vitamin and mineral supplementation were common. However, significant discrepancy across these recommendations was evident. There were limited recommendations regarding other nutrients and breastfeeding. A summary of nutritional recommendations to guide clinical practice was constructed. Pregnancy planning, pre-conception dietetic counselling, interprofessional education, and the guidance synthesised in this review could be utilised by clinicians to improve clinical management and optimise outcomes in these patients. Future research should explore the experiences and perspectives of pregnant dialysing women, investigate nutrient losses during intensive dialysis, and evaluate postpartum follow-up.

Keywords: pregnancy; kidney failure; dialysis; food; diet; nutrition; breastfeeding; scoping review

Citation: Cutajar, E.; Lambert, K. Nutritional Recommendations for Pregnant Women Receiving Dialysis: A Scoping Review. *Kidney Dial.* **2024**, *4*, 46–77. https://doi.org/10.3390/kidneydial4010005

Academic Editor: Massimo Torreggiani

Received: 15 December 2023
Revised: 9 February 2024
Accepted: 1 March 2024
Published: 15 March 2024

1. Introduction

Pregnancy is an infrequent event in women with kidney failure (KF) [1]. The incidence in the dialysing population ranges from <1% to approximately 7% [2]. Reasons for infertility in women on dialysis include abnormalities in the hypothalamic–pituitary–ovarian axis resulting in anovulation and/or absent or irregular menses [3], decreased estrogen and progesterone levels, secondary abnormalities in endometrial morphology, and decreased kidney prolactin clearance resulting in hyperprolactinaemia [1] (see Figures 1 and 2 for further details). These physical abnormalities are compounded by the emotional stress that KF and dialysis imposes on patients [4]. Furthermore, pregnancy on dialysis is associated with significant risks [1]. Foetal complications include prematurity (>80%), spontaneous abortion (40%), foetal/neonatal demise (21–33%), intrauterine growth restriction (20%), and polyhydramnios (29–67%) [5].

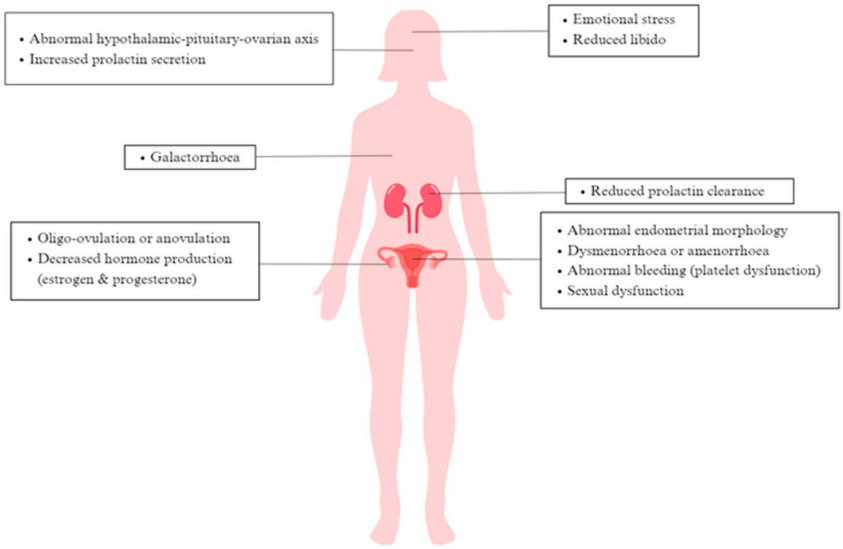

Figure 1. Physiological impact of end-stage kidney disease on female fertility. Information sourced from references [1–3,6].

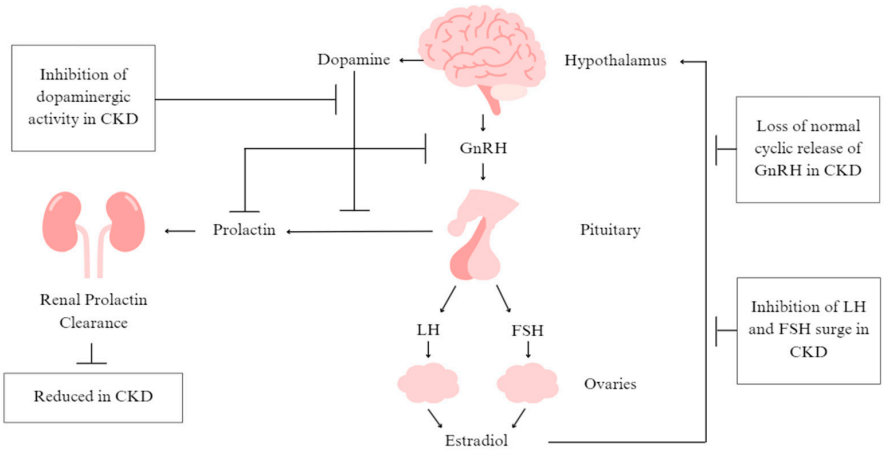

Figure 2. Hypothalamic–pituitary–ovarian axis in end-stage kidney disease. Abbreviations: CKD, chronic kidney disease; GnRH, gonadotropin-releasing hormone; LH, luteinizing hormone; FSH, follicle-stimulating hormone. Adapted from reference [7].

A nationwide survey conducted in 2014 by the Italian Study Group on 'Kidney and Pregnancy' found that the probability of delivering a live-born baby on dialysis was one-hundredth of the general population of the same age group [8]. Additionally, maternal complications include accelerated decline in renal function, worsened hypertension, superimposed preeclampsia, preterm labour, worsened anaemia, and abruptio placentae [5]. Evidently, pregnancy in this context remains a challenging scenario.

Despite this, the occurrence of pregnancy in people with ESKD is being increasingly reported [9]. A recent systematic review highlighted a substantial rise in the number of reported cases of pregnancy in women on dialysis (90 pregnancies in the years 2000 to 2008, compared to 584 pregnancies between 2008 and 2014) [10].

Factors contributing to this increase may include the rise in chronic conditions related to kidney disease in the child-bearing population [11], expanding knowledge about pregnancy during dialysis [12], improved fertility outcomes as a result of intensive dialysis delivery and nocturnal haemodialysis [13], as well as increased waiting time for kidney transplantation [14]. It is therefore likely that a dialysis unit will have to provide care for at least one pregnant patient [14], making it paramount that medical and allied health teams understand how to manage such cases.

Providing nutritional care for pregnant patients with KF is complex. Pregnancy itself is associated with physiologic changes that increase the body's demand for energy and nutrients [15]. Additionally, dialysis schedules are intensified during pregnancy to reduce uraemia and mimic normal kidney function during foetal development [16], resulting in the loss of glucose, amino acids, proteins, vitamins, and trace elements from the blood [17,18]. Care under a dietitian is therefore crucial to ensure that maternal and foetal nutritional requirements are satisfied. A close interactive multidisciplinary team of nephrologists, obstetricians, dialysis nurses, neonatologists, paediatricians, and psychologists is also required to optimise pregnancy outcomes in these scenarios [19,20].

Given that the pregnant dialysing patient presents a challenging case, there remains a need for contemporary guidance for clinicians about the nutritional management of this patient group [9]. Whilst research regarding the dialysis prescription during pregnancy has grown substantially over recent years, the nutritional recommendations for this population remain largely unknown. Therefore, this scoping review aimed to synthesise nutritional recommendations for pregnant women receiving dialysis. The specific objectives of this review were as follows:

1. Identify and evaluate academic and grey literature describing nutritional recommendations for pregnant women receiving dialysis.
2. Synthesise existing guidance on nutritional recommendations for pregnant dialysing women to guide clinical practice.

2. Materials and Methods

This scoping review followed the five-stage framework as outlined by Arksey and O'Malley [21], and was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines [22]. The protocol was registered on the Open Science Framework on 4 March 2023 (Registered form osf.io/8g6tx, Registration DOI: 10.17605/OSF.IO/8G6TX).

2.1. Stage One: Identifying the Research Question

The scoping review study design is appropriate for this study as it intends to map and describe the existing body of literature on an evolving topic [21,23]. It is also useful for conducting research in areas that have not been comprehensively reviewed [21]. The specific research question was: What are the nutritional recommendations for pregnant women receiving dialysis?

2.2. Stage Two: Identifying Relevant Studies

An exhaustive search of five bibliographic databases was conducted (2 May 2023) to ensure an extensive review of the published literature. These databases included Scopus, Web of Science, MEDLINE, CINAHL, and PubMed. The key search terms used for each database search included (pregnant OR pregnancy OR "pregnant woman" OR "pregnant women" OR "expect* mothers" OR "pregnant people" OR "pregnant person") *AND* (dialysis OR hemodialysis OR haemodialysis OR "peritoneal dialysis" OR "renal replacement therapy" OR "kidney replacement therapy" OR "renal dialysis" OR "kidney dialysis" OR "chronic renal failure" OR "chronic kidney failure" OR "kidney failure" OR "end-stage renal failure" OR "end stage renal failure" OR "ESRF" OR "end-stage renal disease" OR "end stage renal disease" OR "ESRD" OR "end-stage kidney failure" OR "end stage kidney failure" OR "ESKF" OR "end-stage kidney disease" OR "end stage kidney disease" OR "ESKD") *AND* (nutrition* OR nutrient* OR "nutrition* therapy" OR "diet* therapy" OR "nutrition* recommendation*" OR "nutrition* requirement*" OR "nutrition* intervention" OR "nutrition* management" OR "medical nutrition therapy" OR "nutrition* assessment" OR diet* OR vitamin* OR mineral*). This search strategy was informed by Levey and colleagues [24], similar work in the field of pregnancy and renal disease [25,26], and guidance from an experienced clinician (KL) and librarians.

A search of the grey literature was also conducted (3–9 May 2023) to obtain any relevant literature that may have been missed by the bibliographic database searches. Grey literature searching comprised four search strategies: (1) the first 300 search results in Google Scholar [27] using the terms (pregnancy) AND (dialysis) AND (nutrition) were retrieved, (2) the advanced search function in Open Grey was used to identify relevant grey literature using the terms (pregnancy) AND (dialysis) AND (nutrition), (3) the home page search function of all relevant quartile 1 and quartile 2 journals listed on SCImago under 'Nephrology', 'Nutrition and Dietetics' and 'Obstetrics and Gynecology' were searched using the terms 'pregnancy and dialysis', (4) the home pages of key societies and associations in the fields of 'Nephrology', 'Nutrition and Dietetics' and 'Obstetrics and Gynecology' were searched using the terms 'pregnancy and dialysis'. A complete list of these grey literature search strategies is shown in Supplementary Table S1. Search restrictions were not applied to database or grey literature searches to ensure that all relevant sources of evidence were retrieved.

2.3. Stage Three: Selecting Studies

All records from database searches and relevant documents from grey literature searches were downloaded into EndNote (Thomson Reuters, Toronto, ON, Canada; Version 20, 2020). These citations were then uploaded to the Covidence online systematic review management tool (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org, accessed on 9 May 2023) for automatic removal of duplicates and screening by the research team. Two reviewers (EC and KL) screened the title and abstracts of all citations according to the inclusion criteria. Any disagreements during this process were resolved by discussion between the reviewers. For studies that passed initial screening, full text articles were retrieved. Two reviewers (EC and KL) examined the full text of 17 (5%) articles to ensure consistency in the application of inclusion criteria. One reviewer (EC) then screened the remaining full text articles to determine inclusion. The reference lists of each included study were also reviewed to ensure a comprehensive scope of the literature.

Sources of evidence considered eligible for inclusion were case reports, case series, reviews, observational studies, editorials, conference abstracts, consensus guidelines, position papers, and book chapters. Each source of evidence had to include nutritional, supplement, breastfeeding, dietary pattern, and/or weight recommendations for pregnant dialysing women. Documents from the grey literature were included only if they were in English, and non-English studies from database searches were included only if they could be translated by the research team. Documents without full text availability, non-human studies, and 'Biology', 'Molecular', and 'Exercise and Sports Science' journals in the grey literature were excluded from the review. Details of eligibility criteria can be found in Supplementary Table S2.

2.4. Stage Four: Charting the Data

Data charting forms were developed in Excel (Microsoft Corporation, Redmond, WA, USA, 2023) by one reviewer (EC). In the initial phases of the data charting process, the research team met regularly to determine whether the approach to data extraction was consistent with the research question and purpose. Once the approach was agreed upon, one reviewer (EC) independently extracted information from the included literature and populated it in the data charting forms.

Sources of evidence were grouped according to their type, i.e., consensus guidelines/position papers, reviews, case reports/case series, editorials, and book chapters. The completed data charting forms were then transferred from Excel to Word (Microsoft Corporation, 2023) by one reviewer (EC). Data charting included authors, year of publication, country of origin, aetiology of kidney disease, number of subjects in the study, maternal age at pregnancy diagnosis, timing of dialysis commencement, dialysis regimen, pregnancy term, and macronutrient, vitamin, mineral, supplement, dietary pattern, breastfeeding, and weight recommendations as well as any other relevant commentary.

2.5. Stage Five: Collating, Summarising, and Reporting the Results

Using guidance from Levac and colleagues [28], the extracted data were synthesised in several ways. First, a descriptive summary of the main findings was constructed. Then, recommendations from the included sources of evidence were reported as relevant to the overall purpose of the research question, i.e., findings were arranged into five main categories: (1) main features of selected studies, (2) recommendations regarding macronutrients, (3) recommendations regarding vitamins, (4) recommendations regarding minerals, (5) recommendations regarding other commentary. Finally, recommendations were synthesised, and the meaning of the findings was discussed as they relate to the overall study purpose, with the implications for clinical practice and future research explored.

It is important to note that in this scoping review the term 'pregnant woman' refers to any person with the potential to be pregnant, including transgender, non-binary, and gender-diverse people who do not have a gender identity and gender modality that aligns with their assigned sex at birth [29].

3. Results

Altogether, 3990 records were identified from the systematic search strategy (Supplementary Materials Figure S1). Of these, 3463 papers were identified from database searches, 523 papers were identified from the grey literature, and 4 papers were identified from citation searches. Following the automatic removal of 738 duplicate records, 3252 articles were screened by title and abstract. A total of 292 records were then reviewed by full text; 136 of these met the inclusion criteria [2,5,9,14,19,20,26,30–265].

3.1. Features of Selected Studies

Of the 136 articles included in this scoping review, 29 (21.3%) were published from 1970 to 1999, and 107 (78.7%) were published from 2000 to 2023. This illustrates a large increase in research around pregnancy and dialysis since the new millennium, when the first global guidelines for nutrition in chronic kidney disease (CKD) were published [50]. A total of 66 papers included in this review were case reports/case series (48.5%), followed by 46 reviews (33.8%), 15 book chapters (11%), 5 editorials (3.7%), and 4 consensus guidelines/position papers (2.9%). The vast majority of included records originated from the United States (51; 37.5%). The remaining studies were from Europe (36; 26.5%), Asia (14; 10.3%), North America (11; 8.1%), South America (3; 2.2%), Africa (3; 2.2%), Australia (3; 2.2%), Russia (2; 1.5%), Turkey (1; 0.7%), and Cuba (1; 0.7%). Eleven papers (8.1%) were multinational.

There were 118 pregnancies on dialysis reported across all case reports/case series (Supplementary Table S7). Of these pregnancies, 102 (86.4%) occurred on haemodialysis (HD) and 15 (12.7%) occurred on peritoneal dialysis (PD). One study (0.8%) did not specify the mode of dialysis used during pregnancy [123]. Additionally, a total of 90 pregnancies (76.3%) occurred after the commencement of dialysis, whilst in 27 cases (22.9%) dialysis was started during the pregnancy. One case report (0.8%) did not specify the timing of dialysis commencement [162].

3.2. Recommendations Regarding Macronutrients

Macronutrient recommendations included energy, carbohydrate, protein, fat, fibre, and fluid (see Supplementary Table S3 for a detailed summary of these recommendations). The 'Australia and New Zealand Nutrient Reference Values (NRVs)' for pregnancy in women aged 14–50 years [30], and the 'Kidney Disease Outcomes Quality Initiative (KDOQI) Clinical Practice Guideline for Nutrition in CKD: 2020 Update' [31] were used as comparators (where available) for all nutrient recommendations summarised in this scoping review. Heat maps have also been used to illustrate whether the recommendations charted in this paper are consistent with the NRV and/or KDOQI guidelines, and where any gaps in the literature may exist (see Tables 1–3).

Table 1. Summary and heat map of macronutrient recommendations for pregnant women receiving dialysis (data included from n = 106 papers with recommendations).

	Energy	Carbohydrate	Protein	Fat	Fibre	Fluid
Nutrient Reference Value for female (Pregnancy, 14–50 years) [30]	1st trimester: No additional requirement 2nd trimester: additional 1.4 MJ/day 3rd trimester: additional 1.9 MJ/day	No EAR, RDI or AI set	RDI: 58–60 g/day or 1.00–1.02 g/kg/day	AI: 10 g/day Linoleic acid: 1.0 g/day Alpha-Linoleic acid:110–115 mg/day	AI: 25–28 g/day	AI: 1.8–2.3 L/day
KDOQI Nutrition Guidelines [31]	25–35 kcal/kg/day	Not reported	1.0–1.2 g/kg/day (HD/PD)	Not reported	Not reported	Not reported
Consensus Guidelines/Position Papers						
de Jong et al. (2022) [32]			1.5–1.8 g/kg IBW (HD)			
Schmidt et al. (2022) [33]	1st trimester: 30–35 kcal/kg/day 2nd/3rd trimesters: 30–35 kcal/kg/day + 300 kcal (HD) 1st trimester: 25–30 kcal/kg/day 2nd/3rd trimesters: 25–30 kcal/kg/day (+300 kcal) (CAPD)		1.2 g/kg pre-pregnancy weight/day + 10 g/day (HD/CAPD)			
Wiles et al. (2019) [26]			1.5–1.8 g/kg IBW/day (HD)			
Reviews						
Esposito et al. (2020) [35]	1st trimester: 30–35 kcal/kg/day (HD), 25–30 kcal/kg/day (PD) 2nd/3rd trimester: 30–35 kcal/kg/day (+300 kcal) (HD), 25–30 kcal/kg/day (+300 kcal) (PD)		1.2 g/kg/day + 10 g/day (HD/PD)			
Jungers and Chauveau (1997) [39]			1 g/kg/day + 20 g/day (HD/PD)			
Holley and Reddy (2003) [19]			1.8 g/kg			
Díaz et al. (2016) [42]	30–35 kcal/day (HD/PD)		1.5–1.8 g/kg/day (HD/PD)			
Alkhunaizi et al. (2015) [43]			1.5–1.8 g/kg (HD)			
Nadeau-Fredette et al. (2013) [1]			≥1.1 g/kg/day			
Hladunewich and Schatell (2016) [34]			1.5–1.8 g/kg/day			
Brookhyser and Wiggins (1998) [46]	2nd/3rd trimesters: Basal energy expenditure × activity factor (1.2 to 1.4) +300 kcal (indivdualise)		1.2 g/kg IBW + 10 g (HD) 1.4 g/kg IBW + 10 g (PD)			1000–2000 mL
Reddy and Holley (2007) [4]	30–35 kcal/kg/day		1.5 g/kg (HD) 1.8 g/kg (PD)			750–1500 mL/day
Oliverio and Hladunewich (2020) [47]			1.5–1.8 g/kg/day			

Table 1. *Cont.*

	Energy	Carbohydrate	Protein	Fat	Fibre	Fluid
Reyes-López et al. (2020) [48]	1st trimester: 105–146 kJ/kg/day + 289 kJ 2nd trimester: 105–146 kJ/kg/day + 1100–1423 kJ 3rd trimester: 105–146 kJ/kg/day + 1891–2096 kJ	≥175 g/day	1st trimester: 1.1–1.5 g/kg/day + 0.7 g 2nd trimester: 1.1–1.5 g/kg/day + 9.6 g 3rd trimester: 1.1–1.5 g/kg/day + 31.2 g [50,51]	Saturated fatty acids 7% TEI Monounsaturated fatty acids 20% TEI		3 L/day
Tangren et al. (2018) [52]			1.5–1.8 g/kg/day (HD) [53]			
Vecchio et al. (2021) [54]	35 kcal/kg (HD) 25 kcal/kg (PD)		1.2 g/kg pre-gestational weight/day (HD) 1.4 g/kg pre-gestational weight/day (PD) [266]			
Kapoor et al. (2009) [55]			1.5 g/kg (HD) 1.8 g/kg (PD)			
Castellano et al. (2011) [56]			1 g/kg + 20 g/day (HD) OR 1.8 g/kg (HD)			
Hladunewich et al. (2011) [2]			1.5–1.8 g/kg (HD)			
Stover (2010) [58]	1st trimester: 30–35 kcal/kg IBW/day 2nd/3rd trimesters: 30–35 kcal/kg IBW/day + 300 kcal/day		1.2–1.8 g/kg IBW/day (HD) 1.2–1.3 g/kg IBW (PD)			
Hall and Brunskill (2010) [59]			≥1.8 g/kg			
Kothari et al. (2019) [60]	25–35 kcal/kg pregnant weight/day		1.5–1.8 g/kg pre-pregnancy weight/day +20 g/day			
Lim and Wah (2018) [61]	30–35 kcal/kg		1.8 g/kg(HD) [63] 1.4–2.1 g/kg (PD)			
Vázquez-Rodríguez (2010) [65]	35–40 kcal/kg (PD)		1 g/kg + 20 g/day to 1.8 g/kg (PD)			
Onder et al. (2016) [67]	30–35 kcal/kg		1.5 g/kg (HD) 1.8 g/kg (PD)			750–1500 mL/day
Furaz-Czerpak et al. (2012) [71]	30–35 kcal/kg [4,19,68,69]		1.5 g/kg (HD) 1.8 g/kg (PD)			
Singh and Pradeep (2012) [72]			1 g/kg/day + 20 g/day			
Stover (2007) [73]	1st trimester: 35 kcal/kg pre-pregnancy IBW/day 2nd/3rd trimesters: 35 kcal/kg pre-pregnancy IBW/day + 300 kcal/day		1.2–1.3 g/kg IBW + ≥10 g/day			
Shehaj and Kazancıoglu (2023) [75]	25–35 kcal/kg pregnant weight/day		1.8 g/pre-pregnancy weight/day + 20 g/day			
Vázquez-Rodríguez (2010) [76]			1 g/kg/day + 20 g/24 h OR 1.8 g/kg/day			
Porter (2009) [77]	30–35 kcal/kg		1.3–1.5 g/kg			
Nikolskaya and Prokopenko (2014) [79]	30–35 kcal/kg + 300 kcal/day		1.5–1.8 g/kg			

Table 1. *Cont.*

	Energy	Carbohydrate	Protein	Fat	Fibre	Fluid
Hui and Hladunewich (2019) [81]			1.5–1.8 g/kg			
Hou (1999) [37]	35 kcal/kg + 300 kcal (HD) 25 kcal/kg + 300 kcal (PD)		1.2 g/kg ideal pre-gravid weight + 10 g (HD) 1.4 g/kg ideal pre-gravid weight + 10 g + dialysate losses (PD)			
Davison (1991) [82]			70 g/day			
Oliverio et al. (2021) [84]			1.5–1.8 g/kg			
Ramin et al. (2006) [85]			1.8 g/kg			
Chan et al. (1998) Canada [86]			>1.5 g/kg (HD) >1.8 g/kg (CAPD)			
Giannattasio et al. (2017) [87]			1.5–1.8 g/kg			
Grossman et al. (1993) [89]	25–45 kcal/kg + 250–300 kcal/day		1.0–1.5 g/kg + 10–20 g/day			
Bili et al. (2013) [90]	30–35 kcal/kg		1.5 g/kg (HD) 1.8 g/kg (PD)			0.75–1.5 L/day
Case Reports/Case Series						
Cao et al. (2018) [94]	35–40 kcal/kg		1 g/kg + 20 g/day			
Manisco et al. (2015) [68]	25–35 kcal/kg		1.2–1.4 g/kg pre-pregnancy weight/day + 20 g/day			
Seker (2016) [99]	2000 kcal/day		1.5 g/kg			
Shanmugalingam et al. (2021) [100]	Not reported		1.8–2 g/kg			
Haase et al. (2005) [101]	3000 kcal/day		>100 g/day			
Yu et al. (2015) [102]	Not reported		1 g/kg/day + 20 g/day			
Espinoza et al. (2013) [104]	35 kcal/kg + 300 kcal		1.8 g/kg			
Choi et al. (2018) [105]	2000 kcal/day		1.5 g/kg			
Tuot et al. (2009) [106]	2100–2250 kcal/day (REE × 1.2–1.3 + 300 kcal)	100 g dextrose (340 kcal) from IDPN	75–85 g/day protein (metabolically active weight × 1.4–1.5) and 95 g protein (15% amino acids, 380 kcal) from IDPN	40 g of lipid (400 kcal) from IDPN		
Ribeiro and Silva (2020) [20]	35 kcal/kg + 300 kcal/day		1.8 g/kg of pre-pregnancy weight + 10–20 g/day [108,109]			
Giofre' et al. (2007) [110]	35 kcal/kg		1.8–2 g/kg			
Campos-Collado et al. (2016) [112]	~2000 kcal/day	55% TEI, then 45% TEI	1.4 g/kg pre-gestational IBW + 10 g/day	26% TEI	28 g/day	1000–1100 mL/day (no fluid restriction)

Table 1. *Cont.*

	Energy	Carbohydrate	Protein	Fat	Fibre	Fluid
Reister et al. (1999) [115]			1.02 g/kg			
Swaroop et al. (2009) [116]			1 g/kg + 20 g/day			
Yoo et al. (2004) [117]			1.8 g/kg			
Giatras et al. (1998) [41]	3000 kcal/day		>100 g/day			
Pepperell et al. (1970) [120]			40 g/day protein diet			
Abu-Zaid et al. (2013) [121]	3000 kcal/day		100 g/day			
Al-Saran and Sabry (2008) [122]			1 g/kg + 20 g/day			
Gómez Vázquez et al. (2007) [124]	30–45 kcal/kg		1.3–1.5 g/kg	<30% polyunsaturated		Variable 1.5 L to unlimited
Mohammed et al. (2021) [125]	2500–3000 kcal/day		1.5–1.8 g/kg			
Alhwiesh (2015) [126]	45 kcal/kg		1.5 g/kg			1500 mL/day
Pipili et al. (2011) [127]			1.8 g/kg			
Ramadani et al. (2018) [128]	30–35 kcal/kg/day		0.6–1.5 g/kg			750–1500 mL/day
Hussain et al. (2005) [129]			1.6–1.8 g/kg			
Bahadi et al. (2010) [80]			1.8 g/kg/day			
López-Menchero et al. (2004) [132]	35 kcal/kg gestational weight/day + 300 kcal/day		1–1.2 g/kg pre-pregnancy weight/day + 10–20 g/day			
Coyle et al. (2008) [133]			IBW + 10 g			
Sheriff et al. (1978) [134]			80 g/day			
Walsh (2002) [135]			1.8 g/kg			
Cocîrţă et al. (2016) [137]			1.8 g/kg (HD)			
Guida et al. (2003) [139]	35 kcal/kg + 300–400 kcal/day		1.2 g/kg + 6 g/day			
McPhatter and Drumheller (2008) [141]			70 g/day			
Sandhu et al. (2014) [143]			1 g/kg/day + 20 g/day			
Brookhyser (1989) [144]	1900 kcal/day + 300 kcal/day		1.5 g/kg/day (125 g high biological value protein)			
Park et al. (2006) [145]			1.5–1.8 g/kg			
Yattara et al. (2019) [146]	30–35 kcal/kg/day		1.2 g/kg			750–1500 mL/day [147]
Henderson (1996) [149]	2000 kcals/day (30 kcals/kg pre-gravida weight + 250 kcals/day, then 2200 kcals/day at 28 weeks gestation		70–80 g of protein/day (1.2 g/kg IBW + 10–20 g/day) [89]			
Melendez et al. (1988) [150]	35–45 kcal/kg IBW + 300 kcal/day		1.2–1.5 g/kg IBW + 30 g/day (CAPD)			
Vidal et al. (1998) [176]	1st trimester: 35 kcal/kg IBW/day 2nd trimester: 35 kcal/kg dry weight/day + 300 kcal/day		1st trimester: 1.1–1.2 g/kg IBW/day 2nd trimester: 1.5 g/kg dry weight/day			

Table 1. *Cont.*

	Energy	Carbohydrate	Protein	Fat	Fibre	Fluid
Brookhyser et al. (1996) [153]	1700–1900 kcal/day		>70 g/day			40 oz/day (liberalised)
Cattran and Benzie (1983) [157]			60 g/day			
Villa et al. (2007) [158]			1.2–1.3 g/kg OR 1.8 g/kg			
Molaison et al. (2003) [107]	Increase daily intake by 300 calories [253]		Increase intake by 10 g/day [253]			
Stover (2004) [142]	35 kcal/kg IBW or SBW/day + 300 kcal (2nd/3rd trimesters)		1.2 g/kg IBW/day + 10 g/day (2nd/3rd trimesters)			
Unzelman et al. (1973) [161]	2200 kcal/day		80 g/day			Unrestricted
Perry (1994) [162]	2000 kcal/day		60 g/day			800 mL/day, then 500 mL/day above urine output
Editorials						
Levy et al. (1998) [136]			1 g/kg + 20 g/day			
Mercadal and Nizard (2019) [164]			1.5–2 g/kg			
Ellis (2012) [166]			1.8 g/kg (HD)			
Jagielski (2015) [167]	30–35 kcal/kg/day + 300 kcal/day (2nd/3rd trimesters) (HD)		1.2 g/kg + 10 g/day (HD)			
Book Chapters						
Lawrence (2012) [169]	1st trimester: BEE × activity factor (1.2–1.4) or 35 kcal/kg of pre-pregnancy IBW 2nd/3rd trimesters: Add 300 kcal/dL (HD/PD) [37,73,170]	Remaining calories to be met with CHO sources (after protein and fat requirements have been met)	1.1–1.4 g/kg of pre-pregnancy IBW + 10 g/day (HD) 1.2–1.5 g/kg of pre-pregnancy IBW + 10 g/day (PD) [37,73,170]	Saturated fat < 7% TEI, trans-fat < 1% TEI, cholesterol < 300 mg/day Hyperlipidemia: Total fat intake 25–35% TEI, saturated fat < 7% TEI, remaining fat calories (up to 20%) distributed toward monounsaturated fats and polyunsaturated fats, cholesterol < 200 mg/day		1000–2000 mL/IDWG ≤ 2 kg (HD) No recommendation (PD)
Flecha (2020) [172]			1 g/kg/day + 20 g/day			
Pahl (2019) [173]	3000 kcal/day		1.8 g/kg/day [41]			
Sandhu (2016) [174]			1 g/kg/day + 20 g/day			
Hou (1994) [40]			1 g/kg/day + 20 g (HD) 1.5 g/kg/day + 20 g (CAPD)			

Table 1. *Cont.*

	Energy	Carbohydrate	Protein	Fat	Fibre	Fluid
Fisher et al. (2018) [5]	30–35 kcal/kg/day		1.5 g/kg (HD) 1.8 g/kg/(PD)			
Stover (2008) [175]	35 kcal per kg/day of pre-gravida IBW + 300 kcal/day (2nd/3rd trimesters)		1.2 g/kg pre-gravida IBW + 10 g/day (HD) 1.2–1.3 g/kg pre-gravida IBW + 10 g/day (PD)			
Stover (2014) [177]	35 kcal/kg pre-gravida SBW + 300/day (in 2nd/3rd trimesters)		1.2 g/kg pre-gravida SBW + 10–25 g/day (HD) 1.2–1.3 g/kg pre-gravida SBW + 10–25 g/day (PD)			
Stover and Trolinger (2020) [179]	1st trimester: 35 kcal/kg/day of pre-gravida SBW 2nd/3rd trimesters: 35 kcal/kg/day + 350–450 kcal/day		1.2 g/kg SBW + 10–25 g/day (HD) 1.2–1.3 g/kg SBW + 10–25 g/day (PD)			
Plant (2008) [181]	Up to 3000 kcal/day		Up to 1.8 g/kg			
Stover (2022) [182]	25–35 kcal/kg pre-pregnancy weight/day + 300 kcal/day (2nd/3rd trimesters)		1.0–1.2 g/kg pre-pregnancy weight/day + 10–25 g/day			
Goody and Umans (2004) [183]	>35 kcal/kg/day + 300 kcal/day		1.2 g/kg ideal pre-gravid weight + 10 g (HD)			
Vellanki and Hou (2019) [184]			1.0–1.1 g/kg			
Shahid et al. (2018) [185]			1.5–1.8 g/kg (HD)			
Piccoli et al. (2023) [186]			1.2–1.5 g/kg			

Legend: Red, inconsistent with NRV for pregnancy (women aged 14–50 years) and/or KDOQI guidelines for dialysis; blue, consistent with NRV for pregnancy (women aged 14–50 years) and/or KDOQI guidelines for dialysis; yellow, no relevant NRV for pregnancy (women aged 14–50 years) or KDOQI guidelines for dialysis; grey, no data. Abbreviations: NRV, nutrient reference value; KDOQI, Kidney Disease Outcomes Quality Initiative; EAR, estimated average requirement; RDI, recommended daily intake; AI, adequate intake; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; DPA, docosapentaenoic acid; HD, haemodialysis; PD, peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; IBW, ideal body weight; REE, resting energy expenditure; IDPN, intradialytic parenteral nutrition; TEI, total energy intake; BEE, basal energy expenditure; CHO, carbohydrate(s); SBW, standard body weight.

Table 2. Summary and heat map of vitamin recommendations for pregnant women receiving dialysis (data included from n= 17 papers with recommendations).

Daily Amounts	Vitamin A (RE)	Vitamin C	Vitamin D	Vitamin E	Vitamin K	Vitamin B1	Vitamin B2	Vitamin B3	Vitamin B5	Vitamin B6	Vitamin B12	Folate	Biotin
NRV Female (Pregnancy, 14–50 years) [30]	RDI: 700–800 µg/day	RDI: 55–60 mg/day	AI: 5 µg/day	AI: 7–8 mg/day	AI: 60 µg/day	RDI: 1.4 mg/day	RDI: 1.4 mg/day	RDI: 18 mg/day	AI: 5 mg/day	RDI: 1.9 mg/day	RDI: 2.6 µg/day	RDI: 600 µg/day	AI: 30 µg/day
KDOQI Dialysis Guidelines [31]	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported

Table 2. *Cont.*

Daily Amounts	Vitamin A (RE)	Vitamin C	Vitamin D	Vitamin E	Vitamin K	Vitamin B1	Vitamin B2	Vitamin B3	Vitamin B5	Vitamin B6	Vitamin B12	Folate	Biotin
Consensus Guidelines/Position Papers													
Schmidt et al. (2022) [33]			25–50 µg									2–5 mg	
Reviews													
Esposito et al. (2020) [35]			25–50 µg									2–5 mg	
Brookhyser and Wiggins (1998) [46]		≥170 mg				3 mg (HD)	3.4 mg (HD)	≥20 mg (HD)		≥5 mg (HD)		1.8 mg (HD)	600 µg (HD)
Reddy and Holley (2007) [4]												1 mg	
Hou (1999) [37]		≥170 mg				3 mg	3.4 mg	≥20 mg		>5 mg		1.8 mg	
Grossman et al. (1993) [89]		≥170 mg				3 mg	3.4 mg	≥20 mg		≥5 mg		1.8 mg	
Case Reports/Case Studies													
Campos-Collado et al. (2016) [112]	800 µg	≥170 mg										1.8 mg	
Yoo et al. (2004) [117]												800 µg	
Yattara et al. (2019) [146]												1.8 mg	
Henderson (1996) [149]		≥170 mg				3 mg	3.4 mg	≥20 mg		≥5 mg		1.8 mg	
Shah et al. (2007) [155]												800 µg	
Racette (1997) [159]												1.8 mg	
Book Chapters													
Lawrence (2012) [169]												≥1.8 mg	
Stover (2008) [175]												≥2 mg	
Stover (2014) [177]												2–4 mg	
Stover and Trolinger (2020) [179]												2–4 mg	
Stover (2022) [182]												2–4 mg	

Legend: Red, inconsistent with NRV for pregnancy (women aged 14–50 years) and/or KDOQI guidelines for dialysis; blue, consistent with NRV for pregnancy (women aged 14–50 years) and/or KDOQI guidelines for dialysis; grey, no data. Abbreviations: NRV, nutrient reference value; KDOQI, Kidney Disease Outcomes Quality Initiative; RDI, recommended daily intake; AI, adequate intake.

Table 3. Summary and heat map of mineral recommendations for pregnant women receiving dialysis (data included from n = 38 papers with recommendations).

Daily Amount	Na	K	Ca	Mg	Fe	Zn	P	I	Cu	Se	Mn	Mo
NRV Female (Pregnancy, 14–50 years) [30]	AI: 460–920 mg/day (20–40 mmol/day)	AI: 2800 mg/day (72 mmol/day)	RDI: 1000–1300 mg/day	RDI: 350–400 mg/day	RDI: 27 mg/day	RDI: 10–11 mg/day	RDI: 1000–1250 mg/day	RDI: 220 µg/day	AI: 1.2–1.3 mg/day	RDI: 65 µg/day	AI: 5 mg/day	RDI: 50 µg/day
KDOQI Nutrition Guidelines [31]	<100 mmol/day (<2.3 g/day salt)	Adjust intake to maintain serum potassium within normal range.	Adjust intake considering use of vitamin D analogs and calcimimetics to avoid hypercalcemia or calcium overload.	Not reported	Not reported	Not reported	Adjust intake to maintain normal serum phosphate levels. Consider the bio-availability of phosphorus sources.	Not reported	Not reported	Not reported	Not reported	Not reported
Consensus Guidelines/Position Papers												
de Jong et al. (2022) [32]			≥1000 mg/day									
Schmidt et al. (2022) [33]		3 g/day (<75 mmol/day) (HD)	1500–2000 mg (HD)		20–30 mg (HD)	15 mg (HD)						
Reviews												
Esposito et al. (2020) [35]	80 mmol or 4 g/day (salt)	3 g/day (<75 mmol/day) or 50 mmol (HD)	1500–2000 mg (HD)		20–30 mg (HD)	15 mg (HD)	1000–1250 mg					
Brookhyser and Wiggins (1998) [46]	~2–3 g(salt)	~2–3 g	~1200 mg	200–300 mg (HD)		15 mg (HD)	1200 mg (HD)					
Reddy and Holley (2007) [4]	80 mmol	50 mmol	1500–2000 mg									
Reyes-López et al. (2020) [48]	3–4 g (salt) (HD)	3 g (HD)										
Kapoor et al. (2009) [55]			1500 mg									
Hladunewich et al. (2011) [2]					>30 mg							
Hou (2004) [66]					>1 g over usual requirement							
Onder et al. (2016) [67]			1500–2000 mg									
Furaz-Czerpak et al. (2012) [71]			1500 mg									
Singh and Pradeep (2012) [72]			1500 mg									

Table 3. *Cont.*

Daily Amount	Na	K	Ca	Mg	Fe	Zn	P	I	Cu	Se	Mn	Mo
Stover (2007) [73]	2–4 g		≥1000 mg			15 mg						
Nikolskaya and Prokopenko (2014) [79]			1500 mg				800 mg for high serum phosphate					
Hou (1999) [37]			2000 mg/day	200–300 mg		15 mg	1200 mg					
Davison (1991) [82]	80 mmol	50 mmol	1500 mg									
Giannattasio et al. (2017) [87]	100 mmol											
Grossman et al. (1993) [89]				200–300 mg		15 mg	1200 mg					
Bili et al. (2013) [90]			1500 mg									
Case Reports/Case Series												
Manisco et al. (2015) [68]			800 mg									
Campos-Collado et al. (2016) [112]	2–3 g salt	2512 mg/day (40 mg/kg IBW/day, restriction of foods > 250 mg/serve)	1000–1200 mg	200–300 mg	200 mg		1200 mg					
Abu-Zaid et al. (2013) [121]			1500 mg									
Gómez Vázquez et al. (2007) [124]	3 g (salt)	2 g					800 mg					
Alhwiesh (2015) [126]							800 mg					
Ramadani et al. (2018) [128]			1500 mg									
Hussain et al. (2005) [129]			1500 mg				800–1600 mg					
Sandhu et al. (2014) [143]					30 mg							
Henderson (1996) [149]	4 g (salt)	3 g		200–300 mg	200 mg	15 mg	1200 mg					
Melendez et al. (1988) [150]	2 g salt											
Vidal et al. (1998)[176]	1st trimester: 3–4 g/day (salt) 2nd/3rd trimesters: flexible	1st trimester: 3 g/day 2nd/3rd trimesters: flexible										
Perry (1994) [162]		60 mmol					1200 mg					

Table 3. *Cont.*

Daily Amount	Na	K	Ca	Mg	Fe	Zn	P	I	Cu	Se	Mn	Mo
Editorials												
Hou (2002) [165]					>1 g above usual requirement							
Book Chapters												
Lawrence (2012) [169]	~2–3 g/day (salt) (HD) ~2–4 g/day (salt) (PD) [37,73,170]	HD: ~40 mg/kg pre-pregnancy IBW (individualise per serum values)	~1000–1200 mg				~1200 mg					
Sandhu (2016) [174]					30 mg							
Stover (2008) [175]						≥15 mg						
Stover (2014) [177]						≥15 mg						
Stover and Trolinger (2020) [179]			1500 mg			≥15 mg						
Stover (2022) [182]						5 mg						

Legend: Red, inconsistent with NRV for pregnancy (women aged 14–50 years) and/or KDOQI guidelines for dialysis; blue, consistent with NRV for pregnancy (women aged 14–50 years) and/or KDOQI guidelines for dialysis; grey, no data. Abbreviations: NRV, nutrient reference value; KDOQI, Kidney Disease Outcomes Quality Initiative; Na, sodium; K, potassium; Ca, calcium; Mg, magnesium; Fe, iron; Zn, zinc; P, phosphorous; I, iodine; Cu, copper; Se, selenium; Mn, manganese; Mb, molybdenum; AI, adequate intake; RDI, recommended daily intake; HD, haemodialysis; IBW, ideal body weight; NaCl, sodium chloride; PD, peritoneal dialysis.

The overall number of macronutrient recommendations collated in this review was 213, see Supplementary Table S3. There were 107 recommendations made for protein (50.2%), followed by 59 (27.7%) for energy, 14 (6.6%) for fluid [4,46,48,67,90,112,124,126,128,146,153,161,162,169], 5 (2.3%) for fat [48,106,112,124,169], 4 (1.9%) for carbohydrate [48,106,112,169], and 1 (0.5%) for fibre [112]. These figures highlight the scarcity of literature regarding carbohydrate, fat, fibre, and fluid recommendations for pregnant women receiving dialysis. A total of 23 (10.8%) additional macronutrient recommendations were also charted [1,5,41,48,56,68,86,94,101,104–106,112,121,124,128,133,139,141,169,177,182,183], which included general commentary as well as recommendations from studies other than the ones made or prescribed by those charted in this review. Of the 136 included papers, 29 did not make any macronutrient recommendations [3,9,14,45,66,70,78,83,88,91–93,95–98,111,118,119,123,130,148,152,154–156,159,163,165].

Approximately three-quarters (72.9%) of energy recommendations were consistent with the NRV for energy in pregnancy (an additional 1.4 MJ/day in the second trimester and 1.9 MJ/day in the third trimester) or the KDOQI guideline for dialysis (25–35 kcal/kg/day). The remaining energy recommendations varied and suggested values differed to the comparative standards. In contrast, 92.5% of protein recommendations exceeded the corresponding NRV for pregnancy (58–60 g/day or 1.00–1.02 g/kg/day in the second and third trimesters) or KDOQI guidelines (1.0–1.2 g/kg/day). Approximately 6.5% of protein recommendations were consistent with these ranges, whilst only one (0.9%) was below [120]. There are no NRV or KDOQI recommendations for carbohydrate intake in pregnant women or people undertaking dialysis. Notably, the recommendations for dietary fat intake were inconsistent with the types of fat recommended by the NRV guidelines.

There was only one recommendation for fibre made (28 g/day) [112] which was consistent with the respective NRV for pregnancy of 25–28 g/day. Most (85.7%) fluid recommendations were lower than the NRV for fluid intake during pregnancy (1.8–2.3 L/day).

Recommendations for macronutrients were specific to HD in 88 publications, and PD in 19 publications. Altogether, 43 publications made macronutrient recommendations for both HD and PD, whilst 62 made recommendations that were not specific to a mode of dialysis.

3.3. Recommendations Regarding Vitamins

A total of 42 recommendations regarding vitamin intake were made across 17 studies (see Supplementary Table S4). The majority of these were for folate (40.5%), with recommendations ranging from 0.8 to 5.0 mg/day. One publication suggested 800 µg/day of vitamin A [112], whilst another advised 600 µg/day of Biotin during HD [46]. The recommendation for Vitamin a was consistent with the corresponding pregnancy NRV.

Recommended or prescribed levels of intake for vitamin C were described in five publications [37,46,89,112,149], each of which suggested a minimum intake of 170 mg/day (one of these being specific to HD). Two studies suggested 1000–2000 IU/day of 25 OH vitamin D for those undertaking HD [33,35]. Recommendations for B vitamins were described in 16 separate publications. Four studies each suggested 3 mg/day of vitamin B1, 3.4 mg/day of vitamin B2, and a minimum intake of 20 mg/day for vitamin B3 [37,46,89,149]. One recommendation for each of these B vitamins were specific to HD [46]. Suggested intakes for vitamin B6 included greater than 5 mg/day in one publication [37], and equal to or greater than 5 mg/day in three publications [46,89,149] (one of these being specific to HD) [46]. No additional vitamin recommendations were made in any of the 136 publications.

3.4. Recommendations Regarding Minerals

A total of 83 mineral recommendations for pregnant women receiving dialysis were identified in 38 papers; however there were no suggested levels of intake for Iodine, Copper, Selenium, Manganese, or Molybdenum (see Supplementary Table S5 for a detailed summary of mineral recommendations).

There were 13 recommendations regarding sodium intake. Of these, 10 exceeded the corresponding NRV and KDOQI guidelines [35,46,48,73,87,112,124,149,169,176], whilst

3 were consistent with the KDOQI guideline only [4,82,150]. Six recommendations for potassium were lower than the respective NRV [4,82,112,124,162,169], whilst six were higher [33,35,46,48,149,176].

Twenty-one studies made recommendations for calcium ranging from 800 to 2000 mg/day. Fifteen of these were above [4,33,35,37,55,67,71,72,79,82,90,121,128,129,179], five were consistent with [32,46,73,112,169], and one was below the corresponding NRV for calcium in pregnancy (1000–1300 mg/day) [68]. All five recommendations for magnesium were 200–300 mg/day [37,46,89,112,149], each less than the NRV of 350–400 mg/day. Nine studies made recommendations for iron. Of these, seven were greater than the NRV for pregnancy [2,66,112,143,149,165,174], whilst two provided a range (20–30 mg/day) that sat both above and below the NRV recommendation (27 mg/day) [33,35]. In all, 11 zinc recommendations were charted, with 8 suggesting 15 mg/day [33,35,37,46,73,89,149,182] and 3 recommending equal to or above 15 mg/day [175,177,179], all of which were greater than the NRV for pregnancy. The NRV for phosphorous during pregnancy is 1000–1250 mg/day.

Eight publications were consistent with this [35,37,46,89,112,149,162,169]; however, three made recommendations of 800 mg/day [79,124,126] and one suggested 800–1600 mg/day [129]. A total of 14 mineral recommendations charted in this review were specific to HD [33,35,46,48], whilst 11 were specific to PD [124,126,149,150,162,176], and 4 recommendations suggested intakes for both HD and PD [169]. The remaining recommendations did not explicitly state what mode of dialysis they were specific to.

3.5. Recommendations Regarding Other Commentary

Supplementary Table S6 summarises 318 recommendations regarding additional nutritionally related commentary (112; 35.2%), weight (95; 29.9%), dietary patterns (88; 27.7%), and breastfeeding (23; 7.2%). The additional commentary included, but was not limited to, supplementation, physical activity, and diabetes management.

Diet liberalisation (including calories, protein, sodium, potassium, phosphorous and/or fluid) was suggested or prescribed in 70 studies. Seven publications specifically recommended high biological value protein to ensure adequate and optimal nutrition [48,87,107,144,161,167,176]. One study stressed that culturally appropriate diets should be prescribed, with the main objective of preventing malnutrition [98]. The authors of another publication prescribed their patient a plant-based diet at the commencement of HD as per the treating nephrologist's advice [148]. This diet made the patient's request to cease HD at 31 weeks gestation possible due to stability of renal function.

Additionally, 14 publications recommended breastfeeding in dialysing patients or described cases where women on dialysis decided to breastfeed their infants [34,43,45,46,52,60,70,96,98,100,125,132,164,169]. Four studies emphasized that a review of all medications is necessary to determine their compatibility with breastfeeding [45,52,70,164]. Seven articles warned that the urea content of breastmilk may be higher in renal patients which can cause diuresis in infants [46,93,143,174,177,179,182]. Of these publications, four suggested giving water with breastmilk feedings to mitigate this issue [46,177,179,182], whilst one also recommended supplementing breastmilk feedings with formula so that the nutrient needs of infants can be met. One publication advised against breastfeeding in dialysing patients due to the low concentration of nutrients and high levels of toxic substances such as pro-inflammatory cytokines and urea in breastmilk samples [93].

Another study described significant variations in breastmilk composition between pre and post HD samples, suggesting that breastfeeding after a dialysis session is preferable to breastfeeding prior to a dialysis session [60]. The same study stressed that there is no available data on breastfeeding in PD. Three publications stated that there is a lack of literature regarding the safety or efficacy of breastfeeding in infants born to mothers with CKD [177,179,182]. Breastmilk is the best source of nutrition for an infant and also exerts health benefits for the mother. Should a woman choose to breastfeed their infant while dialysing, an extra 330 kcal/day than the weight-maintenance needs of her non-pregnant counterpart during the first 6 months postpartum, and an additional 400 kcal/day during

the second 6 months postpartum has been recommended [169]. Another study suggested increasing caloric intake by 500 kcal/day in dialysing women who wish to breastfeed [179].

According to four publications [47,66,106,165], the recommended total weight gain per singleton pregnancy in a dialysing woman with a healthy pre-pregnancy body mass index (BMI) is 11.5–16 kg. Thirteen publications advised a total weight gain of 1.0–1.5 kg in the first trimester [35,48,67,71,79,102,143,146,166,173,174,181,185]. Moreover, 19 studies suggested weight gain of 0.5 kg/week from the second trimester [1–3,35,48,52,59,60,75,77,92,118,125,146,173,175,177,179,185], whilst 12 recommended weight gain of 0.3–0.5 kg/week during the second and third trimesters of pregnancy [5,47,58,61,66,70,79,80,84,137,165,182].

Finally, 101 studies charted in this scoping review provided additional commentary regarding nutrient supplementation. Prescriptions of 1.5–2 mg/day of calcium, 0.8–5 mg/day of folate, 15 mg/day of zinc, and up to 30 mg/day of iron (preferably intravenous) were common. It was suggested that 25 OH vitamin D should be measured every trimester and supplemented if low; however, vitamins A and E should not be routinely supplemented due to risk of toxicity. Instead, doubling the dose of a water-soluble or renal-formulated vitamin was suggested, especially for intensive dialysis schedules. Other recommendations included the use of parenteral nutrition for severely decreased oral intake [37,46,78,82], lower calorie diets for patients on PD (due to calories provided by dialysate glucose absorption) [35], and regular meals and dialysis times so that daily meal, blood sugar, and insulin timing can remain constant for patients with diabetes [46]. Moderate physical activity was encouraged [110,112], and weekly follow-ups using dietary recalls and/or food intake records to evaluate nutritional adequacy in these patients was specifically suggested in two publications [175,177]. The importance of providing referral assistance to patients with low socioeconomic status to ensure access to foods and supplements that meet the increased protein and calorie needs during pregnancy was also emphasised by one publication [167].

3.6. Synthesis of Recommendations from Scoping Review Findings

A synthesis of recommendations charted in this scoping review is provided in Table 4. It is intended for clinicians requiring guidance around the nutritional management of pregnant women receiving dialysis. This synthesis is constructed using a consensus of nutritional recommendations from the current literature, clinical judgement, recently published guidance regarding vitamin requirements in CKD patients [267], and the NRVs for pregnancy or KDOQI guidelines for dialysis.

Table 4. Synthesis of nutrition recommendations for pregnant women undertaking dialysis from scoping review findings.

Macronutrients		
Energy [# †]	1st trimester: 25–35 kcal/kg/day 2nd/3rd trimesters: 25–35 kcal/kg/day + 300 kcal/day	
Carbohydrate	After protein and fat requirements have been satisfied, meet remaining calorie requirements with carbohydrate sources Factor in calories received from glucose in PD dialysate	
Protein	1.5–1.8 g/kg/day (HD/PD)	
Fat *	Linoleic acid: 10 g/day (AI) a-Linoleic acid: 1.0 g/day (AI) Total LC n-3, DHA+EPA+DPA: 110–115 mg/day (AI) Absence of hyperlipidemia: Saturated fat <7% TEI Trans fat <1% TEI Cholesterol <300 mg/day Remaining fat calories (up to 20%) distributed primarily toward monounsaturated fats and secondarily toward polyunsaturated fats	Hyperlipidemia: Saturated fat <7% TEI Total fat 25–35% TEI Cholesterol of <200 mg/day

Table 4. *Cont.*

Macronutrients	
Fibre *	25–28 g/day (AI)
Fluid †	Liberalise if undertaking daily or longer hours dialysis
Vitamins ‡	
Vitamin A	800 µg/day; do not supplement
Vitamin C	Minimum 170 mg/day
Vitamin D	1000–2000 IU/day (25 OH vitamin D/D3) (HD)
Vitamin E *	7–8 mg/day (AI); do not supplement
Vitamin K *	60 µg/day (AI); supplementation usually not necessary
Vitamin B1	3 mg/day
Vitamin B2	3.4 mg/day
Vitamin B3	Minimum 20 mg/day
Vitamin B5 *	5 mg/day (AI)
Vitamin B6	Minimum 5 mg/day
Vitamin B12 *	2.4 µg/day
Folate	Minimum 1.8 mg/day
Biotin	600 µg/day (HD)
Minerals ‡	
Sodium	Individualise but maintain reduced salt diet
Potassium	Individualise and liberalise if undertaking daily or longer hours dialysis
Calcium	1500–2000 mg/day
Magnesium	200–300 mg/day
Iron	Minimum 30 mg/day
Zinc	Minimum 15 mg/day
Phosphorous	Approximately 1200 mg/day (RDI)
Iodine *	220 µg/day (RDI)
Copper *	1.2–1.3 mg/day (AI)
Selenium *	65 µg/day (RDI)
Manganese *	5 mg/day (AI)
Molybdenum *	50 µg/day (RDI)
Nutrient Supplementation ‡	
Vitamins	
✓ Double regular daily dose of standard water-soluble or renal vitamin supplements especially if undertaking daily or longer hours dialysis.	
✓ Supplementation of vitamin A is usually contraindicated as it is non-dialysable and can lead to toxicity. For this reason, standard prenatal vitamins are not recommended.	
✓ Measure 25 OH vitamin D every trimester and supplement if low; use serum levels, calcium/phosphate	
✓ balance, and PTH to guide supplement dosages.	
✓ Supplementation of vitamins E and K are not usually necessary. However, if a patient has low food vitamin K intake combined with prolonged antibiotic therapy, 10 mg/day of vitamin K is advised.	

Table 4. *Cont.*

Minerals
✓ Supplement up to 2 g/day of calcium carbonate as required (i.e., if dietary intake is insufficient or in cases of hypocalcaemia); if used for supplementation only, calcium carbonate should be given apart from meals for
✓ better calcium absorption.
✓ Oral phosphate supplementation as required (i.e., in cases of hypophosphataemia or long-hour daily HD). Phosphate binders may not be needed due to increased absorption of calcium from dialysate with more
✓ frequent dialysis. However, if required, calcium-containing supplements are usually given due to increased calcium needs of the developing foetus.
✓ Supplement vitamin B12 as necessary (based upon serum levels).
✓ Supplement up to 15 mg/day zinc as required.
✓ Supplement up to 5 mg/day folate.
✓ Provide IV iron as required at no more than 62.5–100 mg/dose to avoid deposition in the foetus (oral
✓ supplementation is less well absorbed).
✓ Supplement oral magnesium as required especially if undertaking daily or longer hours dialysis.
Dietary Patterns
• Generally, diet can be liberalised if doing daily or longer hours of dialysis (particularly for protein, sodium, potassium, phosphorous, and fluid).
• Ensure the dietary pattern is balanced to ensure adequate foetal growth and maternal health. A healthy dietary pattern contains fruit, vegetables, wholegrain breads and cereals, legumes, nuts and lean sources of red meat, chicken, and fatty fish. It is recommended women avoid excessive added sugars, ultra-processed foods, and saturated fats.
• Encourage high biological value protein where possible to ensure adequate and optimal nutrition in the context of increased protein losses during intensive dialysis.
• Consider factors such as culture, health literacy, and socioeconomic status when prescribing medical nutrition therapy to patients and provide support where possible to ensure equitable access to food and supplements that meet the increased energy/nutrient needs of these pregnancies.
Weight
• Anticipate weight gain of approximately 1.0–1.5 kg in the 1st trimester, and up to 0.5 kg/week from the 2nd trimester.
• Aim for a total weight gain of approximately 11.5–16 kg per singleton pregnancy with a healthy pre-pregnancy BMI. For women who are overweight, pregnancy weight gain should be 7–11.5 kg.
Breastfeeding ‡
• Breastfeeding is the best source of nutrition for infants and mothers. Breastfeeding should be encouraged in dialysing mothers who so desire; however, a review of medications for breastfeeding compatibility is necessary. It is also necessary to consider technical aspects to facilitate breastfeeding in women undertaking dialysis. For example, use of one arm, placement of cots next to a machine, assistance with infants to attach.
• Breastmilk concentration of urea varies between pre and post HD samples. It is suggested that women express after a dialysis session. The higher urea content of breastmilk could potentially provoke diarrhoea in infants and contribute to infant dehydration secondary to infant inability to handle large solute loads. Therefore, adequate water should be given with breastmilk feedings to prevent this problem.
• Mothers who choose to breastfeed should increase their daily energy intake by approximately 400–500 kcal/day.

[#] Take into account energy expenditure, body mass index, pregnancy weight gain, and mode of renal replacement therapy (with the higher end of these ranges generally for HD). * Evidence unclear, recommendations developed with clinical judgement and adapted from references [30]. [†] Take into account urine output and mode of renal replacement therapy. [‡] Individualise according to serum concentrations, blood pressure, medications, hydration status, and mode of renal replacement therapy (with the higher end of these ranges generally for HD). [‡] Assess on an individual basis. Legend: PD, peritoneal dialysis; HD, haemodialysis; AI, adequate intake; TEI, total energy intake; RDI, recommended daily intake; PTH, parathyroid hormone; BMI, body mass index.

4. Discussion

Nutrition plays a pivotal role in optimising the health outcomes of people with kidney disease. This scoping review intended to collate and synthesise nutritional recommendations for pregnant women undertaking dialysis, identify where gaps in the current literature exist, and propose recommendations that will inform clinical practice.

From the 136 publications charted in this review, it is clear that recommendations regarding vitamin and mineral intake are scarce and/or vary widely. The number of

recommendations concerning energy, protein, dietary patterns, weight, and nutrient supplementation is considerable; however, specific suggestions for carbohydrate, fat, fibre, and fluid intake as well as breastfeeding are lacking. The recently published literature regarding the haemodialysis prescription for pregnant women also failed to provide in depth guidance [26,193,266,268]. Evidently, nutritional recommendations in this field are still lacking, forcing healthcare providers to rely heavily on clinical judgement in an area of significant uncertainty.

This scoping review also highlighted significant heterogeneity between recommendations, particularly those regarding energy, protein, dietary patterns, weight, breastfeeding, and supplementation. Inconsistencies between the published guidance may be attributed to the sizeable time span over which the included sources of evidence were published, along with the anecdotal nature of recommendations provided by position papers, case reports/case series, and editorials.

Additionally, where recommendations were made to a specific mode of dialysis, HD dominated the majority of these recommendations. This is likely because the incidence of pregnancy in women on PD is lower than for HD due to challenges posed by high dialysate osmolality, fallopian tube injury secondary to peritoneal infection, risk of small-for-gestational-age infants, and technical difficulties with the volume and frequency of exchanges that can be provided as pregnancy progresses [5,26]. The discrepancies between recommendations and a paucity of data regarding the nutritional management of pregnant dialysing patients, especially for those on PD, presents a significant challenge for healthcare professionals when providing specific medical nutrition therapy or nutritionally related advice for this patient population.

Several limitations exist within this scoping review. For instance, the grey literature was limited to those written in English only. Therefore, despite an extensive search strategy, relevant publications may have been missed. Additionally, many included sources of evidence were more than two decades old and may not reflect current dialysis practices utilised for pregnant women.

Variance in the details of nutritional recommendations reported across the literature contributed to the heterogeneity of data extracted, and thus posed challenges with synthesising and interpreting the results. Heterogeneity in the reporting of other information was also apparent. For example, we were unable to report comprehensive information on the demographics, baseline biochemistry or anthropometry. Pre-existing supplement use and adherence was also variable and may have influenced nutrient needs. Although not mandatory in the scoping review process, an appraisal of methodological quality was not completed. Hence, the quality of evidence and risk of bias of studies within this review was not assessed but is likely to be very low. A strength of this review was the broad systematic search strategy used across five bibliographic databases as well as the grey literature. As a result, a wide range of relevant evidence in the field was explored. The use of scoping review methodology enabled the available literature to be exhaustively mapped to identify knowledge gaps and discrepancies.

As a result of this scoping review, we have constructed several recommendations for the nutritional management of pregnant women receiving dialysis. Firstly, pregnancy planning should be undertaken so that patients and the multidisciplinary team can prepare for this high-risk situation. Mothers must be counselled on the risks that these pregnancies carry, and information provided where possible in advance about the significant changes that will occur to dialysis regimens, medications, nutrition, and dry weight. These changes are critical to ensure that foetal growth and the demands of pregnancy can be accommodated [25,26,70]. Comorbid conditions, such as diabetes and hypertension, should also be well managed prior to pregnancy to optimise health outcomes for mothers and their infants [26,70].

Secondly, pre-conception dietetic counselling should be provided to patients so that plans for medical nutrition therapy can be devised and their nutritional status optimised in advance. Pregnancy itself results in increased nutritional requirements so that maternal

metabolism can be maintained, and foetal development supported [269]. It has been shown that standard dialysis sessions (i.e., 4 h three times weekly) [270] can result in the removal of up to 12 g of amino acids, 600–1200 mg of phosphate, and 60–150 mmol of potassium [270–273]. Depletion of folic acid, vitamin B6, vitamin C, iron, and zinc has also been demonstrated [274,275]. Dialysis regimens during pregnancy are commonly intensified to 36 h/week over 5–7 sessions [268], leading to an even greater loss of these nutrients from the blood. Therefore, patients planning to conceive must be counselled about the necessary changes to their dietary prescription, including the need for diet liberalisation and supplementation. Individualised strategies to optimise nutrition should also be provided pre-conception, with consideration of the socioeconomic status and cultural background of each patient.

Thirdly, we suggest that clinicians use the summary of evidence provided in Table 4 as a starting point to inform their decisions regarding medical nutrition therapy for pregnant dialysing patients. Additional adjustments may also be required in those undertaking intensive daily dialysis regimens due to significantly greater nutrient losses from the blood. In these circumstances, vitamin and mineral supplementation will be required.

Lastly, interdisciplinary collaboration is critical in the management of the pregnant dialysing woman. Regular case conferencing between members of the dietetics, social work, nephrology, obstetrics and gynaecology, midwifery and critical care teams is necessary. While the safe arrival of the infant is paramount, there are ongoing challenges to mothers managing babies and children when maintaining regular dialysis for the longer term, and discussion about how these challenges will be managed by the kidney care team are also important.

Areas for future work in this field include qualitative research exploring the experiences and perspectives of pregnant women receiving dialysis and empirical studies exploring losses of protein, water-soluble vitamins, and minerals during intensive dialysis (i.e., 36 h/week over 5–7 sessions). This would assist clinicians to develop more accurate insights into the nutrient prescription and patient-centred approaches to care required by these patients. Furthermore, although there has been a 90% increase in the pregnancy success rate of this population since the year 1980 [75], the health outcomes of these women and guidelines for dietetic follow up after these pregnancies remain unclear. Therefore, we also recommend that women who have had pregnancies on dialysis should receive ongoing dietetic input and be monitored regularly postpartum to ensure optimal nutritional status in the long term. Future research examining foetal outcomes would also be useful.

5. Conclusions

This scoping review provides an exhaustive overview of nutritional recommendations for pregnant women receiving dialysis. While significant knowledge gaps and inconsistencies remain, several recommendations to inform the nutritional management of this population have been constructed. These recommendations are critical to the provision of proactive, effective, and collaborative nutritional care in this patient population, so that maternal and foetal health outcomes may be optimised.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/kidneydial4010005/s1, Figure S1: PRISMA flow diagram of study selection; Table S1: Grey literature search strategy; Table S2. Scoping review eligibility criteria; Table S3. Macronutrient recommendations from the literature for pregnant women receiving dialysis; Table S4. Vitamin recommendations from the literature for pregnant women receiving dialysis; Table S5. Mineral recommendations from the literature for pregnant women receiving dialysis; Table S6. Other relevant commentary from the literature regarding pregnant women receiving dialysis; Table S7. Summary of included case reports/case series.

Author Contributions: Conceptualization, E.C. and K.L.; methodology, E.C. and K.L.; formal analysis, E.C. and K.L.; data curation, E.C.; writing—original draft preparation, E.C.; writing—review and editing, E.C. and K.L.; supervision, K.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created as part of this research.

Conflicts of Interest: The authors declare no conflicts of interest.

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