Public Health Nutrition: 20(1), 30–45 doi:10.1017/S1368980016001543

Review Article

How dietary evidence for the prevention and treatment of CVD is translated into practice in those with or at high risk of CVD: a systematic review

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Submitted 12 December 2015: Final revision received 23 March 2016: Accepted 13 May 2016: First published online 22 June 2016

Abstract

Objective: CVD is a leading cause of mortality and morbidity, and nutrition is an important lifestyle factor. The aim of the present systematic review was to synthesise the literature relating to knowledge translation (KT) of dietary evidence for the prevention and treatment of CVD into practice in populations with or at high risk of CVD.

Design: A systematic search of six electronic databases (CINAHL, Cochrane, EMBASE, MEDLINE, PsycINFO and Scopus) was performed. Studies were included if a nutrition or dietary KT was demonstrated to occur with a relevant separate measureable outcome. Quality was assessed using a tool adapted from two quality checklists.

Subjects: Population with or at high risk of CVD or clinicians likely to treat this population.

Results: A total of 4420 titles and abstracts were screened for inclusion, with 354 full texts retrieved to assess inclusion. Forty-three articles were included in the review, relating to thirty-five separate studies. No studies specifically stated their aim to be KT. Thirty-one studies were in patient or high-risk populations and four targeted health professionals. Few studies stated a theory on which the intervention was based (*n* 10) and provision of instruction was the most common behaviour change strategy used (*n* 26).

Conclusions: KT in nutrition and dietary studies has been inferred, not stated, with few details provided regarding how dietary knowledge is translated to the end user. This presents challenges for implementation by clinicians and policy and decision makers. Consequently a need exists to improve the quality of publications in this area.

Keywords
CVD
Nutrition
Diet
Behaviour change
Knowledge translation
Prevention

CVD is the leading cause of non-communicable deaths worldwide[1]. The direct and indirect costs associated with CVD are high, with CVD-related health-care costs accounting for 12% of the total Australian heath-care budget in 2008–09 ($AU 7605 million) and an estimated lost income of $AU 1·1 billion due to exit from the labour force (2009)[2,3]. As the population in Australia ages, so too does the economic burden of chronic CVD conditions[4]. Nutrition is recognised as an important contributor to the prevention of primary and secondary CVD events[5–8]. Dietary intakes affect the biochemical pathways contributing to hypercholesterolaemia, hypertension, hyperglycaemia, insulin resistance and inflammation, which contribute to the development and progression of CVD[9]. High-quality diets, such as those containing greater amounts and variety of fruits and vegetables and lower amounts of energy-dense, nutrient-poor foods, are associated with a lower risk of subsequent CVD related morbidity and mortality in those with pre-existing CVD risk factors[10]. However, the Prospective Urban Rural Epidemiology study found that of 7519 individuals from seventeen countries who had experienced a self-reported CVD event, only 39% were considered to have a healthy diet at 4–5 years following the event[11]. This indicates that appropriate nutrition

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knowledge for the prevention and treatment of CVD failed to be incorporated into long-term behaviour change for these individuals. It is likely that this was due to a range of reasons.

Knowledge translation (KT) describes the process that encompasses the stages from development and synthesis of the evidence-based knowledge through to the translation of this knowledge by health-care providers to consumers into subsequent health behaviours, with the end goal of improved individual health. The Canadian Institute of Health Research defines this process as 'a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically-sound application of knowledge'[12]. It is also described as the knowledge-to-action cycle where a knowledge creation process precedes an action cycle in which the created knowledge is utilised by a range of decision makers and stakeholders, ranging from patients to health-care policy makers[13,14]. It is the action cycle that is the focus of the present review, where end users implement and utilise the evidence-based knowledge[15]. As this is a behaviour change process, it is suggested that implementation of KT should be based on a theoretical framework[16,17].

In a previous review (2012) of KT in the allied health fields of nutrition and dietetics, occupational therapy, pharmacy, physiotherapy and speech pathology, Scott *et al.*[18] found that research publications reported mixed results from studies seeking to translate knowledge into practice. Studies of KT strategies were reported generally to be of poor methodological quality and no particular type of KT strategy was shown to be more effective than others. Education only as a KT strategy was commonly employed, with consistent non-significant results. A literature review of strategies used to achieve lifestyle changes following CVD events found that education was commonly used to support adherence to heart-healthy dietary recommendations, with staff highly trained to provide the intervention[19]. However, that review did not focus on diet exclusively, nor how nutrition knowledge was translated. It is the need for this nutrition KT that was specifically highlighted in the European Guidelines on CVD prevention in clinical practice (2012): 'The challenge for coming years is to translate nutritional guidelines into diets that are attractive to people and to find ways in which to make people change their (long-standing) dietary habits'[7].

The objective of the present systematic review was to identify how the best available current evidence on diet for the prevention and treatment of CVD is translated into practice in those with or at high risk of CVD. The primary aim was to identify aspects of successful health-service nutrition translation studies in CVD in terms of the methodology, including theoretical framework, implementation strategies, programme design, resources, use of technology and message transmission channels. A secondary aim was to evaluate the methodological quality of these translation studies and the effectiveness of nutrition evidence translation on diet-related CVD risk factors.

Methods

The conduct and reporting of the present systematic review adhered to the guidelines stated in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) Statement[20]. The systematic review protocol was registered with PROSPERO (http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42014007404) as CRD 42014007404.

Eligibility criteria

Participants

Adults (classed as 18 years or older) with one or more CVD diagnoses were included. Relevant CVD diagnoses included angina (stable or unstable), coronary artery disease, CHD, myocardial infarction, acute myocardial infarction, or intervention such as coronary artery bypass graft or percutaneous transluminal coronary angioplasty. In cases where adults and minors were included together, results for adults had to be reported separately. Due to the nature of some CVD where living skills may be diminished, interventions targeting the carers of people with a CVD diagnosis were also included. As KT studies can also relate to service providers, health professionals directly treating those with a CVD diagnosis were included, as were interventions targeting heath-care systems or policies directly related to the treatment of patients with diagnosed CVD conditions. The review also intended to provide KT strategies for nutrition in the treatment and prevention of CVD; thus those defined as high risk, 16 % and above by the 5-year absolute CVD risk assessment[21], were also included. If an intervention population was a combination of those at moderate and high risk of CVD, either a minimum of 50 % of the population had to be at high risk or the results had to be reported separately.

Study inclusion criteria

Studies were included with either experimental or quasi-experimental designs, with comparators, control groups, wait-list control groups or pre–post designs. Studies were limited to English language in the years from 1985 to 2013, as there is no evidence to show that a lack of studies in languages other than English will bias the results[22], and the time span reflects recent acknowledgement of the need for translation strategies (see online supplementary material, 'Additional File 1: Search strategy and results for the systematic review'). To be relevant for inclusion, studies needed to assess and report diet or nutrition KT as a separate measureable outcome.

The methods of the published study interventions were required to clearly state the dietary or nutrition knowledge

https://doi.org/10.1017/S1368980016001543 Published online by Cambridge University Press

that was to be translated and the method by which this KT was to occur. The KT needed to be applicable to one or more of the following areas: evidence synthesis, dissemination, exchange, application or ethically sound application of knowledge. No set length of follow-up was determined as this would be dependent on the intervention delivered. As the focus of the review was on diet and nutrition, the KT had to relate to whole foods, not nutrient supplements only. For example, KT regarding fish intakes would be considered eligible, whereas a focus on *n*-3 fatty acid supplementation would not. Studies including supplementation within their intervention were not excluded if whole foods were reported separately.

The KT could be at the personal, community or healthcare level. Both pre- and post-intervention outcome measures had to be reported in the results to evaluate effectiveness.

Outcomes

The primary outcomes were dependent upon the stage of the KT spectrum at which the intervention was determined to occur. Outcomes for KT at patient, caregiver, health professional, health system and public health levels were the following.

1. Patient level: cardiovascular risk markers, e.g. serum lipids, blood pressure, arterial stiffness, anthropometrics.
2. Caregiver level: cardiovascular risk markers, e.g. serum lipids, blood pressure, arterial stiffness, anthropometrics.
3. Health professional level: changes in practice.
4. Health system level: changes in cardiovascular prevention or treatment policies, guidelines, recommendations or best practice.
5. Public health or community level:
   a. improvement in cardiovascular risk rates, as measured by biochemical risk markers;
   b. hospitalisations, morbidity or mortality due to CVD; and
   c. health expenditure per capita.

Secondary outcomes appropriate to the stage of KT were the following.

6. Patient level: knowledge or behaviour change related to dietary intake.
7. Caregiver level: knowledge or behaviour change related to dietary intake.
8. Health professional level: none.
9. Health system level: none.
10. Public health or community level: none.

Search strategy and selection of studies (information sources)

A search strategy was developed and implemented with the search conducted in the databases of CINAHL, Cochrane, EMBASE, MEDLINE, PsycINFO and Scopus. Key terms for KT were sourced from Armstrong *et al.*[23] and Scott *et al.*[18,24] and cardiovascular terms were identified from two Cochrane systematic reviews by Hooper *et al.*[25] and Hartley *et al.*[26]. Nutrition terms encompassed nutrients and nutrition, eating, foods, diets and terms specific to CVD such as dietary fats. Reference lists from included and related studies, relevant conference abstracts and theses were searched for additional citations. Protocol publications or references to gain further information on methods related to the included studies were sourced and included if relevant. Multiple publications from the same intervention were combined and all relevant outcomes reported.

Process of study selection

Two reviewers independently assessed records based on title and abstract for eligibility and full text retrieval. Full-text articles were assessed independently by two reviewers. Disagreements were discussed and until consensus was reached, with a third reviewer consulted when consensus was not reached.

Data extraction

Data were extracted using a spreadsheet, initially piloted for consistency and to ensure all required data were obtained. One reviewer extracted all of the data and a second reviewer checked the extracted data for accuracy and consistency. Disagreements were discussed until consensus was reached. Data items included for extraction related to details about the population, intervention, use of control groups and study outcomes related to nutrition or diet. Details regarding the KT strategy used were also extracted, such as the framework, theory or principle on which the translation strategy was based, the behaviours targeted and the change techniques used, as defined by Abraham and Michie[27].

Assessment of study quality

Risk of bias in individual studies was assessed by two reviewers independently using a tool adapted from the *American Dietetic Association Evidence Analysis Manual* quality criteria checklist[28] and relevant items from the checklist of the Workgroup for Intervention Development and Evaluation Research (WIDER) recommendations[29]. These items included a detailed description of the intervention, clarification of the assumed change process and access to intervention manuals[29]. The combined tool (see online supplementary material, 'Additional File 2: Quality checklist') was required to assess both the quality of the nutrition study and also of the behaviour change intervention. Each item was coded as Yes (clearly indicated and present), No (missing or not appropriate), Unclear (if indicated, but insufficient information provided) or Not Applicable (N/A; see 'Additional File 2: Quality checklist' for questions to which N/A could be applied). Each item was considered individually.

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Relevance questions 1–4 (see 'Additional File 2: Quality checklist') and validity questions B, C, F and G were weighted for importance according to the *American Dietetic Association Evidence Analysis Manual*[28] and quality for the items from WIDER recommendations[29] was reported separately. Quality items as per the WIDER recommendations were given as questions K, L and M. Quality was designated as positive if both questions K and L were yes, neutral if either K or L was positive and M was positive, and negative for one or zero yes in total for all WIDER questions. K and L were designated as the more important translation items as clinicians would have access to their own resources as appropriate (question M).

Data analysis/synthesis

Meta-analysis of data was not expected to be possible due to heterogeneity in both the stage of KT in which interventions could occur and the expected reporting of outcomes. Data were synthesised into the study characteristics, KT characteristics, intervention content and study quality by one reviewer, with data synthesis checked for accuracy and consistency by a second reviewer. Data were further stratified by target population: (i) those with CVD diagnosis/diagnoses; (ii) populations assessed as being at high risk of CVD; (iii) interventions targeting heart failure patients; and (iv) interventions targeting health professionals. Data were stratified using these methods because:

- those with a CVD diagnosis would be expected to have different perceptions of CVD risk or may be at a different stage of change compared with those assessed at high risk of CVD;
- those with heart failure would be expected to receive dietary advice primarily addressing sodium and fluid restrictions; and
- interventions targeting health professionals would be expected to use a substantially different theoretical framework from those perceiving risk to self.

Results

The search strategy identified 4420 titles after duplicates were removed (see Fig. 1), with 354 full texts retrieved and screened for inclusion/exclusion, and forty-three texts included that described thirty-five separate studies[30–72]. Primary reasons for exclusion were populations not specifically related to CVD and outcomes not related to nutrition KT.

Risk of bias within studies

The quality of the studies was assessed using the composite tool described above and provided in the online supplementary material, 'Additional File 2: Quality checklist'. Three major areas of quality were assessed as relevance, internal validity and strength of KT reporting. The results of the quality assessments are reported in 'Additional File 3: Methodological quality scores and risk bias assessment in nutrition knowledge translation studies for cardiovascular disease'. No studies were excluded based on quality, as all studies were determined to have limitations in at least one major area related to study quality. Five studies were scored negatively for relevance, due to lack of feasibility of study replication with a limited budget, with the remaining twenty-nine studies assessed as positive in terms of relevance. Seven studies achieved a positive rating for internal validity, with twenty scored as neutral and eight scored as negative. There was limited reporting in terms of details related to the translation of nutrition and dietary knowledge as only three studies were scored positive, three scored as neutral and twenty-nine scored negative. No studies scored positive responses in all three areas, although four studies scored two positive and one neutral response[32,45,49,66]. Three scored neutral for validity[32,45,49] and one for KT strategy[66]. Three studies scored negatively or neutral in all three areas[44,46,54]. In particular, these three studies all scored negatively for relevance as they were judged as not being feasible for a clinician to replicate in the context of current cardiovascular clinics due to high resourcing costs, although they may have been feasible during the time at which the studies were performed. Excluding relevance, these studies were not significantly different from many of the other studies included in the review in either the way KT was reported or the level of detail provided to determine validity.

Disagreements between evaluators of manuscript quality were found in five of the thirty-five reviewed manuscripts, in individual questions contributing to the overall categories of validity and KT strategy. However, these did not affect the overall category grading given for these manuscripts.

Study characteristics

Although all included studies were evaluated as translating nutrition-based knowledge as part of their intervention strategy, no studies specifically stated nutrition or dietary KT to be their primary or secondary aim. Therefore the internal validity of the KT strategy cannot be established as it cannot be proven that it was directly responsible for the primary and secondary outcomes. However, as KT was a fundamental part of the intervention strategy, the effectiveness of the translation has been inferred through the measures used.

In total, thirty-seven publications from thirty-one separate studies targeted patients[30–66], whereas four studies (six publications) targeted health professionals[67–72] (see Table 1). Of those targeting patients, eighteen measured the primary outcome of cardiovascular risk markers[33–36,39,40,42–45,50,52–54,57,59–62,64–66]. Eight of these

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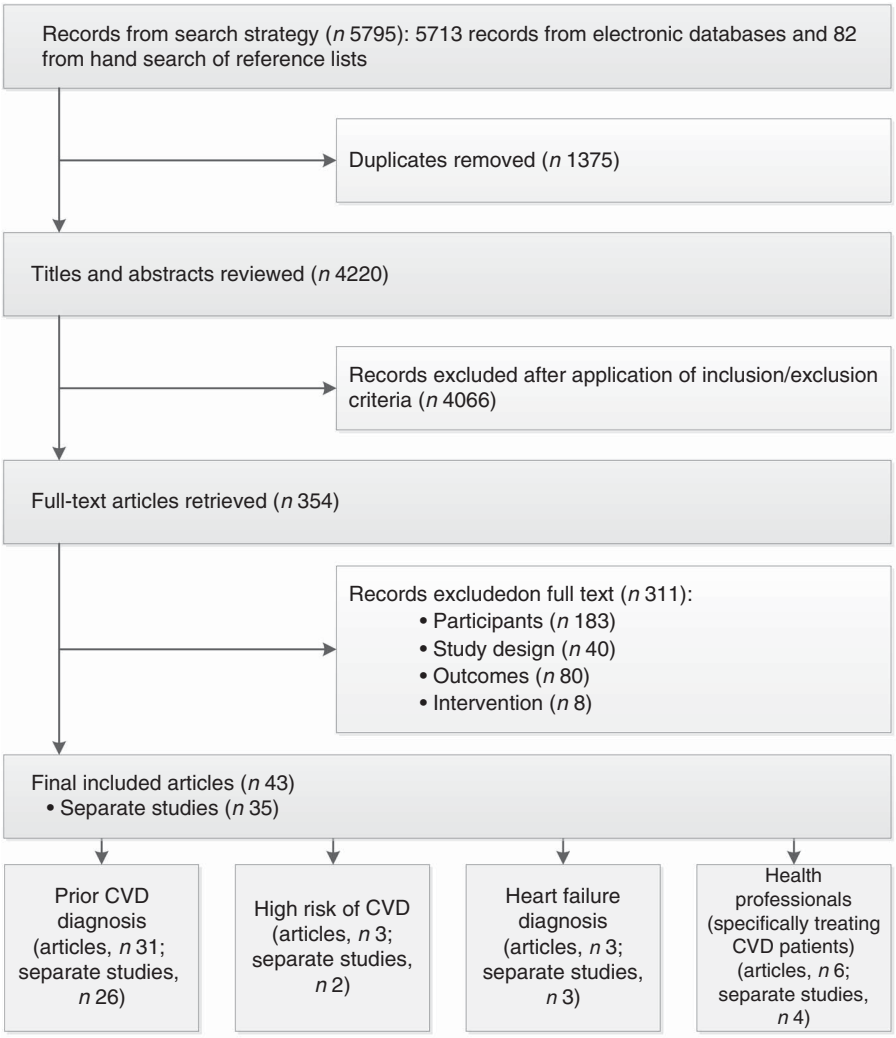

Fig. 1 Flowchart showing results of the search strategy

had diet or nutrition as the only risk factor being targeted[33,34,39,40,42,44,50,52,64,65], whereas ten had intervention strategies for multiple risk factors[35,36,43,45,53,54,57,59–62,66]. All four studies targeting health professionals addressed the primary outcome of changes in practice[67–72] and three had diet as their sole focus[67–71], with the remaining study targeting multiple risk factors[72]. In total, seventeen included studies focused only on diet[30,31,33,34,38–40,42,44,47–50,52,55,63–65,67–71], with the remaining eighteen extending the focus to other risk factors, such as smoking, physical activity or adherence to medication.

All participants in the patient-focused studies were on medications for CVD, with only two studies accounting for the effect of medication by requiring participants to maintain constant dosage[44] or initially stratifying based on dosage of relevant medications, although some dosages for that particular study were changed throughout the study[65]. Therefore, all patient studies are reported as measures for the secondary outcome of knowledge or behaviour change relating to dietary intake for consistency. Primary outcome results for the two studies accounting for the effects of medication are included with secondary outcomes in Table 1.

There were twenty-six studies in adults with prior CVD diagnoses (angina: stable or unstable, coronary artery disease, CHD, myocardial infarction, acute myocardial infarction, coronary artery bypass graft or percutaneous transluminal coronary angioplasty)[30–60]. Two studies included populations identified as at high risk of CVD[61–63], three studies were in those with a heart failure diagnosis[64–66] and four interventions targeted health professionals treating patients with CVD[67–72].

Studies were predominantly randomised controlled trials (*n* 24, 69 %), with the remainder using uncontrolled pre–post interventions (*n* 6), pre–post interventions with a control group (*n* 4; two concurrent and two historical control groups) and one case series. Sample sizes ranged between sixteen and 6428 participants. Studies targeting participants with a prior CVD diagnosis primarily included myocardial infarction (*n* 10), angina (*n* 9) or coronary

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Table 1 Characteristics of studies included in the present review

First author, year, reference	Country	Setting	*n*	Diagnosis	Length of follow-up	Population (age, sex)	Risk factors targeted	Study design	Control group
CVD diagnoses									
Aish (1996)[30] Aish (1996)[31]	Canada	Community general hospitals	104	MI	7 weeks	34–83 years 60 % M	Diet	RCT	Yes (concurrent)
Allen (1996)[32]	USA	Teaching hospital	138	CABG	12 months	Age not stated 100 % F	Smoking, exercise, diet	RCT	Yes (concurrent)
Arntzenius (1985)[33] Kromhout (1986) [34]	Netherlands	University hospital	53	Angina	24 months	<60 years Sex unclear	Diet	Pre-, post-test	No
Billings (2000)[35] Koertge (2003)[36]	USA	Hospital	440	CAD	12 months	58 (SD 10) years 79 % M	Diet, exercise	Pre-, post-test	No
Campbell (1998)[37]	Scotland	General practices	1343	CHD	12 months	Age unclear Sex unclear	Smoking, medication, diet	RCT	Yes (concurrent)
Dalgard (2001)[38]	Denmark	University hospital	36	MI, CABG, PTCA	12 months	<70 years 86 % M	Diet	RCT	Yes (concurrent)
de Lorgeril (1994)[39] de Lorgeril (1999)[40]	France	Multi-clinic	605	MI	5 years	<70 years 90 % M	Diet	RCT	Yes (concurrent)
Evon (2004)[41]	USA	Multi-outpatient cardiac rehabilitation	80	MI, CABG, PTCA, angina	12 weeks	Age not stated 100 % M	Exercise, diet, medication	Case series	No
Frost (2004)[42]	UK	Hospital	55	MI, angina, CAD	12 weeks	30–70 years 89 % M	Diet	RCT	Yes (concurrent)
Giannuzzi (2008)[43]	Italy	Cardiac rehabilitation centre	3241	MI	3 years	57·9 (SD 9·2) years 86 % M	Smoking, exercise, medication, diet	RCT	Yes (concurrent)
Gleason (2002)[44]	USA	Home	35	CHD	8 weeks	40–79 years 60 % M	Diet	Pre-, post-test	No
Goodwin (2012)[45]	USA	Community	16	MI, angina	Unclear	18–75 years 69 % F	Smoking, exercise, diet	Pre-, post-test	No
Hofman-Bang (1999)[46]	Sweden	Residential stay	93	PTCA	24 months	<65 years 84 % M	Smoking, exercise, diet	RCT	Yes (concurrent)
Jackson (2005)[47] Jackson (2005)[48]	UK	CHD clinic in primary care	120	CHD	3 months	65 (SD 9) years 59 % M	Diet	RCT	Yes (concurrent)
Luszczynska (2007)[49]	Unclear	Unclear	114	MI	8 months	39–67 years 64 % M	Diet	RCT	Yes (concurrent)
Masley (2001)[50]	USA	Multi-speciality clinics	97	CAD	12 month	Mean: 65 years 30 % F	Diet	RCT	Yes (concurrent)
Mildestvedt (2007)[51]	Norway	Cardiac rehabilitation centre	176	CAD	24 months	56·0 (SD 9·3) years 78 % M	Smoking, exercise, diet	RCT	Yes (concurrent)
Shenberger (1992)[52]	USA	Unclear	59	CABG	2 months	38–73 years 100 % M	Diet	Pre-, post-test	No
Singh (2002)[53]	India	Unclear	1000	Angina, MI	2 years	28–75 years 90 % M	Diet, exercise	RCT	Yes (concurrent)
Sundin (2003)[54]	Sweden	Residential stay + community	132	PTCA, CABG, AMI	12 months	58·8 years 100 % M	Smoking, exercise, diet	RCT	Yes (concurrent)

Table 1 *Continued*

First author, year, reference	Country	Setting	*n*	Diagnosis	Length of follow-up	Population (age, sex)	Risk factors targeted	Study design	Control group
Timlin (2002)[55]	USA	Cardiac outpatient rehabilitation	104	MI, PTCA, CABG, angina	3 months	35–85 years 81 % M	Diet	Pre-, post-test	Yes (concurrent)
Toobert (1998)[56]	Not stated	Residential stay + community	28	CHD	Unclear	57–63 years 100 % F	Diet, exercise, smoking	RCT	Yes (concurrent)
Vale (2003)[57]	Australia	Telephone service	792	CABG, PTCA, AMI, angina	6 months	58·5 (SD 10·6) years 77 % M	Smoking, exercise, medication, diet	RCT	Yes (concurrent)
van Elderen-van Kemenade (1994)[58]	Netherlands	Hospital + telephone service	60	AMI	12 months	33–69 years 82 % M	Exercise, smoking, medication, diet	Pre-, post-test	Yes (historical)
Vestfold Heartcare Study Group[59]	Norway	Rehabilitation centre in hospital	197	CABG, angina, AMI, PTCA	24 months	55 (SD 8) years 82 % M	Diet, smoking, exercise, medication	RCT	Yes (concurrent)
Wallner (1999)[60]	Austria	University cardiology & metabolism clinic	60	CAD, angina, PTCA	18 months	<70 years 78 % M	Smoking, exercise, diet	RCT	Yes (concurrent)
High risk of CVD									
Gorder (1986)[61] Van Horn (1997)[62]	USA	Community-based	6428	High risk	6 years	35–57 years 100 % M	Smoking, diet, medication	RCT	Yes (concurrent)
Siero (2000)[63]	Netherlands	Community-based	262?	High risk	4 years	30–70 years 55 % F	Diet	Pre-, post-test	Yes (concurrent)
Heart failure									
Donner Alves (2012)[64]	Brazil	Outpatients	46	Heart failure, NYHA class I–III	6 months	58 (SD 10) years 70 % M	Diet	RCT	Yes (concurrent)
Philipson (2010)[65]	Sweden	Unclear. Community?	30	Heart failure, NYHA class II–IV	12 weeks	74 (SD 8) years 73 % M	Diet	RCT	Yes (concurrent)
Powell (2010)[66]	USA	Outpatients + telephone service	902	Heart failure, NYHA class II–III	2–3 years	63·6 (SD 13·5) years 47 % F	Medication, diet, exercise	RCT	Yes (concurrent)
Health professionals									
Banz (2004)[67]	USA	Community	172	CVD prevention & treatment	11 weeks	Dietitians	Diet	RCT	Yes (concurrent)
Carson (2002)[68]	USA	University	196	CVD patients	25 d	4th year medical students	Diet	Pre-, post-test	Yes (historical)
Perry (2000)[69] Perry (2003)[70] Perry (2003)[71]	UK	Hospital	400	Stroke patients	Hospital stay only	Doctors, nurses, therapists	Diet	Pre-, post-test	No
Van der Weijden (1998)[72]	Netherlands	General practice	32	Hypercholesterolaemia patients	Unclear	General practitioners	Medication, diet, smoking	RCT	Yes (concurrent)

MI, myocardial infarction; CABG, coronary artery bypass graft; angina, stable or unstable; CAD, coronary artery disease; PTCA, percutaneous transluminal coronary angioplasty; AMI, acute myocardial infarction; NYHA, New York Heart Association; M, male; F, female; RCT, randomised controlled trial.

artery bypass graft (*n* 8). Interventions targeting populations with or at risk of CVD were followed up for between 7 weeks and 6 years, with most following patients for ≤3 months (*n* 8) or up to 12 or 24 months (*n* 6 and *n* 5, respectively). Those targeting health professionals were medium or short term (11 weeks, *n* 1 and 25 d, *n* 1 respectively) or unclear (*n* 2). Population ages ranged from 18 to 85 years and populations were primarily male, with four studies including males exclusively, and ranging from 53 to 90 % male in twenty-two studies. Only two studies focused exclusively on females, with two other studies including more women than men (55 and 96 % female). Studies were implemented primarily in hospital settings (general, teaching and university; *n* 9), outpatient or cardiac rehabilitation centres (*n* 7), clinics or general practices (*n* 5). Three studies used a residential stay as part of their intervention. Five studies[30–34,52,58] were published prior to the release of the first Consolidated Standards of Reporting Trials (CONSORT) statement in 1996[73] and another ten were published within five years of the release date[37–40,46,50,56,60–63,72].

Table 2 summarises the KT characteristics of the included studies, including the nutrition-focused KT outcomes and associated results. The heterogeneity between KT outcomes and measures precluded any combining of results. Validated dietary intake assessment measurement tools were used in seventeen studies, while twenty-one studies used measurement tools that were unclear or not validated; some studies used a combination of both. Twenty-two studies found statistically significant results for outcomes related to nutrition and/or dietary KT, with eleven being non-significant, mixed significance for outcomes or significance not stated. One study[38] found the usual care group (comprehensive counselling) had greater improvements than the brief counselling intervention being tested.

The theoretical framework for the intervention was not stated (*n* 18) or was unclear (*n* 7) in the majority of studies. Ten studies specifically stated the theoretical framework, with no one theory being used predominantly (see Table 2). The most commonly used behaviour change strategies, as defined by Abraham and Michie[27], were provision of instruction (e.g. 'no day without fruit'; *n* 26), followed by provision of feedback on performance (e.g. from analysis of dietary intake; *n* 12), the prompting of intention formation (e.g. new resolutions about health habits; *n* 11) and provision of the behaviour–health link (e.g. information on the influence of diet on blood cholesterol levels; *n* 8). Five studies reported provision of instruction as the only behaviour change strategy used, with twenty-five studies employing three or more identifiable behaviour change strategies. It must be noted that these behaviour change strategies may not have been used exclusively for diet when other risk factors such as physical activity or smoking cessation were also the target of the intervention.

Many studies reported that the dietary advice provided to participants targeted the reduction in total fat intake (*n* 12) or asked participants to adopt a Mediterranean or Mediterranean-like eating pattern (*n* 7; see Table 2). The range of dietary advice provided extended from asking participants to adhere to the particular country's guidelines for the prevention and treatment of CVD, such as the National Cholesterol Education Program Step 2 Diet, through to general healthy eating. This advice was provided by a range of health professionals (*n* 9), dietitians (*n* 6), nurses (*n* 5), nutritionists (*n* 2), physicians (*n* 2), psychologists (*n* 2) or local experts (*n* 1, local opinion leader). The nutrition advice provider was unclear in seven studies. All interventions were delivered interpersonally, in either individual (*n* 16) or group-based sessions (*n* 13), or a combination of both (*n* 5), with one study unclear. The degree of intervention standardisation was either unclear or not stated in twenty-five studies; five studies undertook rigorous measures to ensure standardisation and four had varying levels. Further details on the intervention content, resources and intensity are summarised in the online supplementary material, 'Additional File 4: Intervention content'.

Discussion

The present review aimed to determine how nutrition-related evidence for the prevention and treatment of CVD is effectively translated into practice. The results indicate that KT is inferred, not stated in this area, and is being under-reported in terms of reproduction for clinicians and policy and decision makers. No studies were identified with the primary aim to translate dietetic knowledge to impact on objective CVD risk markers, which indicates a need for KT strategies in this area to be purposefully conducted and evaluated. The evidence base confirms the relationship between dietary change and improved outcomes of populations living with CVD in clinical interventions, but the KT studies are lacking. Overall, methods describing strategies to initiate and maintain nutrition behaviour changes were of limited value. In addition to this, the measures used to assess the dietary outcomes were varied, with the sensitivity of the tests to determine the extent of change in the outcome of interest unclear in many cases.

Only ten of the thirty-five studies clearly identified a theoretical framework that addressed processes involved in the changing of behaviours. This is in contrast to the fact that all studies required participants to change behaviour if the intervention was to be successfully implemented. The results of larger-scale successful dietary intervention studies such as the GOSPEL study (*n* 3241)[43] and the Lyon Diet Heart Study (*n* 605)[39,40] found that dietary behaviour changes were initiated and persisted in the longer term. However, the detail as to how this was

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Table 2 Knowledge translation characteristics of studies in the present review

First author, year, reference	Knowledge translation aims	Knowledge translation measure*	Intervention theory*	Behaviour change strategies employed*	Results
CVD diagnosis					
Aish (1996)[30] Aish (1996)[31]	Nutrients & food habits reflecting adherence to guidelines for primary prevention of cardiac disease (Health & Welfare, Canada 1990)	Dietary intake: 3 d food record^{UC} Nutritional self-care: FHQ^{Y}	Orem's self-care deficit theory	Prompt intention formation, Provide feedback on performance, Provide general encouragement	Significant differences between INT & CTRL at week 7 for PE total fat (26·4 (SD 5·6), 32·38 (SD 6·3), respectively, $P<0·01$) & sat. fat (8·8 (SD 2·9), 11·1 (SD 3·6), respectively, $P<0·01$). INT significantly healthier food habits (2·2 (SD 0·5), 2·3 (SD 0·4), $P<0·05$)
Allen (1996)[32]	Adherence to low-fat diet	Modified Block FFQ^{UC}	Social Cognitive Theory	Provide instruction, Prompt intention formation, Prompt practice, Prompt specific goal setting, Provide feedback on performance	PE total fat ↓ from 38 % to 35 % (INT > CTRL, $P=0·008$). PE sat. fat ↓ 1 % (INT > CTRL, $P=0·02$). No ↓ total energy
Arntzenius (1985)[33] Kromhout (1986)[34]	Adherence to vegetarian diet: P:S of 2:1 & cholesterol <100 mg/d	WFR^{Y}	Not stated	Provide instruction	↑ P:S from 0·91 (SD 0·62) to 2·54 (SD 0·47; $P<0·001$), ↓ cholesterol (mg/1000 kcal) from 88·6 (SD 23·5) to 29·5 (SD 11·5; $P<0·001$)
Billings (2000)[35] Koertge (2003)[36]	Dietary adherence: PE fat ≤ 10 % total energy, whole foods, plant-based diet	3 d food diary^{UC}	Unclear	Provide instruction, Model or demonstrate behaviour, Plan social support or social change, Stress management	Men: ↓ PE total fat from 12·8 (SD 7·8) to 6·3 (SD 2·6), women: ↓ PE total fat from 16·9 (SD 8·5) to 7·6 (SD 4·1); ($P=0·00$, value over time)
Campbell (1998)[37]	Low-fat diet (DINE score <30)	DINE score^{Y}	Not stated	Prompt specific goal setting, Provide feedback on performance	Proportion of INT achieving DINE score <30 ↑ from 49·0 % to 56·5 % (95 % CI 2·4, 12·6 %). CTRL: no change, 48·6 % (baseline) & 48·6 % (12 months)
Dalgard (2001)[38]	Comparison of total & sat. fat intakes from brief (BDC; Plate Model) & comprehensive dietary counselling (CDC; NCEP Step 1) groups	7 d WFR^{Y}	Not stated	Provide instruction, Provide feedback on performance, Provide information about behaviour–health link, Unclear	↓ 4·8 % PE total fat in CDC group ($P<0·005$) from baseline (32·7 (SD 6·2)); BDC, NS. ↓ 2·7 % PE sat. fat in CDC ($P<0·005$); BDC, NS. ↑ 3·9 % PE CHO in CDC; BDC, NS
de Lorgeril (1994)[39] de Lorgeril (1999)[40]	Adoption of a Mediterranean-type diet (INT) compared with Western prudent diet (CTRL)	24 h recall^{UC}, FFQ^{UC}, plasma lipid analysis^{Y}	Not stated	Provide instruction	After mean of 48 months (INT *v.* CTRL, mean (SE) g/d, $P \leq 0·01$): ↑ bread (167 (6) *v.* 145 (7)), ↑ fruit (251 (12) *v.* 203 (12)), ↑ margarine (19·0 (1·0) *v.* 5·1 (0·6)); ↓ butter & cream (2·8 (0·6) *v.* 16·6 (1·6)), ↓ meat (40·8 (5·0) *v.* 60·4 (5·5)) & ↓ delicatessen meats (6·4 (1·5) *v.* 13·4 (2·4))
Evon (2004)[41]	Whether amount of total fat and cholesterol consumed is mediated by dietary self-efficacy	Quick check for Diet Progress^{UC}, Cardiac Diet Self-efficacy Instrument (questionnaire)^{Y}	Unclear	Provide instruction, Provide general encouragement, Unclear	Significant correlations between early–mid self-efficacy & PE fat intake (−0·31) & mid–late self-efficacy & fat intake (−0·29; $P<0·05$)
Frost (2004)[42]	20 % reduction in GI of diet	4× (unclear) day food record^{Y}	Not stated	Provide instruction, Prompt review of behavioural goals, Provide general encouragement, Unclear	13 % reduction achieved between baseline & 12 weeks in INT mean (SE) GI units: INT, ↓ 81 (2) to 71 (1), $P<0·05$; CTRL, 82 (2) to 81 (1), NS. Mean (SE) GI load: INT, ↓ 195 (9) to 164 (11); CTRL, ↓ 176 (10) to 152 (9), NS difference in GI load between groups
Giannuzzi (2008)[43]	Adherence to healthy Mediterranean-like diet	Mediterranean diet score^{N}	Not stated	Provide instruction, Plan social support or social change, Stress management, Unclear	Baseline: 26·1 % of patients had dietary score ≤19/24. At 3 years, 56·1 % of CTRL (usual care) & 64·4 % of INT had score ≤19/24 ($P<0·001$ time × treatment)
Gleason (2002)[44]	Dietary compliance with NCEP Step 2 by consuming meals provided	1^{O}: serum cholesterol 2^{O}: 3 d food record^{UC}	Not stated	Provide instruction, Prompt barrier identification, Provide general encouragement, Provide feedback on performance, Prompt specific goal setting	1^{O}: ↓ 0·17 (SD 0·08) mmol/l in total cholesterol ($P<0·05$), ↓ 0·19 (SD 0·09) mmol/l in LDL cholesterol ($P<0·05$) 2^{O}: 93 % of energy consumed was part of prescribed menu
Goodwin (2012)[45]	Adherence to heart-healthy lifestyle: decreased energy, fat and sodium intakes	ASA-24 (NCI)^{Y} & weight	Acceptance-Based Behaviour Therapy	Provide instruction, Prompt barrier identification, Prompt intention formation, Prompt review of behavioural goals, Prompt self-monitoring of behaviour, Provide opportunities for social comparison, Stress management, Teach to use prompts or cues, Time management	↓ 523 kcal/d (ES = 1·03), ↓ 32 g fat/d (ES = 1·15), ↓ 1509 mg Na/d (ES = 1·63). BMI ↓ 0·74 kg/m^2 (ES = 0·05)

Table 2 *Continued*

First author, year, reference	Knowledge translation aims	Knowledge translation measure*	Intervention theory*	Behaviour change strategies employed*	Results
Hofman-Bang (1999)[46]	Knowledge of healthy-heart diet & actual dietary behaviours aligning with Swedish official guidelines: <30 % fat, <10 % sat. fat, 15 % protein, 50 % CHO	Questionnaire^{N} & diet index^{N}	Not stated	Prompt practice	Significant improvement in knowledge ($P=0{\cdot}002$) & self-reported dietary habits ($P=0{\cdot}01$); unclear extent of change
Jackson (2005)[47] Jackson (2005)[48]	Increase of 2 portions F&V/d	24 h recall with focus on F&V intakes^{UC}	Theory of Planned Behaviour	CTRL: Provide instruction INT A: Provide instruction, Prompt intention formation INT B: Provide instruction, Prompt intention formation, Prompt specific goal setting	No difference between any groups. All significantly ↑ F&V portions from baseline to 3 months: CTRL, 2·6 (SD 1·5) to 4·1 (SD 2·2); INT A, 3·1 (SD 1·9) to 4·6 (SD 2·0); INT B, 3·0 (SD 1·7) to 4·2 (SD 2·6)
Luszczynska (2007)[49]	Reduction in total & sat. fat intakes	Rapid Food Screener^{Y}	Theory of Planned Behaviour	Provide instruction, Prompt intention formation, Prompt specific goal setting, Provide feedback on performance, Provide general encouragement	Pre-intervention to 6 months, total fat (g/d): INT, ↓ 78·7 (SD 14·2) to 69·7 (SD 10·3); CTRL, 74·1 (SD 14·0) to 74·9 (SD 13·6) Sat. fat (g/d): INT, ↓ 22·9 (SD 6·0) to 19·7 (SD 4·6); CTRL, 22·3 (SD 4·8) to 22·5 (SD 5·2)
Masley (2001)[50]	Mean F&V intakes based on Mediterranean-type diet, antioxidant rich, ≤20 % energy from fat, focus on fat quality	WHI FFQ^{UC} + questionnaire for legumes & fat intakes^{N}	Not stated	Provide instruction, Model or demonstrate behaviour, Plan social support or social change, Prompt self-monitoring of behaviour, Unclear	INT, ↑ F&V intake from 3·1 to 4·9 ½-cup servings/d. CTRL, ↓ from 3·3 to 2·9 servings/d ($P=0{\cdot}002$ change difference). No significant difference in change in fat intakes
Mildestvedt (2007)[51]	Mediterranean-type diet, low sat. fat, ↑ fish, F&V intakes	Three questions with 5-level responses^{N}	Self-determination theory	Motivational interviewing, Prompt barrier identification, Prompt intention formation, Use follow-up prompts	No difference between INT & cardiac rehab (CTRL), baseline to 2 years. Low sat. fat (unit unclear): INT, 3·5 (SD 0·8) to 3·8 (SD 0·6); CTRL, 3·3 (SD 0·9) to 3·8 (SD 0·8). Fish dinners/week: INT, 2·3 (SD 0·7) to 2·4 (SD 0·7); CTRL, 2·2 (SD 0·6) to 2·2 (SD 0·5). F&V, units/d: INT, 3·1 (SD 1·3) to 3·7 (SD 1·2); CTRL, 3·2 (SD 1·4) to 3·7 (SD 1·2)
Shenberger (1992)[52]	Total energy (kcal/d), dietary cholesterol & PE from total & sat. fats, based on NCEP Step 1	24 h recall^{Y}	Not stated	Provide instruction, Unclear	kcal/d ↓ from 1754 (SD 74) to 1502 (SD 64; $P<0{\cdot}05$); PE fat ↓ from 33·4 (SD 1·3) to 25·2 (SD 1·4; $P<0{\cdot}05$); PE sat. fat ↓ from 11·1 (SD 0·6) to 7·0 (SD 0·4; $P<0{\cdot}05$); cholesterol (mg/d) ↓ from 122 (SD 6·1) to 90 (SD 6·3; $P<0{\cdot}05$)
Singh (2002)[53]	Indo-Mediterranean diet CTRL: NCEP Step 1 INT: NCEP Step 1 with ↑ whole grains, legumes, F&V, nuts, mustard/soyabean oil	1 week food record^{UC}	Not stated	Provide instruction, Unclear	Significant differences ($P<0{\cdot}001$) between INT & CTRL at 2 years: ↑ total fibre (23 g/d), ↑ soluble fibre (12 g/d), ↑ fruit/vegetables/nuts combined (334 g/d), ↑ whole grains (127 g/d), ↑ soya/mustard oil (18 g/d)
Sundin (2003)[54]	Changes in diet knowledge index, diet habit index & diet habits based on standard low-fat diet according to Swedish official guidelines	Diet knowledge index^{N} Diet habits: diary assessment^{N}	Type A behaviour?	Provide instruction, Model or demonstrate behaviour, Prompt practice, Prompt review of behavioural goals, Prompt self-monitoring of behaviour, Provide feedback on performance, Provide information about behaviour–health link, Stress management	From baseline to 1 year: dietary habits, 11·4 to 13·7; diet knowledge, 4·8 to 7·0
Timlin (2002)[55]	Changes in fat, sat. fat, cholesterol, CHO and restaurant eating based on AHA Step 2 dietary advice recommendations	Diet Habit Survey^{Y}, Cardiac Diet Self-Efficacy Instrument^{Y}	Social Cognitive Theory, Trans-theoretical Model	Prompt intention formation, Provide general encouragement, Unclear	NS difference in improvement between CTRL (standard care) & INT (baseline to 3 months) except restaurant score: CTRL, 16·4 (SD 4·4) to 17·5 (SD 3·7); INT, 16·8 (SD 3·9) to 18·6 (SD 3·1; $P=0{\cdot}01$)
Toobert (1998)[56]	Adherence to Reversal diet (Ornish): high fibre, PE total fat ≤10, PE CHO 70–75, PE protein 15–20, cholesterol 5 mg/d	Kristal Food Habits Questionnaire^{Y}, 4 d food record^{UC}, screeners for dietary fats^{Y} & fibre^{Y}	Social Cognitive Theory?	Provide instruction, Model or demonstrate behaviour, Plan social support or social change, Provide information about behaviour–health link, Provide opportunities for social comparison, Stress management	Baseline to 12 months: PE fat, 27·0 (SD 10·6) to 13·1 (SD 7·0; $P<0{\cdot}01$); CHO not reported; NS difference reported for fibre; animal protein (g/d), 43·7 (SD 18·9) to 21·8 (SD 8·9; $P<0{\cdot}02$); cholesterol (mg/d), 173·9 (SD 115) to 34·2 (SD 31·8; $P<0{\cdot}01$)

Table 2 *Continued*

First author, year, reference	Knowledge translation aims	Knowledge translation measure*	Intervention theory*	Behaviour change strategies employed*	Results
Vale (2003)[57]	Changes in total fat, sat. fat, cholesterol & fibre intakes	FFQ^{Y}	Unclear. Model based on 5-stage continuous quality improvement cycle	Prompt intention formation, Prompt self-monitoring of behaviour, Prompt specific goal setting, Provide feedback on performance, Provide information about behaviour–health link, Unclear	Significant differences between INT & CTRL (usual care) for total fat (↓ 15·3 g/d, ↓ 10·5 g/d respectively, $P=0·4$), sat. fat (↓ 8·0 g/d, ↓ 4·9 g/d respectively, $P=0·002$), cholesterol (↓ 36 mg/d, ↓ 20 mg/d respectively, $P=0·04$) & fibre (↑ 0·5 g/d, ↓ 0·7 g/d respectively, $P=0·02$)
van Elderen-van Kemenade (1994)[58]	Healthy eating: moderation of salt, fat, cholesterol and sugar intake	General questionnaire for Heart Patients^{UC}	Unclear	Provide instruction, Provide information about behaviour-health link, Prompt intention formation, Prompt review of behavioural goals, Unclear	Significant differences in healthy eating habits at 12 months ($P<0·05$): 12·1 (SD 4·0) to 15·5 (SD 4·1); units unclear
Vestfold Heartcare Study Group[59]	Dietary intake of fat, fibre, cholesterol & sugar based on low-fat diet and Mediterranean regimen	Comprehensive FFQ^{Y}	Not stated	Provide instruction, Plan social support or social change, Provide information about behaviour–health link, Stress management	Significant differences in g/d at 2 years between INT & CTRL (usual care) for sat.·fat (↓ 12·7 (SD 11·8), ↓ 3·6 (SD 14·3)), mono. fat (↓ 9·1 (SD 8·9), ↓ 5·5 (SD 11·6)), sugar (↓ 17·3 (SD 31·2), ↓ 6·2 (SD 37·7)) & cholesterol (mg/d; ↓ 79·4 (SD 94), ↓ 31·6 (SD 114·4)), respectively
Wallner (1999)[60]	Adherence to diet 'close to' actual AHA Step 2, designed according to Reversal diet (Ornish)	7 d WFR^{N}	Not stated	Provide instruction	Significant ↓ in INT for PE total fat (9 (SD 6) %) & ↑ CHO (8 (SD 6) %)
High risk of CVD					
Gorder (1986)[61] Van Horn (1997)[62]	Fat-modified food patterns (basic and progressive nutrient and food pattern targets) Dietary changes made and adherence to advice	24 h recall^{UC}, 3 d record evaluation, subjective assessments^{N}	Not stated	Provide instruction, Provide information about behaviour–health link, Provide information on consequences, Unclear	Major food group changes from year 1 sustained throughout trial. ↓ Energy from foods recommended to avoid. Significant change difference between groups: INT ↓ total fat 4·2 %, ↓ sat. fat. 3·5 %, ↓ mono. fat 2·3 %, ↑ poly. fat 1·9 %. Higher levels of dietary adherence as determined by FRR show correlations with ↓ in serum cholesterol. 58·7 % of participant adherence rated subjectively as excellent/good in initial 20 months
Siero (2000)[63]	Mediterranean diet adapted to Dutch situation: ↑ bread, green and root vegetables, fish, ↓ beef, lamb, pork (replace with poultry), no day without fruit, sufficient dairy, oil & margarine instead of butter & cream	FFQ^{Y}	Prochaska stage of change	Provide instruction, Model or demonstrate behaviour, Prompt intention formation, Prompt specific goal setting, Provide feedback on performance, Provide opportunities for social comparison, Set graded tasks	INT groups A & B, ↑ fish ~15, 16 g/d (respectively; $P<0·05$) & ↑ F&V ~70, 100 g/d (respectively; $P<0·05$) *v.* CTRL at week 16 (usual care: Dutch national nutrition guidelines)
Heart failure					
Donner Alves (2012)[64]	Guidelines regarding salt restriction & diet quality. Nutritional knowledge	24 h recall^{Y}, knowledge scale^{Y}	Not stated	Prompt review of behavioural goals, Provide information about behaviour–health link, Unclear	↑ Nutritional knowledge INT *v.* CTRL ($P=0·007$, extent unclear). Diet quality not defined. Salt intake (from foods, but not including added salt) ↓ ($P=0·017$, extent unclear)
Philipson (2010)[65]	Reduction in sodium & fluid	1^{O}: urine samples using PABA for sodium & urea^{UC} 2^{O}: FFQ^{UC}	Not stated	Provide instruction, Provide information on consequences, Unclear	1^{O}: NS difference between groups, but INT significantly ↓ urine Na ($P=0·04$) & ↓ urine volume ($P=0·04$). INT significantly ↓ fluid intake (1·6 (SD 0·4) to 1·2 (SD 0·5) litres/d) *v.* CTRL (1·9 (SD 0·6) to 1·7 (SD 0·7) litres/d; $P<0·05$) 2^{O}: not reported
Powell (2010)[66]	Sodium restriction	CALS FFQ^{UC}	Social Cognitive Theory?	Provide instruction, Plan social support or social change, Prompt barrier identification, Prompt self-monitoring of behaviour, Stress management	Baseline median Na intake of 3338 mg/d. 28 % INT participants and 18 % CTRL participants ↓ intake to 2400 mg/d ($P=0·01$ for time effect)
Health professionals					
Banz (2004)[67]	Knowledge, consumption & recommendation of soya foods for CVD prevention & treatment	Survey^{N}	Trans-theoretical Model	Provide instruction, Model or demonstrate the behaviour	↑ 38 % in knowledge of soya food benefits, ↑ 37 % recommending soya foods to clients, no change in personal consumption. No change in CTRL
Carson (2002)[68]	Cardiovascular nutrition therapy Knowledge, attitude and self-efficacy regarding cardiovascular nutrition	Questionnaire (21 knowledge items, 22 attitude and 9 self-efficacy)^{Y}	Social learning	Provide instruction, Model or demonstrate behaviour, Provide feedback on performance, Prompt practice, Provide opportunities for social comparison, Set graded tasks	Knowledge score ↑ from 10·3 (SD 2·5) to 14·4 (SD 2·5; $P<0·001$), mean performance <70 %; self-efficacy ↑ from 26·2 (SD 35·7) to 35·7 (SD 5·4; $P<0·001$); attitude ↑ from 90·0 (SD 8·6) to 92·4 (SD 9·9; $P<0·001$)

Table 2 *Continued*

First author, year, reference	Knowledge translation aims	Knowledge translation measure*	Intervention theory*	Behaviour change strategies employed*	Results
Perry (2000)[69] Perry (2003)[70] Perry (2003)[71]	Screening and assessment of dysphagia (i) Screening for nutritional risk and nutritional status (ii) Initiation of nutrition support (iii) Patient outcomes, e.g. time spend without nutrition	(i) Screening for nutritional risk and nutritional status (ii) Initiation of nutrition support (iii) Patient outcomes, e.g. time spend without nutrition[Y]	Not stated	Provide instruction, Prompt barrier identification, Prompt intention formation, Provide feedback on performance, Prompt practice	(i) 17 % ↑ in screening for nutritional risk using validated tool within 24 h ($P<0·01$) (ii) ↑ in decision making instituted from 35 % to 81 % for patients nil oral by day 5 ($P<0·01$) (iii) Mean reduction in time spent without nutrition from 10·2 d to 4·7 d ($P<0·001$)
Van der Weijden (1998)[72]	Low-fat diet or referral to dietitian (cholesterol guidelines) Improved knowledge & attitudes towards cholesterol guidelines	Questionnaire of guideline topics[N]	Not stated	Provide instruction, Model or demonstrate behaviour, Provide feedback on performance	NS differences in agreement with guideline topics between CTRL & INT; high rates of provision of dietary advice or leaflets (46 % of consultations), low support through diet therapy (3 %)

P:S, polyunsaturated:saturated fat ratio; PE, percentage of energy; DINE, unclear abbreviation; BDC, unclear abbreviation; CDC, Centers for Disease Control and Prevention; NCEP, National Cholesterol Education Program; INT, intervention group; CTRL, control group; GI, glycaemic index; sat. fat, saturated fat; CHO, carbohydrate; F&V, fruit and vegetables; AHA, American Heart Association; ↑, increase(d); ↓, decrease(d); FHQ, Food Habits Questionnaire; WFR, weighed food record; 1°, primary outcome; 2°, secondary outcome; ASA-24, unclear abbreviation; NCI, National Cancer Institute; WHI, Women's Health Initiative; PABA, *p*-aminobenzoic acid; CALS, unclear abbreviation; ES, effect size; mono. fat, monounsaturated fat; poly. fat, polyunsaturated fat; FRR, food record rating.
1 kcal = 4·184 kJ.
*Validated measure: [Y], yes; [N], no; [UC], unclear. 'Not stated' was given if no information on the topic could be found and 'Unclear' if the description given was too vague to determine which (if any) behaviour change strategy was used.

achieved was not described and no basis given for why the chosen strategies were appropriate for the context in which they were applied. Therefore replication using the same KT strategy in a given population is not possible and the external validity is unclear. This issue is not limited to nutrition KT strategies in CVD, and has been identified more generally in primary care and general medicine[74]. Also, the need for standardised end points for key performance indicators of cardiovascular outcomes in Australia has been indicated[75]. This extends to dietary intake because of the role nutrition plays in the prevention and treatment of CVD. From the present review, it is evident that standardisation of approaches would be of benefit here as well.

In terms of study quality, all interventions focused on risk outcomes important to the prevention and treatment of CVD, although five scored negatively for relevance, as they are unlikely to be replicated in the current financial climate and funding models due to their intensive resourcing[44,46,54,56,59]. Inconsistencies in the published details required to confirm validity may also be due to their older publication dates, as fifteen were published either before or within five years of the first CONSORT guidelines. Of these fifteen studies, only two scored positive for validity[39,40,56]. No studies scored positive for all three areas of quality. This may be a publication limitation, as intervention methods were either limited or focused on describing the measures used. Glasziou *et al.* showed that authors of publications of non-pharmacological interventions, selected for high validity and relevance, were able to provide information supplemental to that published upon request, to provide a more complete description of interventions to aid replication by clinicians[74].

Of the three studies scoring positive quality for KT, only Luszczynska *et al.*[49] targeted diet as single risk factor. Luszczynska *et al.* used implementation intentions training in patients as an adjunct to Phase 2 cardiac rehabilitation. The intervention itself was brief (10–20 min), yet results showed significant changes that persisted up to 6 months. The authors also provided a sufficiently detailed structure of the intervention that could be replicated within a cardiac rehabilitation setting by other health-care professionals. Allen[32] and Goodwin *et al.*[45] both targeted multiple risk factors, with Allen using Social Cognitive Theory to improve self-efficacy and Goodwin *et al.* using Acceptance-Based Behaviour Therapy to facilitate participant changes to healthier behaviours. Both studies provide details that are less prescriptive than those found in Luszczynska *et al.* and therefore more challenging for clinicians to replicate. Allen targeted self-efficacy by the development of specific strategies to attain goals (see online supplementary material, 'Additional File 4: Intervention content') and reported positive results after 1 year, but the dietary measure used may not have been of sufficient sensitivity to detect the change in outcome reported of total and saturated fat. Goodwin *et al.* had

a small sample size (n 16) and it is therefore more difficult to determine whether the intervention can be applied to a more diverse population sample, such as those found in current clinical CVD prevention and treatment settings, and attain similar results.

Approximately half of the studies herein focused on diet alone, with the remainder targeting other CVD risk factors as well. The KT results are inconclusive with regard to which is the more successful approach. It has been suggested that it may be easier to translate efficacious dietary patterns, such as the Mediterranean-style diet, instead of focusing on single nutrients, and thereby contribute to better CVD outcomes[76]. The American Heart Association Scientific Statement (2010) also considered the advantages of focusing on single lifestyle factors compared with multiple factors, such as physical activity, smoking and dietary modification on CVD biochemical risk factors, with a similar inconclusive result[77]. However, European guidelines for prevention of CVD in clinical practice recommend multimodal behavioural interventions for individuals at very high risk[7].

These constraints may be the result of a difference in focus between explanatory and pragmatic designs in relation to KT. Bhattacharyya *et al.* highlighted the differences in intervention design between controlled trials that investigate the efficacy of a treatment and pragmatic studies that aim to assess the effectiveness of the treatment in the context of clinical practice[78]. In particular, the focus of the outcomes from these two very different types of studies necessarily varies greatly. Explanatory designs use process measures for outcomes whereas pragmatic designs use outcomes relevant to health-care stakeholders such as the patients, the health services and funding bodies.

Very few studies were found where nutrition evidence specifically for the prevention and treatment of CVD was passed between researchers and clinicians. There is a gap in the literature about how researchers are passing on their findings of what works to clinicians. While this is most likely taking place in settings such as conferences, seminars and workshops, the translation strategies are not being described, evaluated or appearing in publications. One such example of publication was the study by Banz *et al.*[67] but the study quality was poor which may be due to the short report format.

A number of further shortcomings were identified within the review that reduced the usefulness for KT replication. For example, it was identified that many of the measures and power calculations used may have been of insufficient quality to detect the extent of change in dietary patterns due to the KT strategy. In particular, the dietary measures used cast doubt on the significance of the results. While many studies declared their dietary measures to be validated, it was unclear from the methods whether the instrument used in the study was validated for the outcome for which it was used. Food records and 24 h dietary recalls are regularly used for obtaining data on usual dietary intakes, but adequate standardised protocols for data collection need to be described in the methods to ensure the data are collected in sufficient detail to be considered valid. Many of the participants were also on medication for their condition, which makes the extent of change in biochemical risk markers attributable to diet unclear. This is typified in the study by Masley *et al.* in which a medication campaign driven by a health-care fund occurred prior to randomisation, accounting for a decrease in LDL cholesterol from 3·7 to 3·1 mmol/l[50]. The use of biochemical risk markers is limited unless medication and other factors are controlled for, such as in the case of Gleason *et al.* and Philipson *et al.*, where medication was held consistent or results stratified by medication use, respectively[44,65]. In addition to this, the type of dietary advice people were given, such as replacing dietary fat with carbohydrates of unclear nutritional quality, is likely to have confounded long-term CVD outcomes[79].

Studies published before the recommendations from the CONSORT statement took effect[73] were of lower methodological quality. This limitation may have been overcome if the inclusion year were changed to a more recent date, such as to approximately 2001. The rationale for this date includes the release of the first updated CONSORT statement[80] with a 5-year lag after the primary statement to allow reporting to become more consistent. As expected, meta-analysis of data was not possible due to heterogeneity in nutrition KT and outcome measures.

Recommendations for future research and practice

There is a clear need for both efficacy and effectiveness KT trials in the area of dietary prevention and treatment of

Table 3 Recommended checklist for nutrition and dietary translation studies*

Item	Recommended items for inclusion in nutrition and dietary translation studies
A	Provide a sound basis for why the theoretical framework chosen was appropriate for the stated population
B	Provide sufficient detail on behaviour change strategies used to allow for replication or adaption by a qualified diet or nutrition specialist in a comparable situation or setting
C	Nutrient or dietary pattern outcomes must be measured with a validated tool or methodology of sufficient sensitivity to detect the expected changes in a sample size to be adequately powered
D	If a behaviour change is the primary outcome, it is recommended that a clear link is established between the behaviour and a clinically useful outcome
E	Confounders such as medication are common in dietetic interventions. It is recommended to account for such confounders in the study design so as to provide a sound basis for why the dietary or nutrition changes instigated were responsible for or assisted in the clinical outcome
F	Clearly designate the purpose of the study design as explanatory or pragmatic

*These recommendations are specific to nutrition and diet translation studies and are to be used in conjunction with the Workgroup for Intervention Development and Evaluation Research (WIDER) recommendations checklist as per Albrecht *et al.*[29].

https://doi.org/10.1017/S1368980016001543 Published online by Cambridge University Press

CVD. Studies need to provide a sound basis for choosing particular theoretical frameworks and behaviour change strategies should be adequately detailed to allow for replication. In addition, study outcomes should use valid measures that are appropriate for the KT and behaviour change strategies, and describe links to a clinically useful outcome. Further information is required as to how clinically useful research findings are effectively translated to clinicians and then patients. Health professionals are the conduits to translating best evidence to at-risk persons, but little evidence currently exists to demonstrate efficacy or effectiveness of the translation link between CVD nutrition research and health professionals. A summary of recommended inclusions for KT publications is given in Table 3.

Acknowledgements

Acknowledgements: The authors would like to acknowledge the collaboration of Neil J. Spratt and the assistance of research librarian Debbie Booth, who assisted with sourcing appropriate key terms and performed the database search. Additional thanks go to Katherine Brain, Alexa Fryer, Li Kheng Chai and Lee Ashton for verifying extracted results. *Financial support:* J.R. is funded by a Career Development and Future Leader Fellowship co-funded by the National Health and Medical Research Council (NHMRC) and the National Heart Foundation, and is an investigator on NHMRC programme grant ID1052555. L.N. is funded by an NHMRC Early Career Fellowship (APP1036763). This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors. *Conflict of interest:* None. *Authorship:* T.L.S. contributed to study design and was primarily responsible for screening and reviewing titles, abstracts and full texts for inclusion, data extraction and manuscript preparation. L.N. and J.R. contributed to study design and manuscript preparation. T.L.B., R.C. and C.E.C. contributed to the study design, screening and reviewing of full texts for inclusion and manuscript preparation. All authors approved the final manuscript. *Ethics of human subject participation:* Not applicable.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1368980016001543

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