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Promoting self-management in chronic disease: a systematic review and meta-analysis of behaviour change interventions for patients on dialysis

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ABSTRACT

Given the importance of patients' ability to effectively self-manage their kidney disease, researchers have developed interventions focused on improving self-management for patients on dialysis. The review and meta-analysis aimed to evaluate the efficacy of these interventions and identify the characteristics of more effective interventions in this domain. A meta-analysis of randomised controlled trials to promote self-management in patients on dialysis (N = 4201, k = 45) evaluated: the effect of the interventions on psychological, behavioural, and physiological outcomes; the relationships between changes in outcomes; the moderation of outcomes by behaviour change techniques employed in the interventions; and intervention duration. The meta-analysis obtained moderate effect sizes, demonstrating improvement in behavioural ($g = 0.50$ to 0.65) and physiological health outcomes ($g = -0.32$ to -0.57). Fewer studies assessed psychological intervention targets, but large effects were obtained for knowledge change and quality of life ($g = 0.65$ and 1.17, respectively). Improved knowledge was positively associated with improved medication adherence, which in turn was associated with one physiological outcome. Interventions incorporating psychotherapeutic techniques such as CBT or rational emotive therapy achieved superior physiological outcomes, particularly when used in isolation. The findings support the interpretation that intervention strategies to enhance emotional self-management are effective in optimising outcomes for patients on dialysis.

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Self-management; meta-analysis; behaviour change taxonomy; interventions; social support; chronic illness

Chronic disease accounts for two-thirds of deaths worldwide (WHO, 2011) and the majority of patients receiving healthcare have a chronic illness. While medical interventions are often available to manage disease progression and quality of life (QoL), patient collaboration via self-management is important for optimising outcomes. Illness self-management here refers to the ongoing process by which individuals with a chronic disease actively engage in managing their condition and the work of living with chronic illness. Self-management processes may involve treatments such as taking medications and attending medical appointments, behavioural self-management such as maintaining dietary or exercise recommendations, and emotional self-management including processing emotions that arise from having a chronic illness (e.g., Corbin & Strauss, 1988; Lorig et al., 2001).

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Understanding how to support and promote illness self-management via interventions is crucial to optimise health outcomes. This review and meta-analysis focuses on self – management interventions in the context of a prevalent chronic illness: dialysis dependent chronic kidney disease (CKD). While numerous interventions have been developed to enhance self-management among CKD patients undergoing dialysis, there remains a lack of clarity regarding the effects of these interventions in changing key behaviours relevant to CKD self – management and outcomes. Additionally, the specific active ingredients driving the effects of interventions are yet to be fully understood.

Chronic kidney disease: prevalence and impact

CKD affects up to 840 million people worldwide, with a global prevalence of 8–14%, and is the third fastest-growing cause of death globally (Bikbov et al., 2020; Hill et al., 2016). CKD typically progresses from stage G3 to G5 and culminates in kidney failure, requiring kidney replacement therapy (KRT) to sustain life. KRT options include dialysis – currently the most prevalent type of KRT worldwide – or kidney transplantation. The number of people receiving KRT globally is projected to reach 5.4 million by 2030 (Liyanage et al., 2015). The cost of managing CKD is significant. Data from 31 countries estimate that the mean cost per patient per year ranges from $3,060 at stage G3 to $57,334 for haemodialysis (Jha et al., 2023). In the UK alone, CKD accounts for approximately 3.20% of NHS expenditure, amounting to £6.4 billion annually in direct treatment costs, including medication and kidney care (Kidney Research UK, 2023).

Kidney replacement therapy, via dialysis to remove excess waste and fluid when the kidneys no longer function adequately, is vital for survival but has profound psychosocial impacts. Dialysis treatment requires frequent (often thrice-weekly) healthcare visits, which disrupt employment and increase dependency on others (Untas et al., 2011). Treatment must be supplemented by self-management of complex dietary and fluid management regimes. Patients often face physical challenges such as pain, fatigue, sleep disturbances, and blood pressure fluctuations, alongside emotional difficulties (Yucens et al., 2019). Depression in dialysis patients is especially concerning and is linked to poor psychosocial outcomes, reduced quality of life, and a 1.5 to 1.59 times higher risk of death compared to non-depressed patients (Davaridolatabadi & Abdeyazdan, 2016; Palmer et al., 2013; Waraich et al., 2004).

Self-management tasks in dialysis dependant CKD

Optimal medical care can reduce morbidity and mortality associated with dialysis. However, effective self-management is equally critical to maximising patient outcomes. Key self-management tasks for dialysis dependent individuals include maintaining physical activity, adhering to dietary and fluid intake restrictions at home, attending dialysis sessions, and consistently taking prescribed medications. These behaviours help maintain plasma potassium and phosphate concentrations within target ranges while avoiding excessive fluid intake, all of which are closely monitored in patients on dialysis.

Dietary intake significantly influences plasma potassium levels, with high potassium levels linked to increased risks of all-cause mortality, hospitalisation, and cardiovascular injuries (Brunelli et al., 2017; Kovesdy et al., 2007; Luo et al., 2016; Noori et al., 2010). Similarly, excessive consumption of phosphorus-rich foods contributes to elevated plasma phosphate concentrations, a strong predictor of mortality and cardiovascular disease in this population. Managing phosphate levels requires restricting dietary phosphate intake and consistently taking phosphate binder medications, which reduce phosphate absorption from food (Gutiérrez et al., 2014; Kalantar-Zadeh, 2013; Russo et al., 2015; Rysz et al., 2017; Snelson et al., 2017). Evidence suggests that following these dietary restrictions can reduce all-cause mortality (Hu et al., 2021; Morris et al., 2020). Excessive fluid intake, resulting in high interdialytic weight gains (IDWG), is another critical risk factor, as it increases cardiovascular morbidity and mortality (Akdam et al., 2014; Mitsides et al., 2017; Tsai et al., 2015). Despite the importance of these self-management tasks, up to 18% of patients miss scheduled dialysis, more than 80% struggle with taking their phosphate binder medication as prescribed, and

between 2–81% do not follow dietary restrictions (Durose et al., 2004; Ghimire et al., 2015; Hecking et al., 2004; Leggat et al., 1998; Schmid et al., 2009).

The self-management burden on patients on dialysis is therefore considerable, requiring motivation, behavioural skills, and opportunities to maintain a complex regimen. This includes the self-management of behaviours related to treatment, such as taking medications as prescribed or attending hospital appointments, self-management of dietary and fluid restriction behaviours, and emotional self-management. Consequently, researchers have developed behaviour change interventions to improve self-management among patients on dialysis. The primary aim of this review is to evaluate the self-management outcomes (physiological, behavioural, and psychological) of such interventions.

Review of behaviour change interventions for patients on dialysis

Our search of the literature identified six previous reviews of behaviour change interventions in dialysis patients published between 2010 and 2020 (Karavetian et al., 2014; Matteson & Russell, 2010, 2013; Milazi et al., 2017; Murali et al., 2019; Tao et al., 2020). These reviews primarily evaluated the effects of interventions on behavioural and physiological outcomes, omitting psychological outcomes. They suggested that cognitive or cognitive/behavioural interventions may improve fluid, diet, and medication adherence (Matteson & Russell, 2010, 2013). Additionally, educational and behavioural approaches have shown promise in improving serum phosphate levels (Karavetian et al., 2014; Milazi et al., 2017), IDWG, and serum potassium and phosphate levels (Tao et al., 2020).

However, these prior reviews are limited by very small numbers of included studies, and the inclusion of non-controlled quasi-experimental studies (Matteson & Russell, 2010, 2013) and non-randomised controlled studies (Karavetian et al., 2014; Milazi et al., 2017). Furthermore, some reviews incorporated a high proportion of studies with a high risk of bias and substantial incomplete follow-up data (Tao et al., 2020). The results of a more extensive review that included only randomised controlled interventions provides more robust findings; Murali et al. (2019) conducted a meta-analysis of 36 studies evaluating interventions to improve physiological outcomes for patients on dialysis. Their results demonstrated significant improvements in phosphate levels ($g = -0.45$, CI −0.66 to −0.21) and IDWG ($g = -0.20$, CI −0.32 to −0.08) in intervention groups relative to controls. However, they did not report intervention effects on behaviour, such as dietary and fluid restriction or taking prescribed medication, due to small numbers of studies, and did not consider intervention effects on psychological targets presumed to underlie behaviour change.

In sum, the limitations of previous reviews mean that there remains a lack of clarity regarding the effects of self-management interventions in this domain. Additionally, no previous meta-analytic review of randomised controlled trials of interventions to improve outcomes among patients on dialysis has investigated changes in psychological, behavioural, and physiological targets simultaneously in the same study. The pre–post assessment of psychological and behavioural constructs targeted by interventions is important to identify relationships between outcomes and the mechanisms through which changes in behaviour or physiological outcomes might occur. For example, changes in psychological outcomes such as knowledge or self-efficacy might be shown to relate to changes in dietary behaviour. These insights are essential for developing future interventions and identifying intervention targets.

Moderators of the impact of interventions on outcomes

An additional aim of our review is to advance understanding beyond assessing physiological, behavioural, and psychological outcomes, to consider under what circumstances, and how, interventions might be more or less effective. A common limitation in behaviour change interventions is the lack of empirical testing of the specific mechanisms they purport to leverage (see Davidson & Scholz, 2020; French et al., 2012; Nielsen et al., 2018; Sheeran et al., 2017). Gaining a clearer understanding of the active components underpinning the effectiveness of interventions (e.g., feedback and monitoring, goal setting) enables more reliable replication of intervention outcomes and facilitates the

development of new, effective interventions. No previous review in this domain has examined the specific behaviour change techniques included in interventions or their role in moderating intervention outcomes. The present review seeks to address this research gap.

In the current review, we investigated two categories of moderator effects: first, intervention content as specified by the Behaviour Change Taxonomy (BCT) (Michie et al., 2013), and second, intervention duration. Intervention content refers to the specific active ingredients used in the interventions. A behaviour change technique (BCT) is an observable, replicable, and intricate component of an intervention developed to modify the causal processes that regulate behaviour, with the technique proposed as an 'active ingredient' (Michie et al., 2013). A comprehensive BCT taxonomy was developed through an international consensus process by Michie et al. (2013). The resulting taxonomy, the Behaviour Change Techniques Taxonomy Version 1, includes 93 distinct BCTs grouped within 16 categories, with detailed definitions, labels, and examples of each. Examples of BCTs include goal setting, self-monitoring of behaviour, problem-solving, social support, and instructions on how to perform the behaviour. Identifying techniques used within interventions that target specific theory-derived interpersonal and intrapersonal processes and comparing interventions that include or do not include such techniques enables researchers to test potential active ingredients of interventions that drive behaviour change and physiological outcomes. This approach to classifying intervention content has been previously employed in meta-analyses of interventions in cardiovascular disease management (e.g., Suls et al., 2020), physical activity interventions among obese adults (Olander et al., 2013), medication adherence, and diabetes management (e.g., Hennessy et al., 2020). However, no previous review of interventions to promote self-management in patients on dialysis has investigated the role of intervention content as a moderator of psychological, behavioural, and physiological outcomes.

The second moderator, intervention duration, refers to the number of contacts during the intervention delivery in the context of this meta-analysis. An intervention might comprise a single session taking place on one day, or might involve repeated engagement with intervention delivery over weeks or months. However, previous reviews and meta-analyses have not examined whether intervention duration has implications for efficacy, particularly across different outcomes which may be more intractable. For example, modifying a diet might require repeated reinforcement and practice before significant changes are observed. The number of contacts may also influence intervention effects differently depending on the targeted outcome. Likewise, daily self-monitoring prompts may expedite behaviour changes and subsequent improvements on measurable outcomes, compared to weekly prompts or self-directed check-ins. Alternatively, the burden – for both health practitioners and patients – associated with administering multiple contact-point interventions may be unnecessary if shorter duration interventions are as effective as those with a longer duration. The current review thus addresses limitations in past empirical work by evaluating the moderating effect of intervention duration on psychological, behavioural, and physiological outcomes.

Summary of objectives of the present review

A schematic representation of the research objectives addressed by our review is provided in Figure 1. Our review has three main objectives, denoted in Figure 1 by (a), (b), and (c):

- Figure 1 (a): To evaluate via meta-analysis the effect of self-management interventions on psychological, behavioural, and physiological outcomes.
- Figure 1 (b): To evaluate the relationships between intervention effects on psychological, behavioural, and physiological outcomes.
- Figure 1 (c): To use moderator analyses to provide insight into the characteristics of more effective interventions. Specifically, to evaluate the moderating effects of intervention content, classified using the behaviour change taxonomy (Michie et al., 2013), and intervention duration (Figure 1 pathway (c)) on psychological, behavioural, and physiological outcomes.

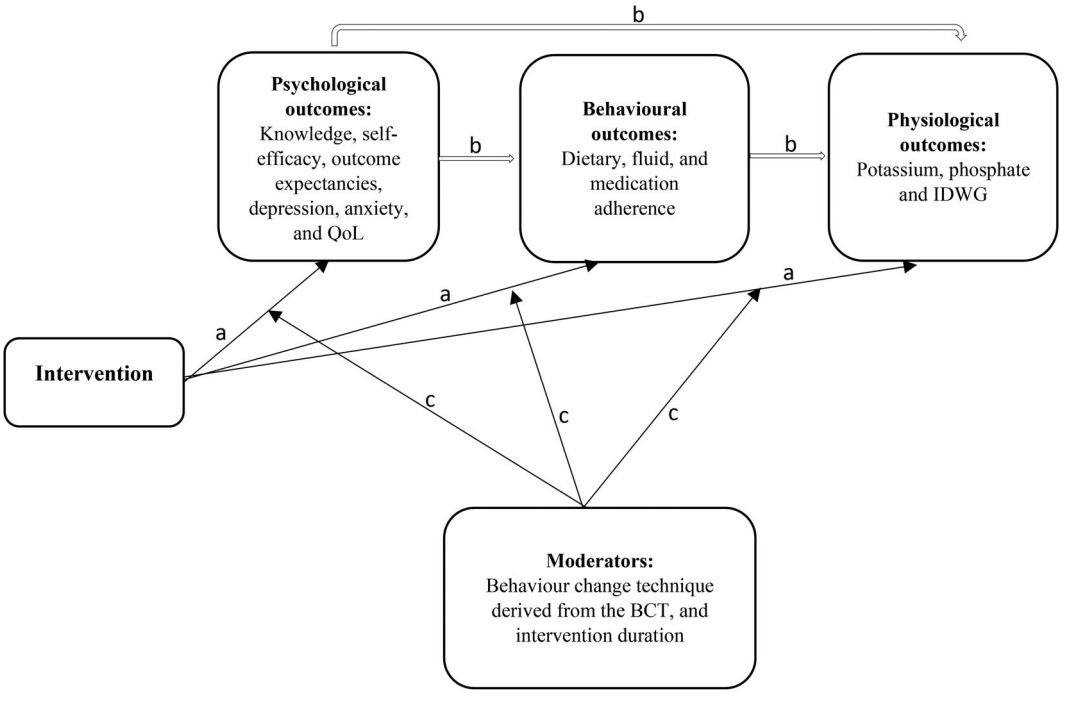

Figure 1. Conceptual model illustrating the review objectives. *Notes*. Research objectives: (a) Examination of intervention effects on psychological, behavioural targets, and physiological outcomes; (b) Analysis of relationships between intervention effects on psychological, behavioural, and physiological outcomes; (c) Moderation analysis of outcomes by intervention content and duration (the number of intervention contacts).

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and checklist were employed to structure this review. The review was registered with the PROSPERO register of systematic reviews in May 2022 (Registration number: CRD42022333522). Our project page on the Open Science Framework includes a dataset containing the effect sizes for each individual study, along with information on the Behaviour Change Taxonomy and intervention duration from all 45 studies reviewed: https://osf.io/ca3fm/?view_only = 3bd898d91375404a95c6b57f60abfd60.

Eligibility criteria

Studies were included in this review if they met all the following PICOS criteria: The population consisted of patients undergoing either haemodialysis or peritoneal dialysis, who were aged 18 years or older. The study reported an intervention that targeted improvements in at least one psychological, behavioural, or physiological outcome among patients on dialysis. Eligible self-management interventions included psychotherapeutic, psycho-social, or psycho-educational approaches. The study included a comparison control group that either received routine dialysis treatment, was placed on a waitlist, or was provided with a simplified alternative version of the intervention. The outcomes were assessed both before and after the intervention, using consistent measures across time points. These measures included biochemical data, such as monthly blood tests or interdialytic weight gain (IDWG) measurements, and indirect assessments (e.g., self-reported dietary and fluid intake charts). Finally, the study design was required to be either a randomised controlled trial (including parallel, cluster randomisation, crossover design, or factorial design) or a controlled study using random allocation of participants to different groups.

Studies were excluded if they met the following criteria: (i) the study did not have a randomised intervention group, (ii) the interventions lacked a comparison or control group, (iii) the study design was observational or qualitative, and (iv) the study was published as a review, letter to the editor, commentary, study protocol, or abstract.

Search strategy

Six electronic databases (Cochrane Central Register of Controlled Trials, Embase, PubMed/Medline, Web of Science, Google Scholar, and Scopus) were searched from their inception through May 2022 for relevant records. The search strategy was developed based on a review of previous literature and in consultation with a consultant nephrologist. Supplementary manual searches were conducted to capture any articles that may have been missed in the database searches. The search strategy employed Boolean operators and Medical Subject Headings (MeSH) terms. The search was limited to English-language publications, with no restrictions on the country of origin.

MeSH terms and search keywords were applied to the title, abstract, and keywords fields, including combinations of 'dialysis', 'renal dialysis', 'haemodialysis', 'peritoneal dialysis', 'patient compliance', 'adherence', 'medication adherence', 'Self Care', 'Self-Management', 'Patient Participation', and text word searches using combinations of 'adheren*', 'non-adheren*', 'nonadheren*', 'complian*', 'non-complian*', 'noncomplian*', 'fluid', 'diet', 'diet*', 'medication', 'dialys*', 'inter-dialy*', 'interdialy*', 'haemodialys*', 'hemodialys*', 'peritoneal dialys*', 'CAPD', 'self-manag*', 'self manag*', 'self-car*', 'self car*', 'self-efficacy', 'self efficacy', 'wellbeing', 'knowledge', 'health literacy', 'psychology *', and 'psych*'. For example, we used the Boolean operator AND to combine terms such as 'haemodialysis AND adherence' or 'dialysis AND self-manag*', ensuring both concepts were present in the search results.

We also employed the OR operator to broaden our search, as in 'ESKD OR ESRD OR CKD', to capture various terminologies for kidney disease. Boolean combinations like '(dialysis OR "renal dialysis" OR haemodialysis OR "peritoneal dialysis") AND ("Self Care"[Mesh] OR "Self-Management"[Mesh] OR "Patient Participation"[Mesh] OR self-manag* OR self manag*)' were used to capture studies related to self-management in the context of dialysis. Additional search terms included 'ESKD', 'ESRD', 'CKD', 'water', 'overload', 'overloading', 'hypervolemia', 'kidney dialysis', 'food', 'phosphate', 'potassium', 'IDWG', 'weight', and 'treatment'. We also incorporated combinations such as '(IDWG OR "interdialytic weight gain" OR hypervolemia) AND (self-efficacy* OR self efficacy* OR self-manag* OR self manag*)' and '(phosphate OR potassium OR "fluid restriction" OR "dietary restriction") AND (self-manag* OR self manag* OR patient engagement)' to capture studies focusing on self-management of specific aspects of dialysis treatment. An example of the full search strategy applied to PubMed can be found in Supplementary Materials S1.

Study selection

The first three authors participated in the study selection process. The initial screening of titles and abstracts was conducted by the lead author, who reviewed all 1,486 identified articles. Articles were excluded at this stage if they were duplicates or failed to meet one or more of the inclusion criteria, such as studies involving paediatric samples or non-dialysis patients. Articles were retained for full-text screening if their eligibility was unclear based on the abstract alone, for example, if the specific measures used could not be determined. Following the initial screening, 117 articles progressed to full-text review. This stage was conducted independently by the lead author and in duplicate by the second and third authors. Reasons for exclusion at the full-text stage included studies that were not randomised trials or did not have an interventional design. The authors met regularly throughout the screening process to discuss and resolve any discrepancies. The lead author performed additional hand searches of the reference lists of included articles and other relevant reviews to identify any

potentially overlooked articles. However, these manual searches did not yield any additional articles for inclusion.

Data extraction

The lead author independently conducted data extraction, which was subsequently verified for accuracy by the second and third authors. This process used the Cochrane review data extraction checklist, alongside a pre-specified standard checklist developed by the authors. The checklist facilitated the extraction of key study features, including the first author's name, publication year, study design, sample size, gender, age, country location of the intervention, intervention characteristics, intervention duration, and reported psychological, behavioural, and physiological outcomes. The extracted data were compiled into a summary table (Table 1) to aid in results interpretation and synthesis.

BCTs were extracted from the included intervention articles using the Behaviour Change Technique Taxonomy version 1 (BCTTv1) (Michie et al., 2013). The coding process followed guidelines adapted from the BCTTv1 online training website (www.bct-taxonomy.com). These guidelines included familiarisation with BCTs (e.g., labels, definitions, and examples), ensuring BCTs were relevant to behaviours at both individual and group levels, and coding BCTs only if they targeted one or more of the intervention's target behaviours. The lead author, trained in BCT coding, and the second author independently coded the intervention contents for BCTs employed by the 45 studies. The total number of BCTs used in each study was also recorded. To assess inter-rater reliability, the 'agree' function in R was used to calculate estimates of inter-rater agreement between the first two authors. The overall estimated agreement was high at 89.1%, indicating strong consistency in BCT identification between coders.

Quality assessment

The first three authors independently assessed the quality of the included studies using the Cochrane ROB 2.0 tool (Higgins et al., 2016). The Cochrane RoB 2.0 tool is a framework for considering the risk of bias in the findings of randomised studies, comprising five domains: (i) bias arising from the randomisation process (containing 3 signalling questions); (ii) bias due to deviations from intended interventions (containing 6 signalling questions); (iii) bias due to missing outcome data (containing 3 signalling questions); (iv) bias in the measurement of the outcome (containing 2 signalling questions); and (v) bias in the selection of the reported result (containing 2 signalling questions). The response options for each signalling question were 'yes', 'probably yes', 'probably no', 'no', and 'no information'. The responses to the signalling questions provided the basis for domain-level judgements about the risk of bias, with one of three options: low risk, some concern, and high risk of bias. Discrepancies between the three authors were resolved through discussions and consensus agreement. Kappa was calculated to assess domain-specific inter-rater reliability.

Statistical methods for meta-analysis

Statistical analyses were conducted using R Studio version 4. For the meta-analysis, we used the R "metafor' and "metasens' packages (Viechtbauer, 2010) and calculated effect sizes using the mean difference and standard deviation between intervention and control groups across psychological, behavioural, and physiological outcomes, as well as the sample size. Given the anticipated considerable between-study heterogeneity, a random-effects model was employed to pool effect sizes. Cochran's Q test was used to assess the degree of heterogeneity (variability) among the pooled effect sizes, while the I^2 statistic estimated the proportion of the observed variability attributable to factors other than sampling error within the selected studies. The restricted maximum likelihood estimator (Viechtbauer, 2005) was used to calculate the heterogeneity variance (τ^2).

Table 1. Characteristics of the (n = 45) randomised control trials included in the review.

Author Country	Study characteristics Trial design, Sample size (Intervention/ Control)	Intervention characteristics Type of Control Number of contacts in intervention	Contents of intervention as determined by taxonomy	Psychological outcome measured, effect size[1] and data collection	Behavioural outcome measured, effect size[2], and data collection	Physiological outcome measured, effect size[3] and data collection
Arad et al. (2021) Iran	Parallel group 66 (33/33)	Intervention: single session of patient education program on the diet, medication use, and fluid restrictions using a patient education booklet and nurse-led telephone follow-up (daily text for 90 d, 2x weekly telephone calls). Control: routine care. Number of contact: 115	1.2 problem solving; 4.1 instruction on how to perform the behaviour 5.1 information about health consequences		Dietary adherence ($g = 0.70$) Fluid adherence ($g = 0.61$) Medication adherence ($g = 1.87$)	Potassium serum ($g = -1.16$) Phosphate serum ($g = -0.80$) Data collected pre, post, 1 & 3 months after intervention
Ashurst and Dobbie (2003) UK	Parallel group 58 (29/29)	Intervention: individual 40 minutes education session by Dietitian aimed at improving patients' knowledge of phosphate management and adherence with diet and medication. Control: routine care. Number of contact: 1	2.3 self-monitoring of behaviour; 2.5 monitoring outcome(s) of behaviour by others without feedback; 4.1 instruction on how to perform the behaviour; 5.1 information about health consequences			Phosphate serum ($g = -0.46$) Data collected monthly for 6m
Baraz et al. (2010) Iran	Parallel group 63 (32/31)	Intervention: oral education lasting 30 minutes in a group session and an educational teaching booklet. Control: 30 minutes education video education during haemodialysis session. Number of contact: 1	3.1 social support (unspecified); 4.1 instruction on how to perform the behaviour; 5.1 information about health consequences			IDWG ($g = 0.01$) Potassium serum ($g = -0.05$) Phosphate serum ($g = -0.02$) Data collected at baseline, 2 & 4m
Chang et al. (2021) Korea	Parallel group 84 (29/27#/28)	Intervention: weekly 60-min fluid-adherence program for 6 weeks (10 mins individual counselling to set fluid intake goals, 20 mins group education regarding the dietary sources of fluid, salt restriction strategies, self-monitoring of urine output and fluid intake, and problem-solving skills, and 30 mins group discussion). They also received additional auricular acupressure at three auricular acupoints for 6 weeks. Control: routine care. Number of contact: 9	1.2 problem solving; 1.3 goal setting (outcome); 1.7 review outcome goal (s); 1.8 behavioural contract; 2.3 self-monitoring of behaviour; 3.1 social support (unspecified); 3.2 social support (practical); 4.1 instruction on how to perform the behaviour; 5.1 information about health consequences	QoL ($g = 1.07$)	Fluid adherence (g = 1.06)	IDWG ($g = -0.86$) data collected at baseline, after the intervention (6w), and 4m

(*Continued*)

Table 1. Continued.

Author Country	Study characteristics Trial design, Sample size (Intervention/ Control)	Intervention characteristics Type of Control Number of contacts in intervention	Contents of intervention as determined by taxonomy	Psychological outcome measured, effect size[1] and data collection	Behavioural outcome measured, effect size[2], and data collection	Physiological outcome measured, effect size[3] and data collection
Chen W et al., (2006) China	Parallel group 70 (35/35)	Intervention: 1-day intensive training course on food contents and appropriate diet and individualised food menu based on food preference. Control: training course without individualised food menu. Number of contact: 1	2.3 self-monitoring of behaviour; 4.1 instruction on how to perform the behaviour; 5.1 information about health consequences; 8.2 behaviour substitution		Dietary adherence ($g = 0.28$) Data collected at baseline & 1m	Phosphate serum ($g = -0.02$) Data collected at baseline & 1m
Chen et al. (2021) China	Parallel group 105 (35/35#/35)	Intervention: volunteer led peer support activities organised face to face (12 2 h fortnightly group activities) alongside routine dialysis care. Volunteers were trained in dialysis knowledge, adherence, and how to support peers. Control: routine care. Number of contact: 12	2.7 feedback on outcome of behaviour; 3.1 social support (unspecified); 3.2 social support (practical)		Dietary adherence ($g = 1.20$) Data collected at baseline, 3 m & 6m	Phosphate serum ($g = -0.29$) Data collected at baseline, 3 m & 6m
Cho (2013) Korea	Parallel group 43 (21/22)	Intervention: 4 x weekly health contract intervention lasting 30–60 minutes including mutual goal setting and reinforcement. A self-care log, which covered fistula management, BP, body weight measurement, exercise, and a dietary intake diary. Control: routine care. Number of contact: 4	1.1 goal setting (behaviour); 1.8 behavioural contracting; 2.3 self-monitoring of behaviour; 3.1 social support (unspecified); 4.1 instructions on how to perform the behaviour; 10 social reward		Dietary adherence ($g = 0.60$) Medication adherence ($g = 0.09$) Data collected at baseline & 1 m	IDWG ($g = -0.52$) Potassium serum ($g = -1.48$) Phosphate serum ($g = -0.53$) Data collected at baseline & 1 m
Cukor et al. (2014) USA	Crossover randomised 59 (33/26)	Intervention, 12 x weekly 60 minutes individual CBT delivered chairside. Control: wait list. Number of contact: 12	3.3 social support (emotional) – CBT; 13.2 framing/reframing	Depression ($g = -3.49$) QoL ($g = 3.03$) Data collected at baseline, 3 & 6m		IDWG ($g = -3.91$) Data collected at baseline, 3 & 6m
Cummings et al. (1981) USA	Parallel group 96 (24/19#/ 28#/ 25)	Intervention:6x weekly behavioural contracting (e.g., identifying behaviour needing change, formal agreement, progress recording and reward schedule) and a family or friend. Control: routine care. Number of contact: 6	1.1 goal setting (behaviour); 1.2 problem solving; 1.7 review outcome goal (s); 1.8 behaviour contract; 2.3 self-monitoring of behaviour; 3.2 social support (practical); 4.3 re-attribution; 5.1 information about health consequences; 10.10 reward (outcome)			IDWG ($g = -0.27$) Potassium ($g = -0.73$) Data collected at baseline, 6w & 3m

de Araujo et al., (2010) Brazil	Parallel group 33 (16/17)	Intervention: 6x 30 minutes educational course about dietary restrictions and medications. Control: course addressing vascular access, types of catheters and arteriovenous graft. Number of contact: 6	4.1 instruction on how to perform the behaviour; 5.1 information about health consequences	Knowledge ($g = 0.39$) Data collected at baseline, 1, 2 & 3m		Phosphate ($g = 0.40$) Data collected at baseline, 1, 2 & 3m
de Freitas et al. (2020) Brazil	Parallel group 87 (47/40)	Intervention: individual 60 mins dietary counselling on sodium restriction by a dietitian that was reinforced at days 30, 90 and 180. Goals were set at each session and followed up. Control: routine care. Number of contact: 4	1.1 goal setting (behaviour); 1.2 problem solving; 1.6 discrepancy between current behaviour and goal; 2.1 behaviour monitoring without feedback; 4.1 instructions on how to perform the behaviour 4.4 behavioural experiments	QoL ($g = 0.03$) Data collected at baseline, 6 & 12m	Dietary adherence ($g = 0.05$) Data collected at baseline, 3, 6 & 12m	
Ford et al., (2004) USA	Parallel group 70 (35/35)	Intervention: 6x monthly 20–30 minutes for 6 months of additional dietary education targeting phosphorus alongside standard care. Control: routine care. Number of contact: 6	2.3 self-monitoring of behaviour; 2.4 self-monitoring outcomes; 4.1 Instruction on how to perform the behaviour; 5.1 information about health consequences	Knowledge ($g = 1.48$) Data collected before and after intervention (6 m)		Phosphate ($g = -0.52$) Data was collected for 6 consecutive months
Forni Ogna et al. (2013) Switzerland	Parallel group 41 (19/22)	Intervention: training on how to use medical device and 3 motivational interviewing to discuss medication adherence. Control: routine care. Number of contact: 4	1.2 problem solving; 1.4 action planning; 2.7 feedback on outcome; 3.3 social support (emotional) motivational interviewing		Medication adherence ($g = 1.10$) Data was collected daily using an electronic device for 6m	
Griva et al. (2018) Singapore	Cluster randomised 235 (101/134)	Intervention: three core and a booster group education session to enhance patients' confidence and capability for self-management (fluid, diet, and medication through goal setting). Control: routine care. Number of contact: 4	1.1 goal setting (behaviour); 1.2 problem solving; 3.1 social support (unspecified); 4.1 Instruction on how to perform the behaviour	Self-efficacy (g = 0.63) Data collected at baseline, 1w, 3 & 9 m post intervention	Dietary adherence ($g = 0.20$) Fluid adherence ($g = 0.22$) Medication adherence ($g = 0.16$) Data collected at baseline, 1w, 3 & 9 m post intervention	IDWG ($g = -0.37$) Potassium serum ($g = -0.37$) Phosphate serum ($g = -0.37$) Data collected at baseline, 1w, 3 & 9 m post intervention
Hanifi et al., (2019) Iran	Parallel group 86 (43/43)	Intervention: 2 individual face to – face consultations, and monthly diet sheet. Access to nurse and dieticians' number for support. Control: routine care. Number of contact: 5	1.2 problem solving, 1.4 action planning; 2.2 feedback on behaviour; 2.3 self-monitoring of behaviour			IDWG (%) Potassium serum (%) Phosphate serum (%) Data collected at baseline, 1, 2 & 3 m.

(*Continued*)

Table 1. Continued.

Author Country	Study characteristics Trial design, Sample size (Intervention/ Control)	Intervention characteristics Type of Control Number of contacts in intervention	Contents of intervention as determined by taxonomy	Psychological outcome measured, effect size[1] and data collection	Behavioural outcome measured, effect size[2], and data collection	Physiological outcome measured, effect size[3] and data collection
Hare et al. (2014) UK	Parallel group 15 (8/7)	Intervention: 4 x l hour weekly group CBT to assist patients' self-management of fluid (e.g., goal setting, thought, emotions and behaviour). Control: CBT waitlist. Number of contact: 4	1.1 goal setting (behaviour); 2.3 self-monitoring of behaviour; 3.3 social support (emotional) – CBT; 4.1 Instruction on how to perform the behaviour; 4.2 information about antecedents; 4.3; re-attribution; 12.1 restructuring the physical environment; 13.2 framing/ reframing	Self-efficacy (g = 1.00) Outcome expectancies (g = −0.16) Depression (g = −0.20) Anxiety (g = −1.67) QoL (g = 2.13) Data collected at baseline, 5 & 10w		
Haq et al. (2014) UAE	Parallel group 23 (12/11)	Intervention: Patients observed dialysis staff administering cinacalcet 3 times a week during dialysis via IV. Control: cinacalcet was prescribed daily to be taken at home. Number of contact: 6	6.1 demonstration of the behaviour			Phosphate serum (g = −0.27) Data was collected at pre-dialysis, 2, 3, 4, 5, 7, 9, & 11w
Hou et al., (2010) China	Parallel group 92 (48/44)	Intervention: 12x rational emotive therapy to identify irrational beliefs, change passive coping modes. Control: routine care. Number of contact: 12	3.3 social support (emotional) /rational emotive therapy (RET); 11.2 reduce negative emotions			IDWG (g = −0.62) Data collected at baseline, 1, 2 & 3m
Howren et al., (2016) USA	Cluster randomised 119 (61/58)	Intervention: 7 × 1-hour weekly group behavioural self-regulation intervention sessions comprising of self-regulation techniques, goal setting, self-administered reinforcement. Control: 7 × 1 hour group sessions covering a topic related to living with CKD and dialysis. Number of contact: 7	2.3 self-monitoring of behaviour 2.4 self-monitoring of outcome; 4.1 instruction on how to perform behaviour; 8.1 behavioural practice; 10.1 material incentive (behaviour); 10.9 self-reward			IDWG (g = 0.02) Data was collected at baseline, 2, 12, 13th, 25th & 26th post-intervention
Karavetian and Ghaddar	Cluster randomised 122 (41/41#/40)	Intervention: 8 × 20 minutes weekly self-management dietary counselling and interactive games.	2.2 feedback on behaviour; 2.3 self-monitoring of behaviour, 2.7 feedback on outcome of behaviour;	Knowledge (g = 0.31) Data collected at baseline and 2m	Dietary adherence (g = 0.62)	Phosphate serum (g = −0.52)

(2013), Lebanon		Control: routine care but received a folder that included the games and educational materials at the end of the study. Number of contact: 8	5.1 information about health consequences		Data collected at baseline and 2m	Data collected at baseline and 2m
Karavetian et al. (2015) Lebanon	Cluster randomised 394 (88/ 201# /96)	Intervention: 2 x weekly intensive nutritional education based on TTM (pre-action, action, and maintenance) provided by a dedicated dietician for 6 months. Control: routine care but study educational material was provided at the end of the study. Number of contact: 52	1.1 goal setting (behaviour); 1.2 problem solving; 1.4 action planning; 1.9 commitment; 3.1 social support (unspecified); 5.1 information about health consequences; 9.2 pros and cons; 14.2 punishment.	Knowledge ($g = 1.91$) Data collected at baseline, 6 & 12m	Dietary adherence ($g = 0.16$) Data collected at baseline, 6 & 12m	Phosphate serum ($g = -0.36$) Data collected at baseline, 6 & 12m
Kauric-Klein (2012) USA	Cluster randomised 118 (59/59)	Intervention: Two BP education sessions, weekly monitoring, goal setting, and reinforcement for 12 weeks. Control: routine care but received free home BP kit at end of study for taking part. Number of contact: 12	1.1 goal setting (behaviour); 1.2 problem solving; 2.3 self-monitoring of behaviour; 2.7 feedback on behaviour; 3.3 social support (emotional); 6.1 demonstration of behaviour; 10.4 social reward	Knowledge ($g = 0.26$) Self-efficacy ($g = -0.22$) Data collected at baseline and 12w	Medication adherence ($g = 0.16$) Data collected at baseline and 12w	IDWG ($g = -0.05$) Data collected at baseline and 12w
Lim et al. (2018) Korea	Parallel group 70 (48/22)	Individual of 30-minute face-to-face education sessions on dietary phosphate restriction and the proper usage of phosphate binder with leaflets. Control: routine care. Number of contact: 1	4.1 Instruction on how to perform the behaviour; 5.1 information about health consequences	Knowledge ($g = 0.27$)	Medication adherence ($g = 0.12$)	Phosphate serum ($g = -0.04$) Data collected at baseline, 1 & 3 months
Luo et al. (2016) Spain	Cluster randomised 80 (41/39)	Intervention: 6x 30 minutes monthly diet education re phosphorus intake. The menus were designed to reduce the phosphorus/ protein ratio in the diet. Control: routine care. Number of contact: 6	4.1 Instruction on how to perform the behaviour; 7.1 prompts/ cues			Phosphate serum ($g = -0.67$) Data collected at baseline & 6m
Mateti et al. (2018) India	Parallel group 153 (78/75)	Intervention: 6 x monthly patient education pharmaceutical care promoting motivation and patient education regarding medication knowledge, disease, lifestyle modifications, alongside a validated pictogram – based information leaflet.	2.7 feedback on outcome of behaviour; 4.1 Instruction on how to perform the behaviour; 5.1 information about health consequences		Medication adherence ($g = 0.63^a$, $g = 0.85^b$, $g = 1.22^c$)	IDWG ($g = -0.84^a$, $g = -1.08^b$, $g = -2.37^c$) Data collected at baseline, 6 & 12m

(*Continued*)

Table 1. Continued.

Author Country	Study characteristics Trial design, Sample size (Intervention/ Control)	Intervention characteristics Type of Control Number of contacts in intervention	Contents of intervention as determined by taxonomy	Psychological outcome measured, effect size[1] and data collection	Behavioural outcome measured, effect size[2], and data collection	Physiological outcome measured, effect size[3] and data collection
		Control: routine care. Number of contact: 6				
Mina et al., (2019) Philippines	Parallel group 23 (12/11)	Intervention: 10–15-min face-to-face health teaching of their treatment regimen and a personalised fluid intake timetable. Control: same health teaching but no personalised fluid intake timetable. Number of contact: 2	1 goals and planning; 2.3 self-monitoring of behaviour; 2.7 feedback on outcome of behaviour; 4.1 instructions on how to perform the behaviour; 5.1 information about health consequences		Fluid adherence (g = 0.90) Data collected baseline, post intervention (wk 1), 2, 3 and 4th wk	IDWG (g = −0.57) Data collected baseline, post intervention (wk 1), 2, 3 and 4th wk
Molaison and Yadrick (2003) USA	Cluster randomised 316 (216/100)	Intervention: weekly 12 weeks dietitian intervention using the trans – theoretical model to improve fluid intake. First 6 weeks Pre-action phase (e.g., precontemplation and contemplation), second 6 weeks Action phase (preparation, action, and maintenance). Control: routine care. Number of contact: 12	2.3 self-monitoring of behaviour; 2.7 feedback on outcome of behaviour; 4.1 instructions on how to perform the behaviour; 5.1 natural consequences; 7.3 reduce prompts/ cues	Knowledge (g = 0.26) Data collected at baseline, 6 & 12w		IDWG (g = 0.04) Data collected at 3w before baseline and 3w to the 6 & 12w fu
Morey et al., (2008) UK	Parallel group 67 (34/33)	Intervention: monthly dietetic consultations for 6 months using motivational counselling aimed at limiting dietary phosphate intake in the diet and improving compliance with phosphate binders. Control: routine care. Number of contact: 6	3.3 social support (emotional)/ motivational counselling; 4.1 instruction on how to perform the behaviour; 7.1 prompts/ cues; 8.1 behavioural practice; 9.2 pros and cons; 10.4 social reward			Phosphate (g = 0.19) Data collected baseline, 1, 2, 3, 4, 6 & 12m
Neumann et al., (2013) Switzerland	Parallel group 120 (60/60)	Intervention: patients given automatic scales, which transferred the weight via telemetry daily. Telephone contact was contingent on weight. Control: routine care. Number of contact: I	2.3 self-monitoring of behaviour			IDWG (g = −0.10) Data was collected pre and post dialysis for 3m
Pasyar et al. (2015) Iran	Parallel group 86 (43/43)	Intervention: 2x educational sessions followed by patients listening twice daily for 20 minutes Benson relaxation	3.3 social support (emotional) /relaxation; 11.2 reduce negative			IDWG (g = −0.36) Potassium serum (g = 0.06)

		technique (BRT) of progressive muscle relaxation with breathing awareness for 8 weeks. Control: routine care but received BRT educational CD after the study. Number of contact:114	emotions – relaxation and breatheworks; 12.6 body changes			Phosphate serum ($g = -0.66$) Data collected at baseline and 2m
Ramezani et al. (2019) Iran	Parallel group 70 (35/35)	Intervention: 4 x1 hour educational training sessions including families about dietary, and fluids restriction, physical activity, skin care and fistula care training and some stretching exercises for flexibility. Practical solutions for improving each area were discussed and patients also received educational content using pamphlets and guidelines. Control: routine care but educational pack received after study. Number of contact: 4	1.2 problem solving; 2.2 feedback on behaviour; 2.3 self-monitoring of behaviour; 4.1 instruction on how to perform the behaviour; 6.1 behavioural demonstration; 8.1 behavioural practice; 8.7 graded tasks	Knowledge ($g = 0.78$) Data collected at baseline & 3m	Dietary adherence ($g = 0.74$) Fluid adherence ($g = 0.76$) Data collected at baseline & 3m	
Reese et al. (2015) USA	Parallel group 36 (12/12#/ 12)	Intervention group: financial incentives for achieving phosphorus level. Messages were designed to incentivise behaviour of those that received money and to stimulate regret aversion among patients who did not get a financial reward. Control: routine care. Number of contact: 1	1.1 goal setting; 4.1 instruction on how to perform the behaviour; 4.2 information about antecedents; 7.1 prompts/cues; 10.1 material incentive (behaviour)			Phosphate serum ($g = -0.18$) Data was collected every 2w (5x)
Sehgal et al., (2002) USA	Cluster randomised 169 (85/84)	Intervention: 6 x monthly education re meaning and importance of dialysis dose, identify barriers with respect to low prescription, shortened treatment time and catheter use. Identified barriers led to liaisons with randomised nephrologist to resolve barriers. Control: routine care. Number of contact: 6	1.2 problem solving; 2.1 monitoring of behaviour without feedback; 4.1 instruction on how to perform the behaviour		Dialysis adherence Data collected pre (3 m) and post intervention (4–6 m)	
Sharp et al. (2005) UK	Cluster randomised 56 (29/27)	Intervention: 4 x I hour weekly group intervention based on the Glasgow University liquid intake program. Sessions included educational (e.g., importance of fluid restriction),	1.1 goal setting; 1.2 problem solving; 1.4 action planning; 2.3 self-monitoring of behaviour; 3.3 social support (emotional) – CBT; 4.1 instruction on how to perform the	Self-efficacy ($g = 0.49$) Outcome expectancies ($g = -0.00$)		IDWG ($g = -0.05$) Data collected pre and post-dialysis for 14w

(*Continued*)

Table 1. Continued.

Author Country	Study characteristics Trial design, Sample size (Intervention/ Control)	Intervention characteristics Type of Control Number of contacts in intervention	Contents of intervention as determined by taxonomy	Psychological outcome measured, effect size[1] and data collection	Behavioural outcome measured, effect size[2], and data collection	Physiological outcome measured, effect size[3] and data collection
		behavioural (e.g., goal setting, self-monitoring skills, self-regulation) and cognitive components (e.g., thoughts, emotions, behaviour). Patients were asked to complete thought records. Control: wait list. Number of contact: 4	behaviour; 5.1 information about health consequences; 7.3 reduce prompts/cues; 12.1 restructuring the physical environment; 12.6 body changes	Depression ($g = -0.09$) Anxiety ($g = -0.22$) QoL ($g = 0.74$) Data collected at baseline and 4w		
Shi et al. (2013) China	Parallel group 80 (40/40)	2 to 3x 20–30 minutes weekly dialogue based individual nurse led intensive education for 6 months. A monthly PowerPoint education re general knowledge of phosphorus and the phosphate binders and methods to maintain phosphorus balance. Control: routine care but educational programme was delivered after study completion. Number of contact: 54	3.1 social support (unspecified); 4.1 instruction on how to perform the behaviour	Knowledge ($g = 0.26$) Data collected at baseline, 3 & 6 m after intervention		Phosphate serum ($g = -0.64$) Data collected at baseline, 3 & 6 m after intervention
Skoutakis et al. (1978) USA	Parallel group 24 (12/12)	Intervention: 2–3 monthly pharmacist review for four months re health concerns, providing educational materials, importance of compliance and simple written reminders for taking their oral medications. Controls: routine care. Number of contact: 12	2.2 feedback on behaviour; 4.1 instruction on how to perform the behaviour; 4.2 information about antecedents; 5.1 information about health consequences; 7.1 prompts/ cues	Knowledge ($g = 0.92$) Data collected at baseline, 4 & 8m	Medication adherence ($g = 0.88$) Data collected at baseline, 4 & 8m	.
Sullivan et al., (2009) USA	Parallel group / Cluster randomised 279 (145/134)	Individual 30 minutes education about phosphorous (e.g., avoiding foods with phosphorus additives when shopping or eating out). Provision of magnifier to read food labels and printed list of additives. Control: routine care. Number of contact: 1	3.2 social support (practical); 4.1 instruction on how to perform the behaviour; 7.1 prompts/cues	Knowledge ($g = 0.15$) Data collected at baseline and 3m		Phosphate serum ($g = -0.20$) Data collected at baseline and 3m
Tanner et al. (1998) USA	Parallel group 38 (28/10)	Intervention: monthly progress report and contracts reviewed monthly. Feedback included (1) acceptable levels	1.3 goal setting (outcome); 1.4 action planning; 1.5 review behaviour goal; 1.7 review outcome goal; 1.8	Knowledge ($g = 1.00$) Self-efficacy ($g = -0.24$)		IDWG ($g = -0.26$) Phosphate serum ($g = 0.17$)

		of IDWG and phosphorus, (2) review of serum adherence levels and provision of rewards if goals are met, (3) goal setting and re-contracting for 6 months. Control: routine care. Number of contact: 6	behavioural contract; 2.7 feedback on outcomes; 4.1 instruction on how to perform the behaviour; 5.1 information about health consequences; 10.4 social reward; 10.10 reward (outcome)	Outcome expectancies (g = 0.14) Data collected baseline and end of intervention (6 m)		Data collected baseline and end of intervention (6 m)
Tsay (2003) Taiwan	Parallel group 62 (31/31)	Intervention: 12 × 1-hour sessions of structured self-efficacy training focusing on the pathophysiology of renal failure, haemodialysis, medications, complications, nutrition, fluid restriction, control of thirst and urge to drink, and stress management. Patients were also advised to maintain food and fluid records. Control: routine care. Number of contact: 12	1.1 goal setting; 2.2 feedback on behaviour; 2.3 self-monitoring of behaviour; 5.1 info consequences; 10.4 social reward; 12.6 body changes			IDWG ($g = -0.31$) Data were collected at baseline, 1, 3 & 6m
Valsaraj et al. (2021) India	Parallel group 67 (33/34)	Intervention: 10 individual CBT weekly sessions lasting approximately 50 minutes to alter maladaptive thoughts and non-adherent behaviours. Control: routine care and non-directive counselling. Number of contact: 10	3.3 Social support (emotional) – CBT	Depression ($g = -0.50$) Anxiety ($g = -0.80$)	Dietary adherence ($g = 0.85$) Fluid adherence ($g = 0.82$) Medication adherence ($g = 0.67$)	IDWG ($g = -1.07$) Data collected baseline, 3 m & 6m
Welch et al. (2013) USA	Parallel group 44 (24/20)	Intervention: patients were trained for 2 hours over 2–3 dialysis sessions on using an electronic dietary self-monitoring application (DIMA) which provided individualised, ongoing information to assist with dietary and fluid self-monitoring for 6 weeks. Controls: Did not receive DIMA. Number of contact: 45	2.3 self-monitoring of behaviour; 5.2 salience of consequences	Self-efficacy ($g = 0.02$) Data collected at baseline, 6 & 14w		IDWG ($g = -0.04$) Data collected at baseline, 6 & 14w
Wileman et al., (2014) UK	Cluster randomised 112 (57/55)	Intervention: Recall of past acts of kindness as part of self-affirmation before receiving health information about phosphate control and risks at baseline.	1.4 action planning; 4.1 instructions on how to perform the behaviour; 5.1 information about health consequences; 13.4 valued self-identity			Phosphate serum ($g = -0.12$) Data collected at baseline, 1, 3, 6, 7, 9

(*Continued*)

Table 1. Continued.

Author Country	Study characteristics Trial design, Sample size (Intervention/ Control)	Intervention characteristics Type of Control Number of contacts in intervention	Contents of intervention as determined by taxonomy	Psychological outcome measured, effect size[1] and data collection	Behavioural outcome measured, effect size[2], and data collection	Physiological outcome measured, effect size[3] and data collection
		Control: routine care. Number of contact: I				and 12 m post-intervention
Wileman et al. (2016) UK	Cluster randomised 89 (49/40)	Intervention: Recall of past acts of kindness as part of self-affirmation before receiving health information about phosphate control and risks at baseline. Control: routine care. Number of contact: I	4.1 instructions on how to perform the behaviour; 5.1 information about health consequences; 13.4 valued self-identity		Fluid adherence (g = 0.26) Data collected at baseline, 1 & 6m	IDWG (g = −0.41) Data collected at baseline, 1, 5, 12,27, 40 & 52w
Wong et al. (2010) China	Parallel group 98 (49/49)	Intervention: Nurse led telephone disease management program for 6 weeks based on comprehensiveness, collaboration, coordination, and continuity. Programme included initial and post discharge assessment using the OMAHA system, mutual goal setting, health coaching, identification of potential complications and reviewing goals. Control: routine care. Number of contact: 6	1.1 goal setting (behaviour); 1.2 problem solving; 1.5 review behaviour goals; 1.7 review outcome goals; 2.7 feedback on outcome of behaviour; 4.1 instructions on how to perform behaviour	QoL (g = 0.36) Data was collected at baseline, 7w (a wk after intervention) and at 13 weeks		
Yokum et al., (2008) UK	Parallel group 34 (17/17)	Intervention: 4x monthly reviews by pharmacist and dietitian to provide education and reinforcement. Control: routine care. Number of contact: 4	2.2 feedback on behaviour; 4.1 instructions on how to perform the behaviour; 7.1 prompts/cues			Phosphate serum (g = −0.79) Data collected at baseline, 1, 2, 3 & 4m

Notes. Abbreviations or symbols used in the table: g = Hedge's g, w = weeks, m = months. Mateti et al. (2018) a = academic hospital, b = government hospital C = corporate hospital. Hanifi et al., (2019) % = data was presented as % and no raw data. 1 = psychological data reported post intervention was used in analyses, 2 & 3 = behavioural and physiological data reported at the last timepoint was used in analyses.

Knapp-Hartung adjustments (Knapp & Hartung, 2003) were applied to calculate the confidence interval around the pooled effect size, with Hedges' g used as a measure of effect size. Standard deviation values were primarily extracted from the papers. However, when this was not possible, standard deviation was computed using the t-statistic derived from the confidence intervals or *p*-values cited in the papers (Fu et al., 2013). When neither probability values nor confidence intervals were reported, the standard deviation was derived using the arithmetic mean of the standard deviations of the mean differences in both the intervention and control groups. Funnel plots were created to visualise publication bias, with the expectation that, in the absence of publication bias, the data points would form a roughly symmetrical, upside-down funnel. Egger's regression test (Egger et al., 1997) was used to quantify asymmetry in the funnel plots and assess potential publication bias. Our analysis revealed evidence of publication bias for medication adherence ($p = 0.04$). To address this, we employed Rucker's limit meta-analysis to estimate the true effect size after accounting for this bias (Rucker et al., 2011).

Meta-regression analyses

Following the overall meta-analysis, we performed additional planned analyses as follows to evaluate the relationship between constructs (Figure 1 pathway (b)) and the moderation of effects (Figure 1 pathway (c)). To ascertain whether intervention effects on psychological and behavioural outcomes were associated with intervention effects on behavioural and physiological outcomes, linear regressions were conducted using each study's individual standardised mean difference as the correlation value (*R*) where outcome data could be retrieved. Moderation effects were examined by random mixed-effects univariate and multivariate meta-regressions on BCT intervention content and intervention duration to test their effects on psychological, behavioural, and physiological constructs.

To conduct this analysis, psychological (e.g., self-efficacy, depression, anxiety, knowledge, outcome expectancies, QoL), behavioural (dietary, fluid, and medication adherence), and physiological (IDWG, potassium, and phosphate serum levels) outcomes were aggregated by combining health outcomes into the above overarching constructs: psychological, behavioural, and physiological. Furthermore, the psychological construct was categorised into wellbeing (depression, anxiety, and QoL) and psychological constructs excluding wellbeing (knowledge, self-efficacy, and outcome expectancies). QoL is considered a psychological construct because it is grounded in theories of wellbeing and adaptation, integrating both hedonic and eudaimonic aspects (Camfield & Skevington, 2008; Ryan & Deci, 2001). Due to some studies measuring multiple health indices and contributing more than one effect size, the study was treated as an additional level. Next, to determine the effects of intervention duration on differences in effect size between the different psychological, behavioural, and physiological outcomes, random mixed-effects meta-regression models were tested.

Results

Characteristics of studies

The PRISMA flow chart is provided in Figure 2. A total of 1,486 publications were identified after an initial search. After the removal of duplicates, reviews, and screening of titles and abstracts, 117 articles were reviewed in full. Following secondary screening to remove papers reporting non-randomised controlled studies, 45 randomised controlled studies were identified and included in the review. Twelve studies were conducted in the United States, eight in the United Kingdom, five studies each in China and Iran, three studies in Korea, two each in Brazil, Lebanon, and Switzerland, and one each in the United Arab Emirates, Singapore, Spain, Taiwan, India, and the Philippines.

Characteristics of the included studies are summarised in Table 1. The total number of participants in the included studies was 4,201, with the intervention and control groups consisting of 2,442 and 1,759 participants, respectively. The majority of participants were male (58%), and the

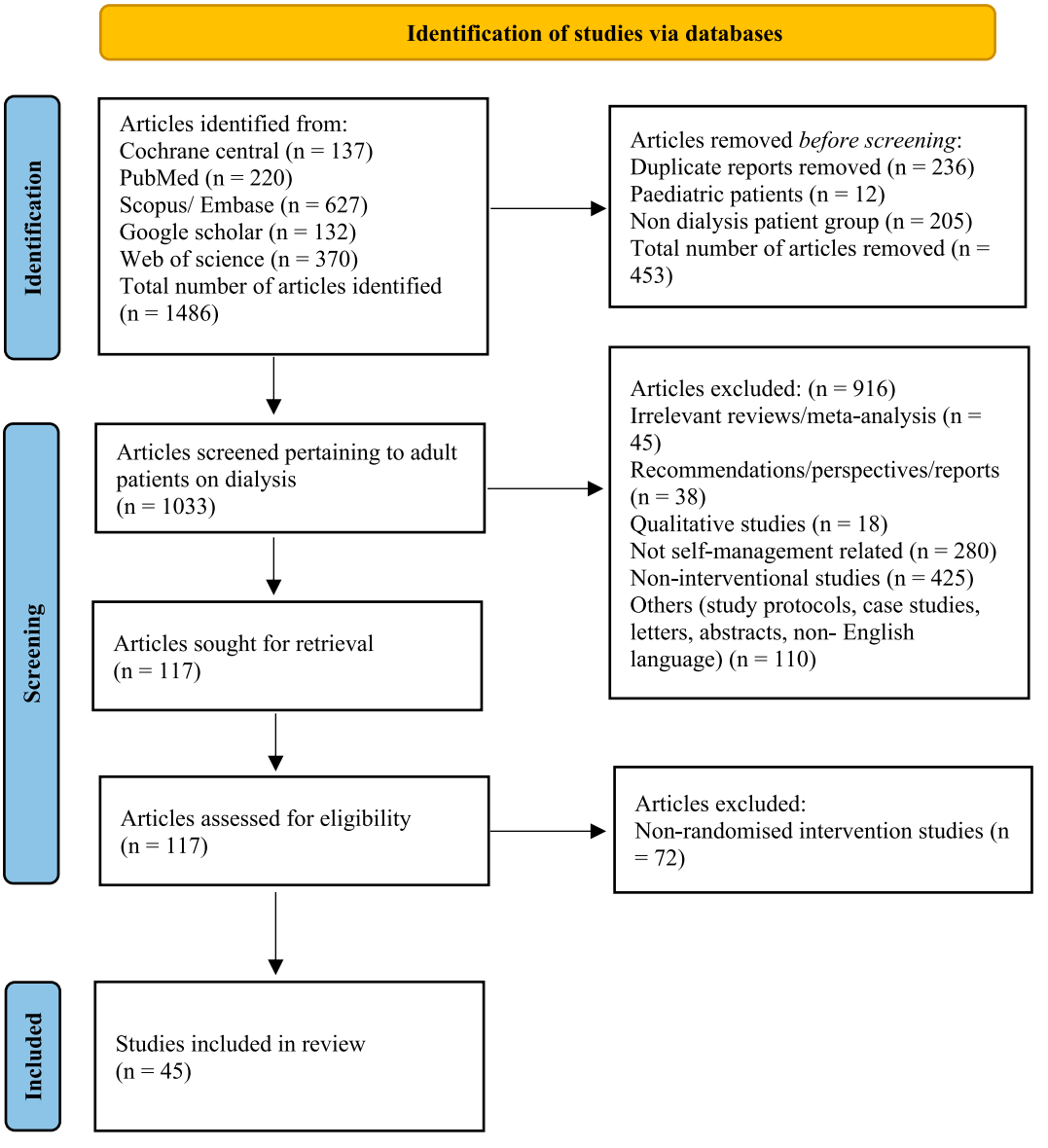

Figure 2. PRISMA flow chart of systematic review process.

mean participant age was 53.66 years (SD_{age} = 7.05). The majority of studies (41) focused on haemodialysis patients, while four studies specifically examined patients undergoing peritoneal dialysis (Chen et al., 2021; Chen et al., 2006; Hare et al., 2014; Wong et al., 2010).

Outcome measures

A detailed account of the measures used to assess outcomes in the included studies is provided in the Supplementary Materials S2. A summary is provided in Table 2. The interventions targeted several psychological constructs, including knowledge (12 studies), self-efficacy (6), outcome expectancies (3), anxiety (3), depression (4), and quality of life (6). These variables were primarily assessed using self-administered questionnaires, with one study employing a clinician-administered interview (Skoutakis et al., 1978).

Table 2. Summary of outcome measures employed across the interventions.

Outcomes	Number of studies	Assessment methods	Example studies
Psychological outcomes			
Knowledge	12	Self-administered questionnaires (multiple-choice, true/false formats) Multiple-choice	Molaison and Yadrick (2003); Karavetian and Ghaddar (2013, 2015); Shi et al. (2013); Ramezani et al. (2019)
Self-Efficacy	6	Self-report questionnaires, visual analogue scales	Tanner et al. (1998); Sharp et al. (2005); Hare et al. (2014); Griva et al. (2018)
Outcome Expectancies	3	Researcher-developed questionnaires, visual analogue scales	Tanner et al. (1998); Hare et al. (2014); Sharp et al. (2005)
Anxiety	3	Validated instruments (e.g., Hospital Anxiety and Depression Scale, PHQ-9)	Sharp et al. (2005); Hare et al. (2014); Valsaraj et al. (2021)
Depression	4	Validated instruments (e.g., Hospital Anxiety and Depression Scale, PHQ-9, Beck Depression Inventory)	Sharp et al. (2005); Hare et al. (2014); Valsaraj et al. (2021); Cukor et al. (2014)
Quality of Life	6	Multi-item general life quality instruments, kidney-specific instruments: (SF-36; Kidney Disease Quality of Life short form)	Sharp et al. (2005); Hare et al. (2014); Cukor et al. (2014); de Freitas et al. (2020); Wong et al. (2010)
Behavioural outcomes			
Dietary adherence	10	Multi-item questionnaires recording food consumption on Likert scales; Phosphate/ protein intake via 24-hour recalls	Arad et al. (2021); Cho (2013); Griva et al. (2018); de Freitas et al. (2020); Ramezani et al. (2019)
Fluid adherence	7	Single items or multi-item questionnaires assessing fluid consumption like the Fluid Control in Haemodialysis Patient Scale	Chang et al. (2021); Wileman et al. (2016); Griva et al. (2018); Cosar and Pakyuz (2016); Ramezani et al. (2018)
Medication adherence	11	Self-reported multi-item scales, pill counts, electronic monitoring devices	Kauric-Klein (2012); Forni Ogna et al. (2013); Griva et al. (2018); Valsaraj et al. (2021)
Physiological outcomes			
Potassium	6	Clinical laboratory records; Biochemical tests at routine intervals.	Cummings et al. (1981); Baraz et al. (2010); Cho (2013); Pasyar et al. (2015); Griva et al. (2018)
Phosphate	22	Clinical laboratory records; Biochemical tests at routine intervals.	Ashurst and Dobbie (2003); Karavetian and Ghaddar (2013, 2015); Wileman et al. (2016); Reese et al. (2015)
IDWG	22	Pre – and post-dialysis weights recorded using electronic scales.	Cummings et al. (1981); Welch et al. (2013); Sharp et al. (2005); Mateti et al. (2018); Chang et al. (2021)

Behavioural outcomes included adherence to dietary (10 studies), fluid (7), and medication regimens (11). Dietary adherence was primarily assessed via multi-item questionnaires using Likert scales (e.g., Arad et al., 2021; Cho, 2013). Fluid adherence was evaluated through single-item scales or multi-item questionnaires, such as the 24-item Fluid Control in Haemodialysis Patient Scale (Cosar & Pakyuz, 2016). Medication adherence was measured using scales like the Morisky Medication Adherence Scale (e.g., Kauric-Klein, 2012) or electronic pill monitoring (e.g., Forni Ogna et al., 2013).

Physiological outcomes comprised potassium (6 studies), phosphate (22), and IDWG (22). Laboratory records were used to assess pre – and post-intervention changes, with reductions in these metrics indicating improved adherence. For IDWG, weight changes were calculated by weighing participants pre – and post-dialysis (e.g., Cummings et al., 1981; Welch et al., 2013).

For the meta-analysis, improvements in knowledge, self-efficacy, outcome expectancies, and QoL were indicated by positive changes, while improvements in anxiety, depression, and physiological measures were indicated by negative changes. See Table 2 for a summary of outcome measures employed across the interventions.

Risk of bias assessment

Results of the risk of bias assessment for the 45 studies are presented in Figure 3. Kappa assessment of inter-rater reliability across domains ranged from 0.7 to 1.0. The first domain is *bias arising from the*

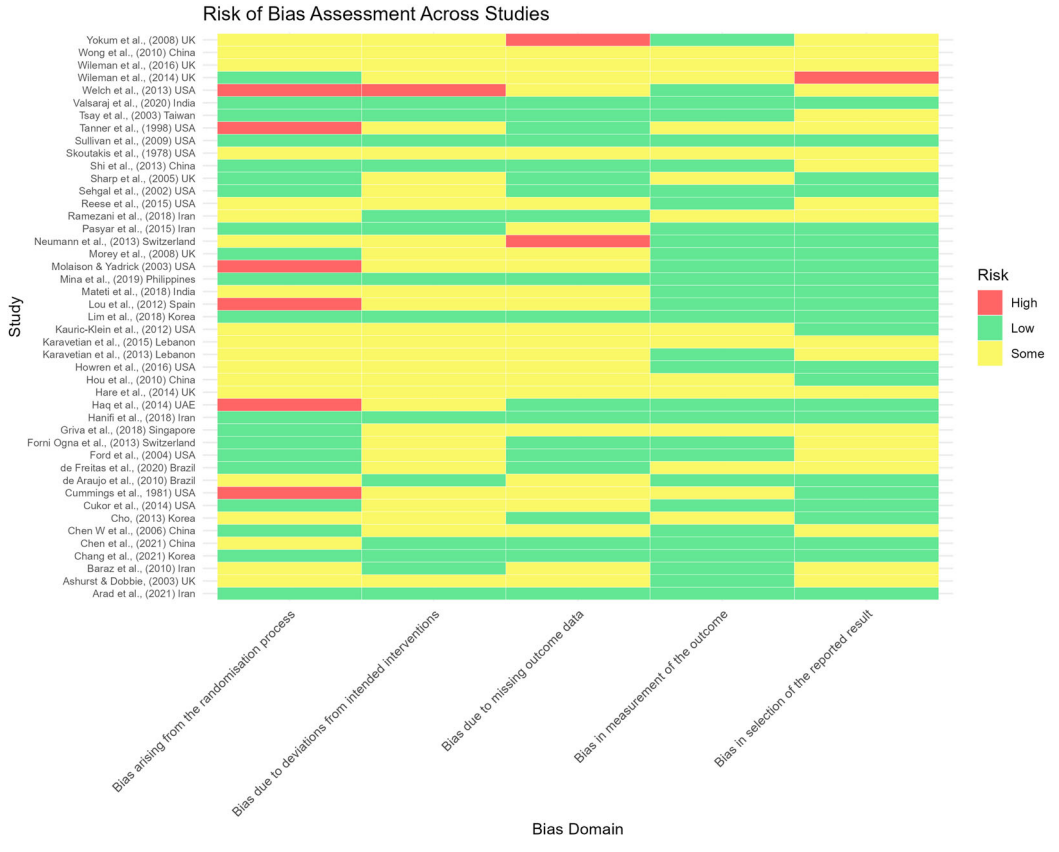

Figure 3. Risk of bias assessment across the 45 studies.

randomisation process which focuses on minimising bias through random allocation to groups through a specified method (e.g., computer generated random numbers, envelopes). Further, the schedule of random assignments must be concealed until participants were recruited and assigned to interventions. 20 studies were 'low concern', 19 were 'some concern' and six were judged as 'high concern'. The second domain *bias due to deviations from intended interventions* relates to systematic differences when the care provided is different from what was intended. For example, planned care not being provided, additional care was provided, or participants were analysed in a different group. Such biases can be reduced or prevented by blinding (masking) intervention from participants and other study personnel. 14 studies were judged as 'low concern', 30 as 'some concern' and one as 'high concern'. The third domain *bias due to missing outcome data* relates to issues around attrition, exclusions from analysis, participant distribution across groups, the reasons provided for the missing data and what has been done to address such issues in data analysis to minimise bias in the observed effect estimate. 19 studies rated as 'low concern', 24 as 'some concern' and two as 'high concern'. The fourth domain *bias in measurement of the outcome* specifically addresses the blinding of intervention assignments to outcome assessors (including participants in self-reported outcomes). 30 studies were scored as 'low concern', 15 as 'some concern' and none as 'high concern'. The final domain *bias in selection of the reported result* relates to outcome non-reporting whereby outcomes are partially or not reported due to the direction or statistical significance of results. This also includes where constructs were measured (e.g., self-efficacy) but no data were reported due to a lack of significance or where multiple measures were used for the same construct, but not all measures were reported. 24 studies were rated as 'low concern', 20 as 'some concern' and one as 'high concern'.

Meta-analysis results

A summary of the results of the meta-analysis is shown in Table 3. The forest and funnel plots for each outcome are provided in Supplementary Material S3. Across outcomes, significant pooled intervention effect sizes, ranging from $g = 0.32$ to g = 1.17, were observed and were associated with heterogeneity values ranging from $I^2 = 31.6\%$ to 90%. Egger's test and funnel plots did not show evidence of publication bias across the analyses.

Effect of interventions on psychological outcomes

Psychological measures included in the studies were either related to proposed mechanisms of action (knowledge, self-efficacy, and outcome expectancy) or affective outcomes (anxiety, depression, and QoL). Significant pooled effects were observed for two of the psychological outcomes assessed: knowledge and QoL. Meta-analytic synthesis of the 12 interventional studies targeting *knowledge* showed a medium effect ($g = 0.65$, $p < 0.01$). Knowledge about kidney disease (e.g., management) was significantly improved in intervention participants relative to controls. Six studies targeted self-reported *QoL* and showed a large significant effect ($g = 1.17$, $p = 0.05$) in the average score of self-reported QoL between participants in the intervention and control groups.

Effects of interventions on behavioural outcomes

Pooled estimates of mean differences in dietary, fluid, and medication adherence showed significant improvements across all three behavioural constructs. The ten studies targeting *dietary adherence* behaviours showed a significant medium effect ($g = 0.50$, $p < 0.001$), with a significant improvement in dietary adherence in response to the intervention relative to controls. The seven studies that investigated *fluid restriction* adherence behaviours showed a medium effect ($g = 0.57$, $p < 0.01$), with significant improvements in fluid restriction adherence in response to the intervention relative to controls. The eleven studies that targeted *medication adherence* behaviours showed a medium effect ($g = 0.65$, $p < 0.01$) and significant improvements in medication adherence in intervention participants relative to controls.

Effects of interventions on physiological outcomes

Significant pooled effects were observed for changes in phosphate and IDWG. In relation to physiological outcomes, it should be noted that a negative sign indicates an improvement in the outcome (lower phosphate, potassium, and IDWG). The 22 studies that assessed reduction in *phosphate* levels

Table 3. Weighted effect size of interventions on psychological, behavioural and physiological outcomes.

		Weighted effect sizes		Heterogeneity		
Outcomes	*k*	*g* (95% CI)	*p*	Q	*p*	I^2(%)
Psychological outcomes						
Knowledge	12	0.65 (0.28, 1.02)	0.0026	94.08	<0.001	88.3
Self-efficacy	6	0.24 (−0.24, 0.73)	0.25	18.62	0.0023	73.1
Outcome expectancies	3	0.06 (−0.24, 0.35)	0.48	0.35	0.84	0
Depression	4	−1.06 (−3.64, 1.51)	0.28	54.37	<0.0001	94.5
Anxiety	3	−0.74 (−2.33, 0.86)	0.18	5.57	0.06	94.1
Quality of life	6	1.17 (−0.02, 2.36)	0.05	55.64	0.0001	91
Behavioural outcomes						
Fluid	7	0.59 (0.29, 0.90)	0.0032	13.38	0.037	55.2
Dietary	10	0.50 (0.24, 0.76)	0.0019	24.19	0.004	62.8
Medication	11	0.65 (0.28, 1.03)	0.0031	43.27	<0.0001	76.9
Physiological outcomes						
Potassium	6	−0.59 (−1.22, 0.04)	0.06	25.16	0.0001	80.1
Phosphate	22	−0.32 (−0.45, − 0.19)	<0.001	30.7	0.07	31.6
IDWG	22	−0.57 (−0.93, − 0.20)	0.004	117.62	<0.0001	82.1

Notes. K number of studies; g hedges g test for overall effect; T^2 variance of the true effects; Q between study heterogeneity; I^2 between study heterogeneity expressed as a percentage of variation due to heterogeneity rather than chance.

showed a significant small effect ($g = -0.32$, $p < 0.001$), with reduced phosphate levels in response to the intervention. The 22 studies testing *IDWG* showed a significant moderate effect ($g = -0.57$, $p = 0.004$) in the average IDWG between participants in the intervention and control groups in response to the intervention. Six studies that examined the intervention effect on potassium serum levels showed a moderate effect ($g = -0.59$). However, changes in potassium levels were not statistically different between participants in the intervention and control groups ($p = 0.06$).

Relationship between outcomes

We tested whether the effect sizes obtained in the meta-analysis for psychological outcomes (knowledge, self-efficacy, outcome expectancies, depression, anxiety, and QoL) were associated with the effect sizes of behavioural outcomes (dietary, fluid, and medication adherence) and physiological outcomes (potassium, phosphate, and IDWG) (Figure 1, path (b)). As previously noted, the effect sizes for psychological outcomes were computed for the first available data point post-intervention in each study, while the effect sizes for behavioural and physiological outcomes were computed for the last available data point post-intervention in each study. Figure 4 illustrates the significant pathways supported by the analyses.

A significant association was obtained between knowledge and medication adherence. The effect size for knowledge was significantly positively associated with that of medication adherence ($b = 1.13$, $SE = 0.07$, $t(4) = 16.65$, $p = 0.03$), indicating that as knowledge improved as a function of the intervention received, medication adherence also improved. The effect size of medication adherence behaviour was, in turn, significantly negatively associated with the effect size of IDWG ($b = -1.64$, $SE = 0.29$, $t(8) = -5.58$, $p = 0.002$). This finding indicates that as medication adherence increased as a function of the intervention received, IDWG decreased (e.g., patients successfully gained less weight between sessions). The effect obtained for QoL was significantly associated with the effect size of IDWG ($b = -1.64$, $SE = 0.11$, $t(4) = -14.98$, $p = 0.04$), showing that improvements in QoL as a function of the intervention received were associated with decreases in IDWG.

Moderation analysis results

Our third aim was to examine moderation of intervention effects. We analysed two categories of potential moderators: intervention content, and intervention duration (Figure 1, path (c)).

Moderation by intervention BCT content

The number of identifiable BCTs across studies ranged from one to seven ($M = 4.23$, $SD = 2.35$). A summary of the techniques employed in the interventions is provided in Table 4. The most

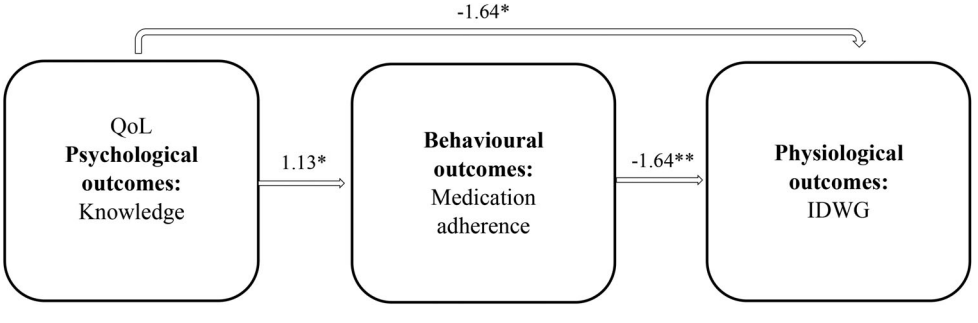

Figure 4. Linear model showing significant relational pathways between psychological constructs and behavioural and physiological outcomes.

Note. Unstandardised beta coefficients are presented (*$p \leq .05$; **$p \leq .01$).

Table 4. Number (%) of interventions including each BCT category (total N = 45 studies).

Moderator	N (%)	Moderator	N (%)
1. Goals and planning	**19 (42.22)**	**9. Comparison of outcomes**	**2 (4.44)**
1.1 Behavioural goal setting	11	9.1 Credible source	0
1.2 Problem-solving	13	9.2 Pros and Cons	2
1.3 Outcome goal setting	2	9.3 Comparative imagining of future outcomes	0
1.4 Action planning	6		
1.5 Review behaviour goal(s)	2		
1.6 Discrepancy between current behaviour and goal	1		
1.7 Review outcome goal(s)	4		
1.8 Behaviour contract	3		
1.9 Commitment	1		
2. Feedback and monitoring	**24 (53.33)**	**10. Reward and threat**	**9 (20.00)**
2.1 Monitoring of behaviour by others without feedback	2	10.1 Behaviour material incentive	3
2.2 Feedback on behaviour	6	10.2 Behaviour material reward	0
2.3 Self-monitoring of behaviour	17	10.3 Non-specific reward	0
2.4 Self-monitoring of outcome(s) of behaviour	2	10.4 Social reward	5
2.5 Monitoring of outcome(s) of behaviour without feedback	1	10.5 Social incentive	0
2.6 Biofeedback	0	10.6 Non-specific incentive	0
2.7 Feedback on outcome(s) of behaviour	10	10.7 Self-incentive	0
		10.8 Outcome incentive	0
		10.9 Self-reward	1
		10.10 Outcome reward	3
		10.11 Future punishment	0
3. Social support	**16 (35.56)**	**11. Regulation**	**2 (4.44)**
3.1 Social support (unspecified)	7	11.1 Pharmacological support	0
3.2 Social support (practical)	4	11.2 Reduce negative emotions	2
3.3 Social support (emotional)	8	11.3 Conserving mental resources	0
		11.4 Paradoxical instructions	0
4. Shaping knowledge	**33 (73.33)**	**12. Antecedents**	**4 (8.89)**
4.1 Instructions on how to perform the behaviour	30	12.1 Physical environment restructuring	2
4.2 Information on antecedents	3	12.2 Social environment restructuring	0
4.3 Re-attribution	2	12.3 Avoidance/reducing exposure to cues for the behaviour	0
4.4 Behavioural experiments	1	12.4 Distraction	0
		12.5 Adding objects to the environment	0
		12.6 Body changes	2
5. Natural consequences	**21(46.67)**	**13. Identity**	**4 (8.89)**
5.1 Information about health consequences	20	13.1 Identification of self as role model	0
5.2 Salience of consequences	1	13.2 Framing/re-framing	2
5.3 Information about social and environmental consequences	0	13.3 Incompatible beliefs	0
5.4 Monitoring of emotional consequences	0	13.4 Valued self-identity	2
5.5 Anticipated regret	0	13.5 Identity associated with changed behaviour	0
5.6 Information about emotional consequences	0		
6. Comparison of behaviour	**3 (6.67)**	**14. Scheduled consequences**	**1 (2.22)**
6.1 Behaviour demonstration	3	14.1 Behaviour cost	0
6.2 Social comparison	0	14.2 Punishment	1
6.3 Information about others' approval	0	14.3 Remove reward	0
		14.4 Reward approximation	0
		14.5 Reward completion	0
		14.6 Situation-specific reward	0
		14.7 Reward incompatible behaviour	0

(*Continued*)

Table 4. Continued.

Moderator	N (%)	Moderator	N (%)
		14.8 Reward alternative behaviour	0
		14.9 Reduce reward frequency	0
		14.10 Remove punishment	0
7. Associations	**9 (20.00)**	**15. Self-belief**	**0**
7.1 Prompts/cues	7	15.1 Verbal persuasion about capability	
7.2 Cue signalling reward	0	15.2 Mental rehearsal of successful performance	
7.3 Reduce prompts/cues	2	15.3 Focus on past success	
7.4 Remove access to the reward	0	15.4 Self-talk	
7.5 Remover aversive stimulus	0		
7.6 Satiation	0		
7.7 Exposure	0		
7.8 Associative learning	0		
8. Repetition and substitution	**4 (8.89)**	**16. Covert learning**	**0**
8.1 Behavioural practice/rehearsal	3	16.1 Imaginary punishment	
8.2 Behaviour substitution	0	16.2 Imaginary reward	
8.3 Habit formation	0	16.3 Vicarious consequences	
8.4 Habit reversal	0		
8.5 Overcorrection	0		
8.6 Generalisation of target behaviour	0		
8.7 Graded tasks	1		

Note. the total number of studies with interventions that included this BCT category.

commonly employed BCT techniques were shaping knowledge, feedback and monitoring, natural consequences, goals and planning, and social support. Seven of the studies used established psychotherapeutic techniques such as CBT, motivational interviewing, relaxation, or rational emotive therapy (Cukor et al., 2014; Forni Ogna et al., 2013; Hare et al., 2014; Hou et al., 2010; Sharp et al., 2005; Pasyar et al., 2015; Valsaraj et al., 2021). Although the BCT subcategory 3.3 (Social Support – Emotional) encompasses both emotional and therapeutic support, we chose to differentiate between the two. Therapy, which is often delivered by a trained professional, requires structured and manualised training, distinguishing it from emotional support provided by friends, relatives, colleagues, or buddies, as defined in the BCT framework. Consequently, we established a separate intervention technique category labelled '*therapy*' for use in subsequent analyses presented in Tables 5 and 6, allowing for a more nuanced examination of the interventions studied.

Moderation analyses were conducted using meta-regression for combinations of BCT categories and outcomes for which data from sufficient studies were available. In the first set of analyses summarised in Table 5, the presence versus absence of single discrete BCT categories were regressed on intervention outcomes. These analyses investigated whether the presence of discrete BCT categories, versus their absence, moderated the effectiveness of the interventions on psychological, behavioural, and physiological outcomes. A positive beta value implies that the presence of the specific technique in the interventions was associated with an increased intervention effect on the relevant outcome. A negative beta value implies that a decreased effect was observed when the intervention technique was present. We limit our discussion to instances where significant differences emerged.

As shown in Table 5, self-efficacy outcomes were larger when *social support* was present in the intervention ($b = 0.80$, $SE = 0.10$, $t(4) = 8.11$, $p = 0.001$), but smaller in interventions that included *reward and threat* ($b = -0.78$, $SE = 0.18$, $t(4) = -4.24$, $p = 0.013$). Interestingly, the presence of three of the eight BCTs (*goals and planning, feedback and monitoring, and shaping knowledge*) also led to significantly smaller intervention effects on QoL ($b = -2.34$, $SE = 0.77$, $t(4) = -3.04$, $p = 0.04$). We observed that the same six studies included these three BCT categories, such that if they contained goals and planning, they also contained shaping knowledge and feedback and monitoring, resulting in identical beta values across these three BCT categories. These analyses revealed no significant moderation effects of BCT techniques on behavioural outcomes and marginal effects on physiological outcomes considered individually.

Table 5. Intervention content (behaviour change technique categories) meta-regressed on psychological, behavioural, and physiological outcomes of interventions.

	Goals & planning	Feedback & monitoring	Social support	Shaping knowledge	Associations	Natural consequences	Reward & threat	Therapy
Psychological outcomes								
Knowledge (k = 12)	b = 0.52	b = 0.22	b = 0.16	b = −0.62	b = −0.37	b = 0.36	b = −0.08	–
	p = 0.14	*p* = 0.53	*p* = 0.68	*p* = 0.16	*p* = 0.36	*p* = 0.36	*p* = 0.86	
Self-efficacy (k = 6)	b = 0.27	b = −0.52	b = 0.80	b = 0.27	b = 0.30	b = −0.68	b = −0.78	b = 0.55
	p = 0.67	*p* = 0.25	*p* = 0.00	*p* = 0.67	*p* = 0.60	*p* = 0.06	*p* = 0.01	*p* = 0.23
Outcome expectancies (k = 3)	–	–	b = −0.17	–	b = −0.09	b = 0.23	b = 0.17	b = −0.17
			p = 0.30		*p* = 0.69	*p* = 0.47	*p* = 0.30	*p* = 0.30
Depression (k = 4)	b = 1.82	b = 1.82	–	b = 1.82	b = 1.31	b = 1.31	–	–
	p = 0.35	*p* = 0.35		*p* = 0.35	*p* = 0.59	*p* = 0.59		
Anxiety (k = 3)	b = −0.03	b = −0.03	–	b = −0.03	b = 0.83	b = 0.83	–	–
	p = 0.98	*p* = 0.98		*p* = 0.98	*p* = 0.40	*p* = 0.40		
Quality of life (k = 6)	b = −2.33	b = −2.33	b = 1.49	b = −2.33	b = −0.52	b = −0.52	–	b = 1.44
	p = 0.03	*p* = 0.03	*p* = 0.13	*p* = 0.03	*p* = 0.72	*p* = 0.72		*p* = 0.13
Behavioural outcomes								
Dietary adherence (k = 10)	b = −0.36	b = 0.13	b = 0.07	b = −0.25	–	b = −0.15	b = 0.10	b = 0.38
	p = 0.13	*p* = 0.59	*p* = 0.77	*p* = 0.31		*p* = 0.54	*p* = 0.82	*p* = 0.36
Fluid adherence (k = 7)	b = 0.01	b = 0.44	b = 0.04	b = −0.26	–	b =−0.13	–	b = −0.12
	p = 0.97	*p* = 0.14	*p* = 0.89	*p* = 0.52		*p* = 0.64		*p* = 0.70
Medication adherence (k = 11)	b = −0.05	b = −0.22	b = −0.29	b = −0.26	b = 0.24	b = 0.29	b = −0.65	b = 0.48
	p = 0.88	*p* = 0.55	*p* = 0.43	*p* = 0.58	*p* = 0.74	*p* = 0.43	*p* = 0.13	*p* = 0.46
Physiological outcomes								
Potassium (k = 6)	b = −0.87	b = −0.72	b = −0.09	b = −0.78	–	b = −0.10	b = −0.72	–
	p = 0.07	*p* = 0.21	*p* = 0.88	*p* = 0.26		*p* = 0.87	*p* = 0.21	
Phosphate (k = 22)	b = −0.04	b = −0.06	b = 0.07	b = 0.15	b = 0.05	b = 0.14	b = 0.29	b = 0.53
	p = 0.78	*p* = 0.67	*p* = 0.61	*p* = 0.31	*p* = 0.75	*p* = 0.29	*p* = 0.14	*p* = 0.07
IDWG (k = 22)	b = 0.37	b = 0.60	b = −0.36	b = 0.38	–	b = 0.37	b = 0.48	b = −0.67
	p = 0.32	*p* = 0.08	*p* = 0.33	*p* = 0.33		*p* = 0.32	*p* = 0.24	*p* = 0.11

Note. Unstandardised beta coefficients and *p* values are reported in the table. Wellbeing denotes an aggregation of depression, anxiety and QoL. K denotes number of studies. Dash indicates that it was not meaningful to test the association between variables due to missing data. BCT categories were coded dichotomously: (present 1 v absent 0).

Exploratory analyses

After completing all analyses specified in our PROSPERO registration, we conducted additional exploratory analyses to increase statistical power. For these, we aggregated outcomes into three constructs: behavioural (dietary, fluid, and medication adherence), physiological (interdialytic weight gain, potassium, and phosphate serum levels), and psychological (self-efficacy, knowledge, outcome expectancy, anxiety, depression, and QoL). We also ran separate analyses for aggregated psychological outcomes denoting wellbeing (anxiety, depression, and QoL) and an aggregated psychological construct excluding wellbeing (self-efficacy, knowledge, and outcome expectancy). The results of these analyses are shown in Table 6 and denoted by ^{1}b. The presence of *shaping knowledge* ($^{1}b = -0.73$, $SE = 0.35$, $t(32) = -2.10$, $p = 0.04$) was significantly associated with a smaller intervention effect on the aggregate psychological construct.

Since interventions rarely employ a single BCT technique and techniques may be enhanced or diminished in their effects by their use in combination with other techniques, a second set of meta-regressions (Table 6) was conducted in which the effects of interventions on outcomes were regressed on the discrete BCT technique category after controlling for the total number of techniques employed in the intervention (shown in the second row for each outcome and denoted ^{2}b), and on the interaction between the BCT category and the total number of techniques employed (shown in the third row for each outcome and denoted ^{3}b). In order to conduct these analyses, the effects on psychological, behavioural, and physiological outcomes were analysed in aggregate. Results are summarised in Table 6.

As shown in Table 6, we observed significantly larger positive effects of the interventions on physiological outcomes when the presence of *therapy* was examined after controlling for additional techniques ($^{2}b = 0.49$, $SE = 0.24$, $t(47) = 2.07$ $p = 0.043$). Consistent with this observation, there was a significant interaction between the presence of therapy and the number of BCTs ($^{3}b = -0.25$, $SE = 0.11$, $t(46) = -2.20$, $p = 0.03$). Simple slopes analysis (Aiken & West, 1991) showed that the inclusion of therapy alone or with fewer other BCTs in interventions was associated with significantly larger intervention effects on physiological outcomes ($b = 0.88$, $SE = 0.29$, $t(46) = 3.02$, $p = 0.004$), whereas the inclusion of therapy and a high number of other BCT techniques was not significant ($b = 0.14$, $SE = 0.27$, $t(46) = 0.52$, $p = 0.61$). This suggests that to improve physiological outcomes, interventions that include therapy should be accompanied by fewer rather than multiple other BCTs. No significant effects on aggregated behavioural outcomes were observed for any BCT technique alone, or in combination with other techniques.

The analyses shown in Table 6 also show distinctive effects of BCT techniques on the aggregate psychological construct excluding wellbeing (e.g., aggregated knowledge, self-efficacy, and outcome expectancy). A significant interaction was observed between the presence of *feedback and monitoring* and the number of BCTs employed in the interventions ($^{3}b = -0.59$, $SE = 0.16$, $t(17) = -3.69$, $p = 0.002$). Simple slopes analysis showed that the inclusion of *feedback and monitoring* with a high number of additional BCT techniques was associated with significantly smaller intervention effects on these psychological measures ($b = -1.77$, $SE = 0.48$, $t(17) = -3.71$, $p = 0.002$), but there was no difference in effect size for studies with, compared to without, *feedback and monitoring* in the intervention when there were fewer BCTs present ($b = 0.32$, $SE = 0.26$, $t(17) = 1.20$, $p = 0.25$). This suggests that the presence of *feedback and monitoring* alone, and accompanied by additional BCTs, was unhelpful in modifying these outcomes. A similar interaction was obtained for the effect of the presence of *shaping knowledge* and the number of BCT techniques employed in interventions on this outcome ($^{3}b = -0.60$, $SE = 0.14$, $t(17) = 4.14$, $p = 0.0007$). Simple slopes analysis showed that the presence, relative to the absence, of *shaping knowledge* and a high number of additional techniques led to significantly smaller intervention effects ($b = -2.11$, $SE = 0.44$, $t(17) = -4.80$, $p = 0.0002$). When the presence, relative to the absence, of *shaping knowledge* was accompanied by a low number of other BCTs, there was no significant difference in intervention effects between the intervention and control conditions ($b = 0.01$, $SE = 0.27$, $t(17) = 0.03$, $p = 0.97$), suggesting that the addition of *shaping knowledge* and more BCTs can have undesirable effects on psychological outcomes excluding wellbeing, compared to when included with fewer others.

Table 6. Presence vs. absence of BCT categories in intervention (^{1}b), BCT categories whilst controlling for number of BCT (^{2}b), and their interaction (^{3}b) meta-regressed on aggregated psychological, behavioural, and physiological intervention outcomes.

	Goals & planning	Feedback & monitoring	Social support	Shaping knowledge	Associations	Natural consequences	Reward & threat	Therapy
Aggregated psychological outcomes (k = 34)	^{1}b = −0.05 *p* = 0.88 ^{2}b = −0.12 *p* = 0.81 ^{3}b = 0.03 *p* = 0.94	^{1}b = −0.28 *p* = 0.39 ^{2}b = −0.39 *p* = 0.31 ^{3}b = −0.15 *p* = 0.58	^{1}b = 0.54 *p* = 0.08 ^{2}b = 0.55 *p* = 0.08 ^{3}b = −0.10 *p* = 0.61	^{1}b = −0.73 *p* = 0.04 ^{2}b = −0.85 *p* = 0.03 ^{3}b = −0.24 *p* = 0.32	^{1}b = −0.39 *p* = 0.35 ^{2}b = −0.40 *p* = 0.35 ^{3}b = −0.01 *p* = 0.96	^{1}b = −0.21 *p* = 0.51 ^{2}b = −0.22 *p* = 0.52 ^{3}b = 0.08 *p* = 0.70	^{1}b = −0.44 *p* = 0.41 ^{2}b = −0.52 *p* = 0.38 ^{3}b = −0.13 *p* = 0.90	^{1}b = 0.62 *p* = 0.09 ^{2}b = 0.66 *p* = 0.10 ^{3}b = −0.36 *p* = 0.054
Wellbeing (k = 13)	^{1}b = −1.33 *p* = 0.12 ^{2}b = −1.90 *p* = 0.14 ^{3}b = −2.52 *p* = 0.009	^{1}b = −1.33 *p* = 0.12 ^{2}b = −1.90 *p* = 0.14 ^{3}b = −2.52 *p* = 0.009	^{1}b = 1.09 *p* = 0.23 ^{2}b = 1.28 *p* = 0.18 –	^{1}b = −1.33 *p* = 0.12 ^{2}b = −1.90 *p* = 0.14 ^{3}b = −2.52 *p* = 0.009	^{1}b = −0.75 *p* = 0.55 ^{2}b = −0.50 *p* = 0.80 –	^{1}b = −0.75 *p* = 0.55 ^{2}b = −0.50 *p* = 0.80 –	– – – 	^{1}b = 0.86 *p* = 0.32 ^{2}b = 0.97 *p* = 0.30 ^{3}b = 1.10 *p* = 0.49
Psychological construct excluding wellbeing (k = 21)	^{1}b = 0.24 *p* = 0.37 ^{2}b = 0.30 *p* = 0.54 ^{3}b = −0.50 *p* = 0.18	^{1}b = 0.53 *p* = 0.88 ^{2}b = −0.17 *p* = 0.60 ^{3}b = −0.59 *p* = 0.002	^{1}b = 0.14 *p* = 0.61 ^{2}b = 0.11 *p* = 0.71 ^{3}b = 0.04 *p* = 0.83	^{1}b = −0.38 *p* = 0.26 ^{2}b = −0.43 *p* = 0.22 ^{3}b = −0.60 *p* = 0.0002	^{1}b = −0.28 *p* = 0.36 ^{2}b = −0.31 *p* = 0.32 ^{3}b = −0.10 *p* = 0.63	^{1}b = 0.11 *p* = 0.71 ^{2}b = 0.10 *p* = 0.74 ^{3}b = −0.07 *p* = 0.74	^{1}b = −0.29 *p* = 0.45 ^{2}b = −0.50 *p* = 0.25 ^{3}b = −0.20 *p* = 0.80	^{1}b = −0.19 *p* = 0.66 ^{2}b = −0.60 *p* = 0.30 ^{3}b = −0.45 *p* = 0.59
Aggregated behavioural outcomes (k = 28)	^{1}b = −0.26 *p* = 0.26 ^{2}b = −0.26 *p* = 0.32 ^{3}b = 0.01 *p* = 0.98	^{1}b = −0.11 *p* = 0.59 ^{2}b = −0.08 *p* = 0.73 ^{3}b = 0.06 *p* = 0.76	^{1}b = 0.00 *p* = 0.99 ^{2}b = 0.02 *p* = 0.93 ^{3}b = −0.15 *p* = 0.37	^{1}b = −0.26 *p* = 0.38 ^{2}b = −0.25 *p* = 0.41 ^{3}b = 0.19 *p* = 0.31	^{1}b = 0.60 *p* = 0.53 ^{2}b = 0.62 *p* = 0.52 –	^{1}b = 0.12 *p* = 0.58 ^{2}b = 0.13 *p* = 0.53 ^{3}b = 0.00 *p* = 0.99	^{1}b = −0.16 *p* = 0.53 ^{2}b = −0.13 *p* = 0.72 ^{3}b = 0.02 *p* = 0.97	^{1}b = 0.29 *p* = 0.46 ^{2}b = 0.25 *p* = 0.53 ^{3}b = −0.18 *p* = 0.65
Aggregated physiological outcomes (k = 50)	^{1}b = −0.08 *p* = 0.65 ^{2}b = 0.16 *p* = 0.52 ^{3}b = −0.00 *p* = 0.98	^{1}b = −0.21 *p* = 0.22 ^{2}b = −0.15 *p* = 0.44 ^{3}b = 0.15 *p* = 0.25	^{1}b = 0.21 *p* = 0.23 ^{2}b = 0.27 *p* = 0.13 ^{3}b = −0.09 *p* = 0.45	^{1}b = −0.20 *p* = 0.30 ^{2}b = −0.11 *p* = 0.62 ^{3}b = −0.00 *p* = 0.99	^{1}b = −0.09 *p* = 0.74 ^{2}b = −0.06 *p* = 0.80 ^{3}b = −0.04 *p* = 0.85	^{1}b = 0.13 *p* = 0.21 ^{2}b = −0.16 *p* = 0.39 ^{3}b = 0.02 *p* = 0.89	^{1}b = −0.21 *p* = 0.31 ^{2}b = −0.04 *p* = 0.89 ^{3}b = 0.14 *p* = 0.60	^{1}b = 0.47 *p* = 0.051 ^{2}b = 0.49 *p* = 0.043 ^{3}b = −0.25 *p* = 0.03

Note. Unstandardised beta coefficients and *p* values are reported in the table. Steps 1 denotes BCT categories meta-regressed on psychological, behavioural, and physiological outcomes, 2 denotes step 1 whilst controlling for the number of BCT's in interventions and 3 denotes the interaction between BCT categories and number of BCT's. Wellbeing denotes an aggregation of depression, anxiety and QoL. K denotes number of studies. Dash indicates that there was no interaction between variables and /or it was not meaningful to run analysis due to incomplete data. BCT categories were coded dichotomously: present 1 v absent 0. *P* values are rounded up.

We also obtained significant interactions between three of the BCT categories (*goals and planning*, *feedback and monitoring*, and *shaping knowledge*)[1] and the number of BCTs in the interventions ($^3b = -2.52$, $SE = 0.76$, $t(9) = -3.30$, $p = 0.009$) on the aggregate wellbeing construct. Simple slopes analysis showed that in the studies that included, relative to those that did not include, *goals and planning*, *feedback and monitoring* and *shaping knowledge* in their intervention, the intervention effect was smaller both when accompanied by fewer other BCTs ($b = -2.57$, $SE = 0.68$, $t(9) = -3.77$, $p = 0.004$), and by more BCT's ($b = -14.44$, $SE = 3.88$, $t(9) = -3.72$, $p = 0.005$). However, the reduction of the effect size was even more pronounced in the presence of more BCTs, suggesting more BCTs per intervention is not always better.

Moderation by intervention duration

Intervention duration was operationalised as the total number of contacts between the intervention provider and participant during intervention delivery. As reported in Table 1, the number of contacts participants experienced across studies ranged from 1 to 115 over the course of the interventions. For example, an intervention might comprise a single session taking place on one day or might involve repeated engagement with intervention delivery over weeks or months. The results of the meta-regression with duration as a continuous moderator variable are summarised in Table 7. Significant moderation by duration was observed for the aggregate wellbeing construct ($b = 0.21$, $SE = 0.09$, $t(11) = 2.36$, $p = 0.03$), such that longer duration interventions were associated with a larger intervention effect. Interventions with a longer duration (above the median) had a larger intervention effect on wellbeing ($g = 1.51$, $p = 0.04$) compared to interventions with a duration below the median ($g = 0.53$, $p = 0.10$). Intervention duration did not significantly moderate intervention effects for any other outcome.

General discussion

This study provides the first comprehensive meta-analysis synthesising the results of 45 randomised controlled studies that aimed to improve psychological, behavioural, and physiological outcomes. We obtained strong evidence that self-management interventions can be effective in improving outcomes among patients on dialysis and that their implementation may contribute to improved patient care. We also extended prior research by examining the contribution of distinct BCTs to

Table 7. Meta-regression models for moderation by intervention duration on psychological, behavioural, and physiological outcomes.

Outcome Variable (number of studies)	*b*	SE	*P*
Aggregated psychological outcomes (k = 34)	0.01	0.01	0.25
Knowledge (k = 12)	0.01	0.01	0.27
Self-efficacy (k = 6)	0.06	0.17	0.73
Outcome expectancies (k = 3)	0.09	0.04	0.29
Depression (k = 4)	−0.31	0.17	0.21
Anxiety (k = 3)	0.00	0.20	0.98
Quality of Life (k = 6)	0.22	0.11	0.11
Wellbeing (k = 13)	0.21	0.09	0.03
Psychological construct excluding wellbeing (k = 21)	0.01	0.01	0.06
Aggregated behavioural outcomes (k = 28)	0.00	0.00	0.92
Dietary adherence (k = 10)	0.00	0.01	0.60
Fluid adherence (k = 7)	0.05	0.04	0.29
Medication adherence (k = 11)	0.01	0.05	0.78
Aggregated physiological outcomes (k = 50)	0.00	0.01	0.47
Potassium (k = 6)	−0.08	0.15	0.61
Phosphate (k = 22)	−0.00	0.00	0.31
IDWG (k = 22)	−0.08	0.04	0.08

Note. Unstandardised beta coefficients, standard errors (SE) and *p*-values for the interaction terms are reported in the table. Wellbeing denotes an aggregation of depression, anxiety and QoL.

intervention effects in order to identify the characteristics of more effective interventions. The meta-analysis yielded moderate and significant effect sizes for improvements in dietary, fluid, and medication adherence, as well as correspondingly moderate reductions in serum phosphate ($g = -0.32$, CI – 0.45 to – 0.19) and IDWG ($g = -0.57$, CI – 0.93 to – 0.20) in intervention groups relative to control groups. A moderate, but non-significant, effect on serum potassium ($g = -0.59$, $p = 0.06$) was observed, likely constrained by the limited number of available studies testing this outcome. The effect size for IDWG observed here, with more studies, was larger than that observed by Murali et al. (2019), who reported significant reductions in IDWG ($g = -0.20$, CI −0.32 to −0.08) among intervention groups compared to control groups. However, for serum phosphate, Murali et al. observed a greater effect ($g = -0.45$, CI −0.66 to −0.21) than our study ($g = -0.32$, CI −0.45 to −0.19). Furthermore, the non-significant effect on serum potassium in this meta-analysis reflects a similar pattern identified by Murali et al., who noted that this outcome was less frequently reported. Our findings build upon all previous reviews (Karavetian et al., 2014; Matteson & Russell, 2010, 2013; Milazi et al., 2017; Murali et al., 2019; Tao et al., 2020), by incorporating a larger sample of randomised controlled studies and providing novel evidence regarding the effects of interventions on behavioural adherence. Psychological measures were categorised into two groups: mechanisms of action and wellbeing outcomes. Relatively few of the 45 studies assessed proposed mechanisms of action, the most commonly assessed being knowledge, evaluated in twelve studies, while self-efficacy and outcome expectancy were assessed in six and three studies, respectively. The second category of psychological outcomes was wellbeing, assessed via changes in depression, anxiety, or QoL. A large, significant positive effect of the interventions on QoL relative to control groups was observed.

Importantly, our investigation into the relationships between outcomes revealed potential pathways through which changes in psychological targets may have influenced intervention effectiveness. The effect size obtained for knowledge was positively associated with effects on medication adherence, and effects on medication adherence were in turn associated with effects on decreasing IDWG. Medication adherence was frequently assessed using objective measures such as pill counts. Whilst phosphate binders commonly prescribed in CKD are not directly known to affect IDWG (Puri et al., 2008), dialysis dependent CKD patients often have comorbidities such as diabetes, hypertension, and cardiovascular conditions, for which medications such as diuretics are prescribed (e.g., Roehm et al., 2020). The finding that knowledge change was associated with improved medication adherence, but not other outcomes, suggests that knowledge or understanding may be sufficient to enhance medication adherence in this population. Future research could investigate which specific aspects of knowledge beliefs (e.g., understanding of medication purpose, concerns about side effects) are linked to medication adherence. Horne et al. (2013) found that medication adherence was positively associated with stronger beliefs of treatment necessity and negatively associated with concerns about treatment. This indicates that adherence may depend not only on medication knowledge but also on addressing the balance between necessity and concern beliefs. Foley et al. (2023) further demonstrated the multidimensional nature of the relationship between medication beliefs and adherence among older adults with multimorbidity, highlighting that medication beliefs are a key factor impacting adherence.

Additionally, we observed a direct relationship between QoL and IDWG, indicating that as QoL improved, IDWG decreased. This finding is consistent with previous research showing associations between QoL improvement and a reduction in IDWG (Akman et al., 2007; Kahraman et al., 2015; Vasilopoulou et al., 2016). These results suggest that healthcare providers should adopt a multidisciplinary approach to patient care, recognising that enhancing QoL can lead to better clinical outcomes, including reduced IDWG. A multidisciplinary approach involving nephrologists, dietitians, and psychologists can significantly optimise physical and mental health outcomes for dialysis patients through integrated care and regular monitoring. Nephrologists can manage optimal dialysis adequacy and medical management, while dietitians address nutritional complexities and potential metabolic challenges. Psychologists can provide crucial mental health support, addressing depression, anxiety, and quality of life concerns inherent in chronic dialysis treatment. Regular

interdisciplinary assessments enable early intervention, allowing timely adjustments to treatment plans and proactive management of potential complications. This approach not only addresses the immediate physiological requirements of dialysis but also supports patients' psychological resilience, ultimately improving overall treatment outcomes, and self-management (Helou et al., 2020; Zimbudzi et al., 2020).

We observed considerable heterogeneity in effect sizes across outcomes, which could be partly due to the limited number of studies available for some outcomes, as well as variations in intervention content and duration. To explore moderators of intervention effectiveness, we conducted meta-regression analyses. We extended previous reviews by examining the intervention content using the BCT taxonomy (Michie et al., 2013) to understand how and why interventions were effective. The interventions primarily consisted of five BCT categories: *4 shaping knowledge* (e.g., behavioural instructions) was used in 33 studies (71.74%), *2 feedback and monitoring* (e.g., behavioural feedback) was used in 24 studies (52.17%), *5 natural consequences* (health, social, and emotional consequences) was used in 21 studies (45.65%), *goals and planning* (e.g., goal setting) was used in 19 studies (41.30%), and *3 social support* (e.g., practical and emotional) was used in 16 studies (34.78%). See Table 4 for a detailed breakdown. Consistent with meta-reviews of evidence across various chronic conditions (e.g., Hennessy et al., 2020; Spring et al., 2021; Suls et al., 2020; Wilson et al., 2020), most studies employed multiple techniques within a single intervention. Despite the popularity of BCTs focusing on knowledge, feedback and monitoring, goals and planning, and/or consequences in the interventions, little conclusive evidence was found that their presence versus absence moderated intervention effects on either behavioural or physiological outcomes. We examined the effects of these techniques while controlling for the presence of additional techniques. It is possible that combinations of techniques, other than those tested here, might have accounted for the moderate, significant effects on behaviour change observed.

However, we obtained evidence that the inclusion of *therapy* (techniques classified by the BCT as 3.3 emotional social support, such as cognitive behavioural therapy, rational emotive therapy, and motivational interviewing) in interventions resulted in larger, significant improvements in aggregated physiological outcomes, particularly when used as a single technique or with fewer additional techniques. The significant effect of psychotherapeutic techniques on distal physiological outcomes deserves consideration. One possibility is that these interventions benefited from greater delivery fidelity, as established procedures exist for delivering these techniques, in contrast with the potentially less effective delivery of other BCTs. However, the specific content of these interventions, often focusing on patients' emotional lives, may also be pivotal especially in improving their quality of life and adjustments to dialysis, further emphasising the value of a multidisciplinary approach in optimising health outcomes.

Recent calls advocate for a greater focus on the role of emotion regulation in managing goal-directed behaviour and self-management in chronic illness (e.g., O'Carroll, 2020). A key component of effective self-management is addressing the emotional challenges associated with living with a chronic condition (e.g., Corbin & Strauss, 1988; Lorig et al., 2001). This underscores the significance of emotional self-management, as the ability to process and regulate emotions is essential for maintaining overall well-being and ensuring adherence to self-management behaviours. It is plausible that a combination of delivery modes, including both individual (e.g., Cukor et al., 2014; Valsaraj et al., 2021) and group formats (e.g., Hare et al., 2014; Sharp et al., 2005), along with an autonomy-promoting, non-directive approach to helping patients discover their own meaning and personal health goals, would be effective. These psychotherapeutic techniques were more effective in promoting self-management than many of the BCT techniques that tend to be more directive or controlling in their delivery, or even include punitive rehearsal of threats of non-adherence and rigid monitoring. The findings underline the importance of viewing psychological wellbeing not simply as a by-product or secondary outcome of behaviour change interventions, but as an important primary route to improving outcomes. Future research might examine the moderating effect of psychological wellbeing on outcomes of interventions.

Analyses testing the moderating effect of intervention duration revealed that interventions with more contact points between the intervention provider and patient were associated with greater intervention effects on the aggregated wellbeing construct (depression, anxiety, and quality of life). This is consistent with research evaluating interventions aimed at improving wellbeing which suggest that interventions with more contact points more effectively improved symptoms of anxiety and depression in the general population than those with fewer contact points (Newby et al., 2015; Tiemens et al., 2019). Our findings extend this to a clinical care context and highlight the importance of frequency of contact in the development of new interventions. However, the underlying mechanism examing why duration improves outcomes were not tested. It is plausible that greater exposure to the intervention, through more contact, could offer sustained support by fostering emotional encouragement and promoting a sense of belonging – factors that may be critical for psychological wellbeing. Furthermore, more contact may enhance patients' learning opportunities, enabling them to better retain session content and apply it in their everyday lives (Bruijniks et al., 2015). Similarly, continuous reinforcement is most effective for learning new behaviours, and more frequent contact facilitates this process. Consequently, our findings demonstrate that interventions aiming to improve psychological outcomes should consider maximising the number of patient contacts to yield greater intervention effects.

A small number of studies ($k = 6$) examined intervention effects on self-efficacy, often considered a key construct for behavioural change (Bag & Mollaoğlu, 2010; Balaga, 2012; Curtin et al., 2008; Rahimi et al., 2014). Although the meta-analysis did not show a significant overall effect of the interventions on improving self-efficacy, the moderator analysis by BCT provided some important insights into why this might have been the case. Examination of techniques that moderated intervention effects on self-efficacy showed that interventions that included social support were more successful in enhancing self-efficacy.

This finding provides important insight into how best to improve self-efficacy in dialysis dependent CKD patients. Inspection of the contents of the interventions suggests that social support enhanced self-efficacy via observation of similar others (e.g., administered in peer support contexts: Griva et al., 2018; Hare et al., 2014). The role of peer support has been extensively shown to improve treatment adherence and psychological wellbeing (Husain et al., 2020; Irajpour et al., 2018; Malek-Khahi et al., 2015), and social support, including family support, has been associated with self-efficacy in the promotion of implementing and maintaining effective self-management in CKD patients (Chironda & Bhengu, 2019; Du et al., 2018; Isnaini et al., 2021; Wiwoot et al., 2017). Social support may also contribute to improved self-efficacy via an improved emotional state, since unpleasant psychological states tend to undermine feelings of competence (Bandura, 1977; Wood & Bandura, 1989).

Conversely, interventions employing *reward and threat* weakened intervention effects on self-efficacy and suggests that some techniques may undermine confidence or increase negative emotional states. For example, some patients in the included studies were offered extrinsic rewards (e.g., lottery tickets; Kauric-Klein, 2012) only when they reached a specific physiological goal. Overreliance on extrinsic motivation (e.g., lotteries) has previously been linked to poorer self-management and self-efficacy in other contexts (e.g., Michaelsen & Esch, 2021; Ryan & Deci, 2020; Schultz & Ryan, 2015; Shin & Bolkan, 2021). By contrast, techniques that enable patients to recognise their strengths and use them to promote understanding of their conditions have been associated with enhanced self-esteem, self-efficacy, and a reduction in the depressive symptoms of patients with chronic illnesses (Yan et al., 2020).

Strength, limitations and future research directions

In common with many reviews in this domain (e.g., Spring et al., 2021; Suls et al., 2020), the identification of BCTs from the multicomponent interventions included in the review required us to assess the contributions of individual techniques post hoc by coding the techniques described in the interventions. The coding process relied on the descriptions provided in the studies and supplementary

materials. Limited descriptions of interventions may have led to the omission of some BCTs, and it is uncertain whether the BCTs were implemented as intended or with full accuracy during the interventions. To mitigate the potential bias associated with coding errors, two authors coded each article independently, and all coding was cross-checked by a third author. Nonetheless, future studies should ensure detailed accounts of the operationalisation of specific BCTs. Additionally, very few studies to date have evaluated changes in proposed mechanisms of action; the few studies that did focused on changes in knowledge, self-efficacy, or outcome expectancies. In our meta-analysis, the effects of BCTs could only be inferred through statistical tests that adjusted for the presence of additional techniques.

Primary tests of interventions, which include the assessment of the technique's efficacy in changing the proposed mechanism of action alongside distal health outcomes, could potentially yield stronger evidence of the causal role of that technique in optimising health outcomes. Such primary tests might ultimately identify an effective 'bundle' of techniques. Although it is understandable that clinicians may be hesitant to rely on a single plausible technique, such an approach could ultimately advance the development of a replicable intervention strategy for clinical care. It should be acknowledged that an updated taxonomy, the Behaviour Change Technique Ontology (Marques et al., 2024), was published in 2023, and future research might consider using this updated version. The updated version builds on BCTTv1 (Michie et al., 2013) and offers a more comprehensive set of 281 BCTs, providing a valuable resource for analysing interventions. This increased granularity allows for more detailed and nuanced coding of interventions, potentially enabling richer analyses of the effectiveness of BCTs. To further enhance the identification and synthesis of intervention components, alternative approaches, such as machine learning and text mining techniques, could be explored. For example, natural language processing (NLP) and clustering algorithms have the potential to automate the analysis of intervention descriptions. NLP could reveal patterns or themes that may not be immediately apparent through manual review (Chu et al., 2019). Similarly, clustering algorithms could group interventions based on shared characteristics, offering insights into which content types are linked to specific outcomes (Engl et al., 2019). These alternative approaches present promising opportunities for future research, potentially providing deeper insights into the complex relationships between intervention components and outcomes.

To date, studies have relied on relatively few types of BCTs. Dialysis is a long-term treatment for a chronic condition requiring ongoing dietary and fluid restrictions. It is, therefore, perhaps surprising that habit formation techniques (e.g., Gardner et al., 2021) were absent from the interventions, despite their potential utility in helping patients develop sustained behaviours. Our study was unable to account for social contextual factors, such as how patients manage their home and social environments, which significantly influence treatment adherence. Factors such as food costs, meal preparation responsibilities, and the types of food available have a substantial impact on self-management. Reliance on others for meal preparation can lead to poor dietary choices, driven by feelings of guilt or a desire not to burden family members. Qualitative studies highlight how CKD affects home relationships, with patients often choosing unhealthy diets to avoid inconveniencing loved ones (Okoyo Opiyo et al., 2020; Walker et al., 2012). The person preparing meals is a key predictor of dietary adherence (Cristovao, 2015).

Future research should consider a more comprehensive approach that examines the restructuring of patients' environments and social dynamics as important predictors of treatment adherence, providing a more nuanced understanding of the circumstances in which certain interventions are more effective than others. Moreover, given the insight that psychotherapeutic techniques providing emotional social support enhanced physiological outcomes, future research might also evaluate the role of psychological states, such as depression, as moderators of the effects of behaviour change interventions.

Conclusion

This review provides crucial insights into promoting self-management among dialysis patients. Our meta-analysis of 45 randomised controlled trials demonstrates that self-management interventions

can effectively improve outcomes for these patients, potentially enhancing overall patient care. Notably, interventions incorporating psychotherapeutic techniques such as CBT, RET and relaxation proved particularly effective in improving physiological outcomes. For those developing interventions to enhance health outcomes in this population, approaches that include psychoeducation, psychotherapeutic techniques, and more contact points show promise in improving psychological wellbeing, as well as behavioural and physiological outcomes.

Note

1. As previously noted, the same studies had these three BCT categories present, such that if they contained shaping knowledge, they also contained goals and planning, and feedback and monitoring, resulting in identical beta values across these three BCT categories.

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