An integrative review of the methodology and findings regarding dietary adherence in end stage kidney disease

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Abstract

Background: Dietary modification is an important component of the management of end stage kidney disease (ESKD). The diet for ESKD involves modifying energy and protein intake, and altering sodium, phosphate, potassium and fluid intake. There have been no comprehensive reviews to date on this topic. The aims of this integrative review were to (i) describe the methods used to measure dietary adherence (ii) determine the rate of dietary adherence and (iii) describe factors associated with dietary adherence in ESKD.

Methods: The Web of Science and Scopus databases were searched using the search terms ‘adherence’ and ‘end stage kidney disease’. Of the 787 potentially eligible papers retrieved, 60 papers of 24,743 patients were included in this review. Of these papers, 44 reported the rate of dietary adherence and 44 papers described factors associated with adherence.

Results: Most of the evidence regarding dietary adherence is derived from studies of hemodialysis patients (72% of patients). The most common method of measuring dietary adherence in ESKD was subjective techniques (e.g. food diaries or adherence questionnaires). This was followed by indirect methods (e.g. serum potassium, phosphate or interdialytic weight gain). The weighted mean adherence rate to ESKD dietary recommendations was 31.5% and 68.5% for fluid recommendations. Adherence to protein, sodium, phosphate, and potassium recommendations were highly variable due to differences in measurement methods used, and were often derived from a limited evidence base. Socioeconomic status, age, social support and self-efficacy were associated with dietary adherence. However, factors such as taste, the impact of the diet on social eating occasions; and dietetic staffing also appear to play a role in dietary adherence.

Conclusion: Dietary adherence rates in people with ESKD are suboptimal. Further research is required on dietary adherence in patients with ESKD from different social, educational, economic and ethnic groups. This research may identify other factors which may impact upon adherence, and could be used to inform the design of future strategies to improve dietary adherence. Future research that reports not just the rate of adherence to individual components of the nutrient prescription but also the overall quality of the diet would be useful.

Keywords: Dietary adherence, Self-management, End stage kidney disease, Adherence, Compliance, Chronic kidney disease, Dialysis; fluid restriction, Potassium, Phosphate

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Background
The prevalence of Chronic Kidney Disease (CKD) is increasing rapidly [1]. Driven by an aging population and increasing rates of obesity, diabetes and hypertension, approximately 1 in 8 adults globally are known to have CKD [2]; and it is estimated that about 2% of these individuals with CKD will progress to End Stage Kidney Disease (ESKD) [3]. An appropriate diet can slow progression of CKD to ESKD [4]; ameliorate the complications of CKD and ESKD [5–8], and increase survival [9, 10], making dietary modification a critical part of the management of CKD and ESKD [11].

There is no standard renal diet. Instead, a progressive accumulation of dietary restrictions occurs as patients’ progress from CKD to ESKD. Typically, people with early CKD need to modify their intake of protein and sodium. In contrast, people with ESKD need to modify their intake of kilojoules; their fluid and protein intake; reduce their intake of minerals, such as sodium, potassium and phosphate; and potentially increase their intake of vitamins and minerals, such as vitamin C, B, folate, B12 and zinc [12]. Because of the large number of dietary modifications required, the diet for people with ESKD is considered by dietitians to be one of the most complex and restrictive therapeutic diets [13, 14]. Adults with ESKD also perceive diet to be complicated and contradictory to typical healthy eating advice [15, 16]. For example, fruits, vegetables and dairy products are often restricted in ESKD due to their potassium or phosphate content.

In addition to these challenges, the diets for people with CKD and ESKD (hereafter referred to as the renal diet for simplicity) also changes when patients commence or change the type of renal replacement therapy. For example, people receiving hemodialysis are routinely required to restrict dietary potassium intake, whereas those undertaking peritoneal dialysis are not [27]. These subtle differences in the renal diet prescription, combined with conflicting dietary advice between health professionals [16], are often cited as an ongoing source of frustration, bewilderment and confusion for people with ESKD [16, 17]. Given the challenges imposed by the renal diet, it is unsurprising that dietary adherence is often reported to be poor [18, 19].

Adherence, also used interchangeably with the term ‘compliance’, is frequently cited as: “the degrees to which patient behaviours coincide with the recommendations of health care providers” ([20], page S188). Previous researchers have investigated adherence to various ESKD treatment components, such as medications [21]; phosphate binders [22]; hemodialysis attendance [23], and peritoneal dialysis treatments [24]. However, dietary adherence in people with ESKD is more complex and has not been explored in detail. The limited evidence that is available suggests that dietary adherence rates vary greatly between studies [25]. It is also unclear if adherence varies between the individual nutrients modified in the dietary regimen for people with ESKD. A better understanding of dietary adherence in ESKD is critical because poor dietary adherence is associated with worse health outcomes [26, 27]. Improved knowledge and understanding of the issues associated with renal diet adherence may translate to improved dietary management strategies and improved health outcomes. Therefore, the aim of this integrative review is to provide a comprehensive summary of the evidence regarding dietary adherence in people with ESKD. The specific research questions posed in this integrative review were:

1. What methods have been used to measure dietary adherence in adults with ESKD?
2. What is the estimated rate of dietary adherence in adults with ESKD?
3. What factors are associated with dietary adherence in adults with ESKD?

Methods
Integrative reviews provide a comprehensive understanding of a complex phenomenon by synthesising qualitative and quantitative literature [28]. To increase rigour, this integrative review utilised methodology described by previous authors [29, 30]. In brief, this methodology includes clearly delineating the focus of the research question/s, undertaking a well-defined literature search strategy, systematically evaluating studies and compiling a transparent collation of findings.

Literature search
Comprehensive searches of the Web of Science and Scopus databases were conducted during April 2015. The key words ‘adherence’ and ‘end stage kidney disease’ were used to identify suitable peer reviewed journal articles. The corresponding MeSH terms and Boolean operators used to retrieve articles in these searches are shown in Table 1. The reference lists of retrieved studies and review articles were also hand searched for additional relevant publications.

Inclusion criteria
Studies considered eligible for inclusion were any experimental, observational or qualitative studies that included

| Table 1 Search terms used in integrative review of dietary adherence in end stage kidney disease |
| Search term | MeSH terms used |
|--------------|----------------|
| Adherence    | adheren*OR non adheren* OR non-adheren* OR complian* OR non complian* |
| End stage kidney disease | end stage kidney failure OR end stage renal failure OR end stage renal disease |

* indicates truncation to find variations of root term
human adults with ESKD (stage 4 or 5 CKD, conserva-

tively managed or on any renal replacement therapy mo-

dality); (ii) reported either the rate of dietary adherence or

examined factors associated with dietary adherence; (iii)

reported the results in English and (iv) were available in

full text. Editorials, practice guidelines, review articles,

paediatric studies, studies not in English and studies not

reporting the rate of dietary adherence were excluded

from the analyses. Dates of publication were restricted to

2000–2015. This coincided with the release date of the

first clinical practice guidelines for the nutritional man-

agement of chronic kidney disease [31].

Data extraction

Extracted data from the eligible included studies were

compiled into three summary tables to assist with inter-

pretation and synthesis of the results. Table 2 is com-

prised of all studies included in this integrative review

and contains a description of the salient features of each

study. Table 3 contains the rates of adherence to the

renal diet. Table 4 outlines the factors associated with
dietary adherence in ESKD.

Results

The number of potential articles relevant for review was

787 (see Fig. 1). An additional 85 articles were identified

after hand searching the references. Following the re-

moval of duplicates and irrelevant articles, a total of 60

articles were included in this review. Of the 60 studies,

16 reported the rate of dietary adherence; 28 studies re-

ported both the rate of adherence and factors associated

with adherence; and 16 studies only contained details re-

garding factors associated with adherence (Fig. 1). For

the final synthesis of findings, a total 44 articles reported

the rate of dietary adherence, and 44 articles described

d factors associated with dietary adherence in ESKD.

A summary of the 60 studies included in this integrative

review are shown in Table 2. Overall, a total of 24,743

adults with ESKD were studied, and sample sizes in the

studies varied from 4 people [32] to more than 7000 [27].

Most of these studies were conducted in Asia (17 studies,

28%) or the USA (16 studies, 27%), followed by studies

conducted in the United Kingdom (9 studies, 15%) and

Europe (8 studies, 13%) (Table 2). Two studies were tran-

scontinental in nature involving the USA and Germany

[33]; as well as Europe, the USA and Japan [27]. The

majority of the data on dietary adherence was from studies

involving people with ESKD undertaking hemodialysis (43

studies, 72%); followed by people undertaking peritoneal
dialysis (7 studies, 12%). Only two studies included people

with a kidney transplant (3%). More than half of all in-
cluded studies were cross-sectional observational studies

(\(n = 31\) studies, 52%), and only four studies (6%) were

qualitative in nature [13, 34–36].

Methods used to measure dietary adherence in ESKD

Of the 60 articles in this review, a range of approaches
to measure dietary adherence were evident. These are

summarised in Table 2, and can be broadly categorised

into the use of subjective approaches (28 studies, 47%),

indirect approaches (23 studies, 38%), and combination

approaches (9 studies, 15%).

Subjective approaches

Of the 28 studies that used a subjective approach to mea-

suring dietary adherence in ESKD, there were 15 variations

of how this was conducted. These are shown in Table 2. The

most common method described was the use of the

Dialysis Diet and Fluid Non Adherence Questionnaire

(DDFQ) [37], a four item self-report instrument that

probes the severity and duration of renal diet and fluid re-

striction non-adherence. This instrument has been de-

monstrated to be weakly correlated indirect measures of
dietary adherence including interdialytic weight gain,

serum albumin, serum potassium and serum phosphate

[37]. The DDFQ was used as the only method to measure

dietary adherence in seven studies [33, 37–42]. Other com-

mon methods for collecting subjective information about di-

etary adherence included various iterations of food records

such as 24 h recalls [43], 3 day food recalls [44], 2 day food

recalls [45, 46], 3 day food records [47–50], and food fre-

quency questionnaires [51–54]. Other subjective methods

included the use of stress scales relating to the diet [55] or

self-reported adherence [35, 36, 56].

Indirect approaches

There were 23 studies that used an indirect approach to

measuring dietary adherence. Interdialytic weight gain

(IDWG), which refers to the fluid gain in kilograms gained

between hemodialysis sessions, was the most frequently

reported indirect method for measuring dietary adherence

(16 studies, Table 2). This was followed by 10 studies using

blood tests to measure serum potassium, phosphate, al-

bumin [57, 58], or urea [59] and urine collections to meas-

ure volume or sodium (2 studies, [60, 61]). Ten studies

used IDWG in isolation to measure adherence [62–71].

Five studies used only blood tests to measure adherence

[59, 72–75].

Combination approaches

A combination approach was used in nine studies, with

the combination of blood tests, the DDFQ, and IDWG

being the most common (Table 2). This type of combi-

nation approach theoretically provides information re-
garding adherence to the overall renal diet, fluid intake

and adherence to the low potassium and low phosphate
components of the renal diet. Another common combina-

tion approach reported was the use of IDWG and food

recalls or food records (3 studies).
| Authors                        | Patient numbers | Location | ESKD group | Type of study                  | Approach used to measure adherence | Methods used to measure adherence | Reports adherence rate | Reports factors associated with adherence |
|-------------------------------|----------------|----------|------------|--------------------------------|------------------------------------|-----------------------------------|-----------------------|--------------------------------------------|
| Agondi et al., 2011 [51]      | 117            | Brazil   | HD         | Cross sectional study         | Combination                        | IDWG, FFQ                        | ✓                     | ✓                                          |
| Ahrari et al., 2014 [38]      | 237            | Iran     | HD         | Cross sectional study         | Subjective                         | DDFQ                              | ✓                     | ✓                                          |
| Antunes et al., 2010 [47]     | 79             | Brazil   | HD & PD    | Prospective observational study | Subjective                         | 3 day food record                 | ✓                     |                                            |
| Baraz et al., 2010 [59]       | 63             | Iran     | HD         | RCT                            | Indirect                           | Blood tests                       | ✓                     | ✓                                          |
| Barnett et al., 2007 [62]     | 26             | Malaysia | HD         | Pre post intervention          | Indirect                           | IDWG                              | ✓                     |                                            |
| Casey et al., 2002 [63]       | 21             | England  | HD         | Prospective observational study | Indirect                           | IDWG                              | ✓                     |                                            |
| Chan et al., 2012 [88]        | 188            | Malaysia | HD         | Cross sectional study          | Combination                        | DDFQ, bloods, IDWG                | ✓                     | ✓                                          |
| Chan et al., 2010 [30]        | 173            | Hong Kong| PD         | Cluster analysis               | Subjective                         | DDFQ                              | ✓                     | ✓                                          |
| Chen et al., 2006 [48]        | 70             | China    | PD         | Prospective cohort study       | Subjective                         | 3 day food record                 | ✓                     |                                            |
| Clark-Cutaia et al., 2014 [44]| 122            | USA      | HD         | Secondary analysis of baseline RCT data | Combination                        | IDWG, 3 day food recall           | ✓                     |                                            |
| DeBrito-Ashurst et al., 2011 [34] | 20         | England  | CKD        | Qualitative study using focus groups | Subjective                         | Focus group                       | ✓                     |                                            |
| DeBrito-Ashurst et al., 2013 [61] | 56         | England  | CKD        | RCT                            | Indirect                           | Urine specimen                    | ✓                     |                                            |
| Dowell et al., 2006 [32]      | 4              | USA      | HD         | Pre post intervention          | Subjective                         | Food diary                        | ✓                     |                                            |
| Durose et al., 2004 [72]      | 71             | UK       | HD         | Cross sectional study          | Indirect                           | Blood tests                       | ✓                     | ✓                                          |
| Eliot et al., 2015 [84]       | 95             | USA      | HD         | Cross sectional study          | Combination                        | PAPM, blood tests                 | ✓                     | ✓                                          |
| Ford et al., 2004 [73]        | 70             | USA      | HD         | Pre post intervention          | Indirect                           | Blood tests                       | ✓                     |                                            |
| Gordon et al., 2010 [36]      | 88             | USA      | KT         | Qualitative interviews         | Subjective                         | Self-report                       | ✓                     |                                            |
| Gordon et al., 2009 [35]      | 82             | USA      | KT         | Qualitative interviews         | Subjective                         | Self-report                       | ✓                     |                                            |
| Harvinder et al., 2013 [45]   | 245            | Malaysia | HD & PD    | Cross sectional study          | Subjective                         | 2 day food recall                 | ✓                     |                                            |
| Hecking et al., 2004 [78]     | 3039           | Europe*a | HD         | Prospective observational study | Indirect                           | Blood tests, IDWG                 | ✓                     |                                            |
| Hollingdale et al, 2008 [13]  | 20             | England  | NDCKD & dialysis | Qualitative study using two focus groups | Subjective                         | Focus group                       | ✓                     |                                            |
| Johansson et al., 2013 [49]   | 106            | England  | HD & PD    | Cross sectional study          | Subjective                         | 3 day food record                 | ✓                     |                                            |
| Kara et al., 2007 [40]        | 160            | Turkey   | HD         | Cross sectional study          | Subjective                         | DDFQ                              | ✓                     |                                            |
| Karavetian et al., 2014 [91]  | 570            | Lebanon  | HD         | RCT                            | Subjective                         | 3 day food recall, DNAQ           | ✓                     |                                            |
| Khalil et al., 2011 [76]      | 100            | USA      | HD         | Cross sectional study          | Combination                        | DDFQ, bloods, IDWG                | ✓                     |                                            |
Table 2: Summary table of studies describing rates or factors associated with dietary adherence in ESKD (n = 60 studies of 24,743 patients) (Continued)

| Authors                          | Patient numbers | Location     | ESKD group | Type of study | Approach used to measure adherence | Methods used to measure adherence | Reports adherence rate | Reports factors associated with adherence |
|----------------------------------|-----------------|--------------|------------|---------------|------------------------------------|----------------------------------|------------------------|------------------------------------------|
| Khalil & Darawad, 2014 [87]      | 190             | Jordan       | HD         | Cross sectional study | Combination                      | DDFQ, bloods, IDWG              | ✓                      | ✓                                        |
| Khoueiry et al., 2001 [52]       | 70              | USA          | HD         | Cross sectional study | Subjective                        | FFQ                              | ✓                      | ✓                                        |
| Kugler et al., 2011 [41]         | 456             | Germany & USA| HD         | Cross sectional study | Subjective                        | DDFQ                             | ✓                      | ✓                                        |
| Kugler et al., 2005 [33]         | 916             | Germany & Belgium | HD     | Cross sectional study | Subjective                        | DDFQ                             | ✓                      | ✓                                        |
| Lam et al., 2010 [42]            | 173             | Hong Kong    | PD         | Cross sectional study | Subjective                        | DDFQ                             | ✓                      | ✓                                        |
| Lee et al., 2002 [56]            | 62              | Hong Kong    | HD         | Cross sectional study | Combination                       | Self-report, bloods, IDWG       | ✓                      | ✓                                        |
| Lindberg et al., 2009 [64]       | 4498            | Sweden       | HD         | Retrospective observational study | Indirect                          | IDWG                             | ✓                      | ✓                                        |
| Mellon et al., 2013 [19]         | 50              | Ireland      | HD         | Cross sectional study | Indirect                          | Blood tests, IDWG               | ✓                      | ✓                                        |
| Molaison et al., 2003 [65]       | 316             | USA          | HD         | RCT            | Indirect                          | IDWG                             | ✓                      | ✓                                        |
| Mason et al., 2014 [60]          | 47              | Australia    | NDCKD      | Cross sectional study | Indirect                          | Urine specimen                   | ✓                      |                           |
| Mok et al., 2001 [55]            | 50              | Hong Kong    | HD         | Cross sectional study | Subjective                        | Stress scale                     | ✓                      |                           |
| Moreira et al., 2013 [77]        | 130             | Portugal      | HD         | Prospective observational study | Subjective                        | 3 day food record                | ✓                      |                           |
| Morales Lopez et al., 2007 [58]  | 34              | USA          | HD         | Cross sectional study | Indirect                          | Blood tests, IDWG               | ✓                      | ✓                                        |
| O'Connor et al., 2008 [66]       | 73              | Scotland     | HD         | Prospective observational study | Indirect                          | IDWG                             | ✓                      | ✓                                        |
| Paes-Barreto et al., 2013 [43]   | 89              | Brazil       | NDCKD      | RCT            | Subjective                        | 24 h food recall                 | ✓                      | ✓                                        |
| Pang et al., 2001 [67]           | 92              | China        | HD         | Cross sectional study | Indirect                          | IDWG                             | ✓                      | ✓                                        |
| Park et al., 2008 [80]           | 160             | South Korea  | HD         | Cross sectional study | Indirect                          | Blood tests, IDWG               | ✓                      | ✓                                        |
| Poduval et al., 2003 [74]        | 117             | USA          | HD         | Cross sectional study | Indirect                          | Blood tests                      | ✓                      |                           |
| Quan et al., 2006 [50]           | 30              | China        | PD         | Prospective observational study | Subjective                        | 3 day food record                | ✓                      | ✓                                        |
| Russell et al., 2011 [57]        | 19              | USA          | HD         | Pre post intervention | Indirect                          | Blood tests, IDWG               | ✓                      |                           |
| Rocco et al., 2002 [46]          | 1000            | USA          | HD         | Analysis of baseline results of RCT | Combination                    | 2 day food recall, bloods        | ✓                      |                           |
| Sagawa et al., 2001 [93]         | 10              | Japan        | HD         | Pre post intervention | Combination                       | IDWG, 5 day food record          | ✓                      |                           |
| Saran et al., 2003 [27]          | 7676            | USA, Europe, Japan | HD     | Prospective observational study | Indirect                          | Blood tests, IDWG               | ✓                      | ✓                                        |
| Sharp et al., 2005 [68]          | 56              | Scotland     | HD         | RCT            | Indirect                          | IDWG                             | ✓                      | ✓                                        |
| Sutton et al., 2001 [82]         | 34              | England      | PD         | Cross sectional study | Subjective                        | 5 day food record                | ✓                      |                           |
Estimated rates of dietary adherence in ESKD

Details regarding the estimated rates of dietary adherence in ESKD were obtained from 44 studies (n = 23,117 adults with ESKD). The rates of adherence from the 44 individual studies are shown in Table 3, and the weighted mean adherence rates for the various components of the dietary prescription for ESKD are summarised in Table 4. The weighted mean adherence rates ranged from 2.9% for fibre recommendations to 85.6% for adherence to the low potassium diet (Table 4). The overall rate of adherence to the renal diet was estimated to be 31.5%.

Attempts to compare dietary adherence rates within or between the various components of the renal diet are difficult. This is due to the highly heterogeneous nature of the study participants and the varying methods used to determine adherence. For example, as shown in Table 3, the gender balance of males in the studies varied from 35% [58] to 71.7% [49]. Studies also included cohorts with a known history of non-adherence [68], high rates of depression [76], high rates of malnutrition [77] or large numbers of highly illiterate adults with ESKD [39, 56]. Furthermore, studies varied according to whether participants were from a single centre, or were from large multi-centre, and/or transcontinental studies. However, to provide some clarity regarding the estimated rates of dietary adherence, the four most frequently reported types of dietary adherence studies are discussed further in the following sections.

Fluid restricted diets

Fluid restrictions are recommended for people with ESKD, and are used to prevent fluid overload and pulmonary oedema. Fluid restricted diets are typically in the range of 1000-1500 ml of fluid per day. For those who have received a kidney transplant, fluid restrictions are not recommended and instead a higher fluid intake is suggested (usually >3000 ml per day [35, 36]). Most studies that report adherence to fluid recommendations in this review were conducted using people undertaking hemodialysis (24 studies), and IDWG was the most frequently used method of measuring adherence.

Overall, adherence rates to fluid recommendations varied from as low as 0% in a population known to be non-adherent [68] to as high as 96.6% [78]. The only two studies which examined adherence to fluid recommendations in people undertaking peritoneal dialysis [39, 42], using the DDFQ to measure adherence found that the adherence rates were between 64 and 85%. In contrast, only one third of adults with a kidney
| Authors, Year, Country | N / gender % male | CKD stage / RRT modality | Adherence Measurement Tool | Reported dietary adherence rate (%) |
|------------------------|-------------------|--------------------------|---------------------------|-------------------------------------|
| Ahrari et al., 2014, Iran [38] | 237 / 57.7 | HD | DDFQ | Renal diet: 58.9, Fluid: 54.8 |
| Antunes et al., 2010, Brazil [47] | 79 / 60.7 | HD & PD | 3 day food recall | Protein: 43.0 |
| Baraz et al., 2010, Iran [59] | 63 / 52.4 | HD | Serum urea, uric acid, creatinine, K, PO4 | |
| Barnett et al., 2007, Malaysia [62] | 26 / 50.0 | HD | IDWG | |
| Casey et al., 2002, England [63] | 21 / 52.0 | HD | IDWG | |
| Chan et al., 2012, Hong Kong [88] | 188 / 48.9 | HD | DDFQ | 36.2, Energy: 48.4 |
| Chan et al., 2010, Hong Kong [39] | 76 / 39.5 | PD | DDFQ | 65.8, Protein: 85.0 |
| Durose et al., 2004, United Kingdom [72] | 71 / 58.0 | HD | Serum PO4, K and IDWG | 77.0, K: 69.0, Na: 96.0 |
| Elliott et al., 2015, USA [84] | 95 / 57.0 | HD | PAPM | 32.6 |
| Gordon et al., 2009, USA [35] | 82 / 57.3 | KT | Self-report | 33.0 |
| Gordon et al., 2010, USA [36] | 88 / 58.0 | KT | Self-report | 35.0 |
| Harvinder et al., 2013, Malaysia [45] | 52 / 51.0 | PD | 2 day food recall | 11.0, CHO: 21.0 |
| | 38 | PD | | 23.0 |
| | 107 / 59.0 | HD | | 25.0, CHO: 33.0 |
| | 48 | HD | | 16.0 |
| Hecking et al., 2004, UK [78] | 620 / 62.0 | HD | Serum phosphate, potassium and IDWG | 96.6, K: 77.1, Na: 90.2 |
| Hecking et al., 2004, Spain [78] | 576 / 57.0 | | | 92.5, K: 77.4, Na: 72.7 |
| Hecking et al., 2004, Italy [78] | 600 / 57.0 | | | 82.3, K: 84.5, Na: 72.0 |
| Hecking et al., 2004, France [78] | 571 / 84.6 | HD | | 94.4, K: 61.5, Na: 84.6 |
| Hecking et al., 2004, Germany [78] | 672 / 57.0 | HD | | 85.7, K: 78.7, Na: 89.1 |
| Johansson et al., 2013, England [49] | 106 / 71.7 | HD & PD | 3 day food record | 20.0, Fat: 60.0 |
| Kara et al., 2007, Turkey [40] | 160 / 57.5 | HD | DDFQ | 49.1, CHO: 31.9 |
| Khalil et al., 2011, USA [76] | 100 / 44.0 | HD | DDFQ | 66.0, CHO: 50.0 |
| Khalil and Darawad, 2014, Jordan [87] | 190 / 54.0 | HD | DDFQ | 27.0, CHO: 23.0 |
| | | | Serum bloods | 46.0, CHO: 20.0 |
| | | | IDWG | 50.0 |
| Authors, Year, Country | N / gender % male | CKD stage / RRT modality | Adherence Measurement Tool | Renal diet | Fluid | Energy | Protein | PO4 | K | Na | Fat | CHO | Fibre |
|------------------------|-------------------|-------------------------|---------------------------|------------|-------|--------|---------|-----|---|----|-----|-----|------|
| Khoueiry et al., 2001, USA [52] | 70 / 54.0 | HD | FFQ | 31.4 | 48.6 | 7.1 | 94.3 | 2.9 |
| Kugler et al., 2011, Germany and USA [41] | 456 / 57.9 | HD | DDFQ | 19.6 | 25.7 |
| Kugler et al., 2005, Germany and Belgium [33] | 916 / 52.9 | HD | DDFQ | 18.6 | 25.4 |
| Lam et al., 2010, Hong Kong [42] | 173 / 51.0 | PD | DDFQ | 38.0 | 64.0 |
| Lee et al., 2002, Hong Kong [56] | 62 / 50.0 | HD | Self-report | Serum PO4, K | 35.0 | 43.5 | 61.0 |
| Lindberg et al., 2009, Sweden [64] | 4498 / 60.3 | HD | IDWG | 40.3 |
| Mellon et al., 2013, Ireland [19] | 50 / 60.0 | HD | Serum PO4, K and IDWG | 38.0 | 72.0 | 66.0 |
| Molaison et al., 2003, USA [65] | 316 / 50.6 | HD | IDWG | 24.6 |
| Mason et al., 2014, Australia [60] | 47 / 51.1 | NDDK | Urine | 32.0 |
| Moreira et al., 2013, Portugal [77] | 130 / 63.8 | HD | 3 day food record | 25.4 | 67.7 |
| Morales Lopez et al., 2007, USA [58] | 17 / 35 | HD | Serum albumin, PO4, K and IDWG | 76.0 | 88.0 | 65.0 |
| O’Connor et al., 2008, Scotland [66] | 73 / 60.3 | HD | Serum PO4, IDWG | 30.0 | 84.0 |
| Paes-Barreto et al., 2013, Brazil [43] | 43 / 51.2 | HD | 24 h food recall | 46.5 |
| Pang et al., 2001, China [67] | 46 / 52.2 | HD | IDWG | 37.0 |
| Park et al., 2008, South Korea [80] | 64 / 56.3 | HD | Serum PO4, K and IDWG | 54.7 | 68.8 | 76.6 |
| Poduval et al., 2003, USA [74] | 117 / 52.1 | HD | Calcium Phosphate product | 37.2 | 44.8 | 71.9 |
| Quan et al., 2006, China [50] | 30 / 46.7 | HD | 3 day food record | 19.5 |
| Russell et al., 2001, USA [57] | 19 / 47.0 | HD | Serum albumin, PO4 and IDWG | 78.9 | 100.0 | 68.4 |
| Rocco et al., 2002, USA [46] | 1000 / 46.4 | HD | 2 day food recall enPCR | 24.0 | 39.0 | 48.0 |
| Saran et al., 2006, USA [27] | 3359 / 55.1 | HD | Serum PO4, K, and IDWG | 83.2 | 84.6 | 93.7 |
| Saran et al., 2006, Europe [27] | 2337 / 59.7 | HD | IDWG | 89.0 | 87.2 | 80.0 |
| Saran et al., 2006, Japan [27] | 1980 / 62.4 | HD | 5 day food recall | 65.5 | 87.9 | 92.4 |
| Sharp et al., 2005, Scotland [68] | 56 / 67.9 | HD | IDWG | 0.0 |
| Sutton et al., 2001, England [82] | 34 / 70.6 | PD | 5 day food record | 11.8 | 21 | 70.6 |
transplant self-reported that they were adherent to fluid recommendations [35, 36].

**Low phosphate diets**

Restriction of dietary phosphate intake is recommended for all adults with ESKD in an attempt to lower the deranged serum phosphate levels [79]. Of the 15 studies that reported low phosphate diet adherence rates, the majority (13 studies) used serum phosphate to measure dietary adherence, and found that rates varied between 43.5%–84.5%. More than half of these studies reported an adherence rate of greater than 70%, with younger people having lower adherence rates (44.8%) when compared to older people (68.8%) [80].

Two studies which measured low phosphate diet adherence used food recalls [81] or food records [82] to obtain data on dietary phosphate intake and neither study reported the proportion of inorganic to organic phosphate intake, an important emerging component of dietary phosphate management [83]. In the only study retrieved that compared the rate of adherence to the low phosphate diet using two different methods, Elliott et al. [84], found that adherence was 32.6% when using a self-report survey on adoption of the low phosphate diet (the Precaution Adoption Process Model tool), compared with an adherence rate of 43.8% using serum phosphate.

| Authors, Year, Country | N / gender % male | CKD stage / RRT modality | Adherence Measurement Tool | Reported dietary adherence rate (%) | Renal diet | Fluid | Energy | Protein | PO4 | K | Na | Fat | CHO | Fibre |
|------------------------|------------------|--------------------------|----------------------------|-----------------------------------|------------|-------|-------|--------|-----|---|----|-----|-----|-------|
| Unruh et al., 2005, USA [75] | 739 / 53.7 | HD | Serum PO4, K | 59.1 79.3 |
| Vlaminck et al., 2001, Belgium [37] | 564 / 49.1 | HD | DDFQ | 18.0 28.0 |
| Wang et al., 2003, Hong Kong [53] | 266 / 52.3 | PD | 7 day FFQ | 25.5 39.1 |
| Wang et al., 2007, Hong Kong [54] | 249 / 50.6 | PD | 7 day FFQ | 75.0 | T:51.0 SF:84.0 |
| Welch et al., 2001, USA [70] | 148 / 52.0 | HD | IDWG | 33.8 |
| Yusop et al., 2013, Malaysia [81] | 90 / 48.9 | HD | 2 day food recall | 31.1 20.0 24.4 82.2 100.0 86.7 |
| **Total number participants** | **23,177** | | Weighted mean adherence rate | 31.5 68.5 23.1 45.5 79.8 85.6 61.4 T:41.4 SF:72.5 83.1 2.9 |

Legend: *gender for total PD group; gender proportion for total HD group; CKD Chronic Kidney Disease, CHO adherence to recommendations for carbohydrate intake, DDFQ Dialysis Diet and Fluid Non Adherence Questionnaire, ePCR equilibrated normalized protein catabolic rate, FFQ food frequency questionnaire, HD hemodialysis, IDWG interdialytic weight gain, K adherence to low potassium diet, Na: adherence to recommendations for sodium intake; NDCKD non-dialysing adults with ESKD; PAPM Precaution Adoption Process Model tool, PO4 adherence to low phosphate diet, PD peritoneal dialysis, Renal diet refers to adherence to all components of the renal diet prescription, RRT renal replacement therapy type; T: adherence to recommendations for total fat intake; SF: adherence to recommendations for saturated fat intake; serum bloods: combination of serum potassium, phosphate and / or others (eg albumin or urea)
**Low potassium diets**
A low potassium diet is recommended for adults with ESKD [85], and is used to prevent the potentially fatal complication of chronic hyperkalemia [86]. Serum potassium was the most frequently reported method for measuring adherence to the low potassium diet, and only one study used a food recall to determine low potassium dietary adherence [81]. All 12 studies of low potassium diet adherence were conducted on in people undertaking hemodialysis, highlighting an obvious lack of research regarding low potassium diet adherence in those undertaking home hemodialysis and in those with CKD.

**Overall renal diet adherence**
One challenge of summarising the literature on renal diet adherence is the varying definitions used by previous researchers about what ‘renal diet’ adherence entails. For example, Baraz et al. [59], defined adherence to the renal diet as serum creatinine, sodium, potassium, calcium, phosphate, albumin, urea and uric acid within acceptable limits. In contrast, Quan et al. [50], defined renal diet adherence as ‘following the dietitian’s prescription’. Despite these differences, the reported adherence rates to the renal diet were relatively poor overall, with a weighted mean adherence rate of 31.5%. Only five of the eighteen cohorts studied achieved an adherence rate greater than 50% ([38, 39, 56, 59, 76].

The measurement tools used to determine renal diet adherence also varied, with five different methods used to describe renal diet adherence: serum measures [59], the DDFQ [33, 37–42], the 3 day food record [50], or a combination of measures including self-report [56, 76, 87, 88]. Furthermore, four studies compared overall...
renal diet adherence using two different methods: the DDFQ and serum measures [76, 87, 88] or self-report and serum measures [56]. The findings indicated that renal diet adherence varied in the same cohort of adults with ESKD by 8.9% [88] to 31% [56], suggesting that simply using different adherence measurement methods can also affect the adherence rate results.

Factors reported to be associated with dietary adherence in adults with ESKD
Adherence to medical treatment is a complex process influenced by many social, individual, cultural and environmental factors (83). This component of the integrative review utilised data from 44 studies. To assist with interpretation of the results, the factors reported to be associated with dietary adherence have been categorised according to the WHO Multidimensional Adherence Model [89], and are shown in Table 5. The categories outlined in the WHO model [89] are (i) socioeconomic factors (ii) condition related factors (iii) therapy related factors (iv) health care team and system factors and (v) patient related factors.

Socioeconomic factors
Twenty four studies provided information on socioeconomic factors associated with dietary adherence. From these studies, age, gender and education level were the most frequently explored socioeconomic factors (Table 5). Older adults and individuals with a higher level of education were consistently associated with greater dietary adherence. Evidence regarding occupation level suggests that those who are not working are more likely to adhere to the renal diet. In contrast, results regarding the relationship between gender and dietary adherence were mixed. Overall, female gender was associated with greater dietary adherence to the renal diet in eight of eleven studies. One of the few studies which reported the opposite result, that is, males were more likely to be adherent to the renal diet, came from the largest study cohort included in this integrative review with more than 7000 adults with ESKD [27].

Condition and therapy related factors
Information on condition and therapy related factors associated with dietary adherence were obtained from 25 studies (Table 5). From these studies, most evidence supported an association between the length of time undertaking hemodialysis and poorer renal diet adherence [27, 64, 88]. Reasons for this remain unexplored, but it is thought to be related to the practical challenge of managing the complex dietary modifications required for many years [64], and to the scale of modifications required to long standing behaviours [90].

The relationship between dietary knowledge and renal diet adherence is not clear and the evidence base comes from only 6 studies of less than 2000 adults with ESKD [35, 43, 72, 88, 91, 92]. Poor dietary knowledge was associated with suboptimal renal diet adherence in four studies [35, 88, 91, 92]. Provision of renal diet related practical skills and knowledge, such as learning food composition details [74], self-monitoring strategies [32, 35, 69, 93] or learning appropriate recipe modifications [48, 61] were found to be associated with greater renal diet adherence and were also highly valued by patients in the three qualitative studies [13, 34, 35]. Factors such as receiving conflicting dietary advice from different health professionals [13], and the complexity of the diet [88] were reported to be associated with poorer dietary adherence.

Health care team and system factors
Research on the relationship between the health care team and health care system factors on dietary adherence in ESKD is scarce, but of increasing academic interest [89, 94]. Evidence from nine studies suggests that the quality of the relationship between the patient and the health care professional is important (Table 5). For example, patients with EKSD who receive intensive education from experienced renal dietitians [73, 91], or patients who received support from renal health professionals [39, 50, 71] were more adherent to the renal diet. Furthermore, inadequate support or infrequent contact from renal dietitians was specifically found to impact negatively on dietary adherence [27, 58, 91]. The main reason suggested by the authors for these findings was inadequate staffing ratios [27, 91]. This is an important finding as staffing surveys of renal dietitians from the US [95, 96], UK [97], Asia [98] and Australia [99, 100] consistently report that renal dietitian staffing ratios are below evidence based practice recommendations.

Patient related factors.
Evidence for patient related factors was obtained from 25 studies with ESKD. Factors such as the presence of social and family support, and positive beliefs and attitudes towards the renal diet were frequently studied and found to be consistently associated with improved renal diet adherence. Patients who understood and valued the potential benefits of dietary modification [19, 34–36, 70, 92] were more adherent to the diet than those who felt the diet posed a burden [71]. Self-efficacy refers to a person’s confidence to control their behaviour to achieve a goal [101]. The impact of self-efficacy on dietary adherence was investigated in six studies, and these studies reported that adults exhibiting greater self-efficacy also experienced higher dietary adherence rates [68, 69, 71, 84, 88, 102].

The impact of the renal diet on social eating events was also a specific patient related factor identified with
| Authors                  | Patient numbers | ESKD group | Socioeconomic factors          | Condition related factors | Therapy related factors          | Health care team and system related factors | Patient related factors |
|-------------------------|-----------------|------------|--------------------------------|---------------------------|--------------------------------|---------------------------------------------|------------------------|
| Agondi et al., 2011 [51]| 117 HD          | Higher education level Older age |                               | Shorter dialysis vintage Dietary knowledge |                               | Positive beliefs regarding the benefits of the diet | Social and family support |
| Ahrari et al., 2014 [38]| 237 HD          | Higher education level Being employed Younger age |                               | Diet complexity |                               |                                            |                        |
| Baraz et al., 2010 [59] | 63 HD           | Retired or not working Female gender Older age |                               | Diet complexity |                               |                                            | Self-efficacy            |
| Chan et al., 2012 [88]  | 188 HD          | Retired or not working Female gender Older age |                               | Diet complexity |                               |                                            |                        |
| Chan et al., 2010 [39]  | 173 PD          | Nurse support for home dialysis patients |                               |                                            |                                            |                                            |                        |
| Chen et al., 2006 [48]  | 70 PD           | Recipe modification knowledge |                               |                                            |                                            |                                            |                        |
| Clark-Cutaia et al., 2014 [44] | 122 HD      | Male gender Older age |                               |                                            |                                            |                                            |                        |
| DeBrito-Ashurst et al., 2011 [34] | 20 CKD       | Recipe modification knowledge |                               |                                            |                                            |                                            |                        |
| DeBrito-Ashurst et al., 2013 [61] | 56 CKD        | Recipe modification knowledge |                               |                                            |                                            |                                            |                        |
| Ford et al., 2004 [73]  | 70 HD           | Intensive patient education |                               |                                            |                                            |                                            |                        |
| Gordon et al., 2009 [35] | 82 KT          | Adequate family income |                               |                                            |                                            |                                            |                        |
| Gordon et al., 2010 [36] | 88 KT          | Male gender Private health insurance Being married | Better self-rated health | | | | |
| Hollingdale et al., 2008 [13] | 20 NDCKD & dialysis | Consistent dietary advice / dietary messages | | | | | |
| Authors                  | Patient numbers | ESKD group | Socioeconomic factors | Condition related factors | Therapy related factors | Health care team and system related factors | Patient related factors                          |
|-------------------------|-----------------|------------|-----------------------|--------------------------|------------------------|---------------------------------------------|-----------------------------------------------|
| Johansson et al., 2013 [49] | 106             | HD & PD    | Higher socioeconomic status | Better quality of life |                        | Absence of depression                        | Presence of social support                      |
| Kara et al., 2007 [40]  | 160             | HD         | Older age             | Being married            |                        | Presence of family support                    | Presence of social support                      |
| Karavetian et al., 2014 [91] | 570             | HD         | Dietary knowledge    |                          |                        | Aduedietitian staffing Experienced renal dietitian |                  |
| Khalil et al., 2011 [76] | 100             | HD         |                        |                          |                        | Absence of depression                        | Non-smoking status                              |
| Kugler et al., 2011 [41] | 456             | HD         | Lower education level | Female gender            | Being married          | Short dialysis vintage                        | Family support                                 |
|                         |                 |            | Older Age             |                          |                        | Non-smoker                                   | Non-diabetic status                            |
| Kugler et al., 2005 [33] | 916             | HD         | Female Gender         | Older Age                | Short dialysis vintage |                            |                                              |
| Lam et al., 2010 [42]   | 173             | PD         | Retired occupational status | Low education level Female gender Older age | Dialysis vintage | 3 years                                      | Perception that diet fits into lifestyle Strategies to manage the diet at social events Positive beliefs & attitudes about the diet |
| Lee et al., 2002 [56]   | 62              | HD         | Unemployment or non-working status |                        | Shorter dialysis hours per week | Positive attitudes to diet High residual renal function >300 ml day |
| Lindberg et al., 2009 [64] | 4498            | HD         | Older age             |                          | Short dialysis vintage | Higher BMI                                   |                                              |
| Mellon et al., 2013 [19] | 50              | HD         | Older age             |                          |                        | Perception that diet fits into lifestyle Strategies to manage the diet at social events Positive beliefs & attitudes about the diet |
| Molaison et al. 2003 [65] | 316             | HD         | Older age Female gender | Self-monitoring          |                        | Adequate psychological coping ability         |                                              |
| Mok et al. 2001 [55]    | 50              | HD         | Adequate finances     | Long dialysis vintage    |                        | Adequate psychological coping ability         |                                              |
| Morales Lopez et al., 2007 [58] | 34            | HD         | Adequate finances     | Culturally appropriate format of patient education Dietary knowledge Presence of a dietitian on staff | Presence of family support |                                             |
| O’Connor et al., 2008 [66] | 73              | HD         | Female gender Older age | Dietary knowledge        | Intensive patient education | Lower comorbid disease burden Presence of social support | |
| Paes-Barreto et al., 2013 [43] | 89             | NDCKD      | Dietary knowledge     |                          |                        |                                             |                                              |
| Pang et al., 2001 [67]   | 92              | HD         | Lower family income   |                          |                        |                                             |                                              |
renal diet adherence in four studies [13, 19, 34, 35]. Findings from the three qualitative studies [13, 34, 35] indicated several situational or contextual factors relating to social eating that impacted on dietary adherence. For example, dietary adherence was influenced by acceptance of the renal diet by family members or friends [13, 34]. One study also reported that patients were not adherent to the diet to avoid ridicule from others or because foods adherent to the renal diet were not readily available when eating out [35].

Taste preferences (particularly for salt) were also reported as a barrier to renal diet adherence in several studies [34, 35, 88]. For example, De Brito-Ashurst et al. [34] reported perceptions that salt was a vital food ingredient and thus not possible to reduce in the diet without reducing palatability [34]. Finally, depression appears to be an under researched area pertaining to renal diet adherence. This is surprising given the high prevalence of the disorder in patients with ESKD [103]. Two studies explored the relationship between depression and renal diet adherence [49, 76], those who were depressed also exhibited worse dietary adherence. Similarly, those with greater mental health [71] or adequate psychological coping skills [66] were more likely to adhere to the renal diet.

### Discussion

Adherence to medical treatment is considered to be the most effective method for improving health outcomes [104]. The intent of this integrative review was to synthesise the body of evidence regarding dietary adherence in adults with ESKD and identify the factors which influence dietary adherence. This review has yielded four key findings that can be used by clinicians and researchers to improve renal diet adherence.

The first key finding of this review was that research on dietary adherence in ESKD is dominated by studies using subjective self-reported information. Measurement
of dietary adherence in ESKD is challenging, and unlike medication or dialysis related adherence studies, there is no ‘gold standard’ or single physiological marker exists that indicates a person is consuming the recommended ESKD diet prescription. Subjective methods such as diet recalls, food frequency questionnaires and diet records impose a significant subject burden in an unwell population. They are also known to be associated with problems of underreporting of dietary intake [105]. Adherence questionnaires like the DDFQ [37] or the Renal Adherence Behaviour questionnaire [106] also assume patients have adequate cognitive capabilities and appropriate levels health literacy; as well as an adequate understanding of the diet to answer the questions appropriately. This is particularly problematic given that cognitive impairment and low health literacy are common in patients with ESKD [107–111]. Consequently, subjective approaches should also be used with caution in those with ESKD.

The second key finding of this review is that indirect physiological measures (such as serum potassium, phosphate or interdialytic weight gain) have been used frequently to measure dietary adherence in ESKD. The obvious advantages of using serum markers are that they are relatively cheap, easy to obtain, and have a low patient burden. However, serum potassium and phosphate are strongly influenced by non-dietary factors such as residual renal function [112, 113], constipation [114]; adherence to prescribed medications [115, 116], acid base balance [117] and time between treatments [118], making them unreliable and inaccurate markers of dietary adherence [119–121]. Future studies of dietary adherence in ESKD should ideally attempt to use direct observation and immediate quantification of dietary intake to provide the most accurate data on dietary intake. However, limited staffing, finances, and the inability to monitor patients for long time periods, make this approach unlikely to be implemented. For pragmatic reasons it is therefore suggested that a combination of indirect measures (eg interdialytic weight gain, urine volume and sodium) and subjective methods (such as dietitian assisted dietary recalls [122]) be used instead to increase the rigour of the information collected [89, 123]. Improved reporting of dietary outcomes in future studies is also needed and future research should include comprehensive details of dietary intake as well as reporting the rate of adherence. This approach has been used in several recent studies [124, 125], and provides superior quality information that could then be used to guide future dietary adherence interventions.

This review provides clinicians with estimates of the rate of adherence to the renal diet and is the third important finding of this review. Attempts to compare the estimated dietary adherence rates to other components of the ESKD treatment regimen are challenging however, because the renal diet contains many components. Overall, the weighted mean adherence rates to fluid, phosphate, potassium and carbohydrate recommendations were similar to rates of adherence in other medical conditions. For example, it is estimated that 50–70% of patients are expected to be adherent to their therapy irrespective of the disease, prognosis or setting [123, 126, 127]. Previous research in people with chronic diseases (such as diabetes, hypertension or ischemic heart disease) [128, 129]; or on other ESKD self-management components [120, 130, 131] have also reported adherence rates of this magnitude. However, the low rate of adherence to the overall renal diet as well as to specific components such as energy, protein, sodium, total fat and fibre reported in this review suggests that designing interventions to improve dietary adherence in those with ESKD is required [132]. Interventions to improve adherence are proposed to have a greater impact on patient health than any further improvements in medical technologies and treatments [89].

The final important findings of this review were that there are several factors that are associated with good dietary adherence: older age; higher education levels; the presence of social or family support; and high levels of self-efficacy. Several other unique factors such as taste, the impact of the diet on social eating occasions; and dietetic staffing also play a role in dietary adherence.

However, several factors impacting on dietary adherence in ESKD examined in this review warrant specific further discussion. For example, the relationship between renal diet knowledge and renal diet adherence requires further investigation. Previous studies of adherence in people with ESKD have demonstrated that knowledge was strongly associated with adherence to the ESKD treatment regimen [23, 133, 134]. However in the present review, greater knowledge of the renal diet was not always associated with improved dietary adherence [72]. This surprising finding is consistent with a recent systematic review on the relationship between dietary knowledge and dietary adherence in general, which also showed that in adults there was only a weak association [135]. In other words, it appears that knowledge alone is not sufficient for optimal renal dietary adherence [65, 136]. Several emerging areas that may explain these findings include the possibility that individuals with ESKD may have lower levels of patient activation [137] and patient engagement [138] for undertaking the changes required when following the renal diet, and therefore further investigation of the reasons for these findings is clearly warranted.

The quality of the relationship between the patient and the health care provider was identified in this review as an important modifier of dietary adherence. In addition, recent evidence indicates that multidisciplinary care slows the rate of decline in renal function [139], suggesting that adherence rates may be better in patients treated by multidisciplinary teams. Further research
exploring how this relationship impacts on dietary adherence is important and could be used to redesign dietary education strategies. Patients with kidney disease have expressed dissatisfaction with the information provided to them by health care providers in numerous studies [16, 140–143]. As a result, patients now use the internet to seek answers to the questions they feel are important to them [140, 142–145]. Whether this occurs with those seeking renal diet information remains unexplored, and the impact of “googling” on dietary adherence is unknown. Similarly, frustrations have been expressed by patients about receiving contradictory dietary information [13, 16], but how this impacts on dietary adherence is also unknown. The perceptions by patients and other staff about the role of the renal dietitian should also be explored further. For example, patients are commonly referred to renal dietitians by medical staff to prevent disease progression or to control side effects [146–148]. However, these are infrequently expressed motivators for attending dietitian appointments or for adhering to the diet [17]. Instead, patients report consulting renal dietitians to either improve their quality of life, or to decrease the negative impact of the diet on social eating occasions [17, 149].

The impact of factors such as health literacy and cognitive impairment on dietary adherence in ESKD also requires further exploration. The renal diet is acknowledged as one of the most complex diets to teach, understand and implement [14]. The presence of cognitive impairment and low health literacy in patients with ESKD could contribute to the poor rates of dietary adherence reported in this review. Previous research has confirmed that health literacy skills and cognitive capabilities are important influences on other self-management abilities in patients with ESKD [150–154]. It seems reasonable therefore, to assume that a poor understanding of the renal diet, poor quality patient education materials or poorly given instructions relating to the diet may lead to errors in the dietary self-management process and worsen health outcomes [150, 152]. Therefore, a better understanding of how these factors impact on dietary adherence is critical for preventing disease progression and further complications.

There are several areas for future research that are evident from this integrative review. For instance, due to the lack of studies on dietary adherence in patients with ESKD not undertaking dialysis, it is recommended that future research on dietary adherence should include this group of patients, as well as kidney transplant recipients. Future studies should also utilise a comprehensive dietitian assisted dietary assessment method such as a diet recall, diet record, FFQ or diet quality index. Exploring differences in adherence that may occur between non-dialysis and dialysis days; as well as the differences in adherence that may occur according to dialysis vintage, or in minority cultural groups are also important. Studies should also investigate differences in adherence to the renal diet according to gender and over time. This is an important area for future research because adherence to the renal diet requires continuous self-regulation and adherence would be expected to vary day to day, as well as over time, between renal replacement therapy modalities and according to season [123, 155]. Future research on renal diet adherence should also consider reporting the impact of the renal diet on overall diet quality [14, 156–158]. The relationship between nutrient modification and overall diet quality is increasingly recognised as important, and is known to influence the risk and development of chronic diseases such as kidney disease [159, 160]. The use of indirect measures will not adequately capture these variations in quality, quantity and adherence [161]. Further research examining how patients make sense of the renal diet, and how this may impact on adherence would also be useful and could be used to inform and guide practitioners about the content of future dietary education strategies and patient education resources.

Several recommendations for clinicians are also evident from this review. Additional support or alternative education and counselling strategies may be required to enhance dietary adherence in individuals who are male; younger; with lower education levels, and with inadequate social and family support. Patients that may be depressed have low self-efficacy and those with a long dialysis vintage may also be another target group for additional support from health professionals. Based on the findings of this review, advice from health professionals within renal units where possible should also be consistent, and delivered utilising appropriate health literacy techniques [162, 163]. Clinicians should also consider utilising or expanding upon the use of pragmatic and flexible dietary prescriptions (such as those described recently for individuals requiring a low protein diets [164–166] in an attempt to improve dietary adherence.

The strengths of this review include the exhaustive coverage of the topic using studies retrieved from a comprehensive search of two large databases and the retrieval of a large number of additional relevant articles from reference lists. There are also limitations relating to this review which need to be acknowledged. The grey literature was not searched and articles in languages other than English were not included. The search strategy used was based on MeSH terms, and alternative or additional search terms may have retrieved other relevant articles.

Conclusions
Dietary modification is an important component of the management of ESKD. Based on the findings of this review it is estimated that around one in three adults with
ESKD are adherent to the renal diet and approximately two thirds of adults with ESKD adhere to recommendations regarding fluid. Uncertainty surrounds these results though due to wide variations in adherence rates between studies, and the use of methodological approaches with inherent flaws in reliability and accuracy. Adults found to be most likely to adhere to the renal diet includes females, older adults, and individuals with adequate family and social support and self-efficacy. This review has also highlighted that further research on dietary adherence is required in several cohorts with ESKD, such as kidney transplant recipients or those with ESKD not undertaking dialysis. Developing strategies to address the barriers identified in this review to dietary adherence in ESKD may improve health outcomes.

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Authors’ contributions
KL: Conceptualisation of study design, data collection, data analysis, primary responsibility for writing the article. JM: Refinements to study design, data analysis, writing the article. KM: Refinements to study design, data analysis, writing the article. All authors read and approved the final manuscript.

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