

BMJ Open Realist synthesis of educational interventions to improve nutrition care competencies and delivery by doctors and other healthcare professionals

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ABSTRACT

Objective: To determine what, how, for whom, why, and in what circumstances educational interventions improve the delivery of nutrition care by doctors and other healthcare professionals work.

Design: Realist synthesis following a published protocol and reported following Realist and Meta-narrative Evidence Synthesis: Evolving Standards (RAMESES) guidelines. A multidisciplinary team searched MEDLINE, CINAHL, ERIC, EMBASE, PsycINFO, Sociological Abstracts, Web of Science, Google Scholar and Science Direct for published and unpublished (grey) literature. The team identified studies with varied designs; appraised their ability to answer the review question; identified relationships between contexts, mechanisms and outcomes (CMOs); and entered them into a spreadsheet configured for the purpose. The final synthesis identified commonalities across CMO configurations.

Results: Over half of the 46 studies from which we extracted data originated from the USA. Interventions that improved the delivery of nutrition care improved skills and attitudes rather than just knowledge; provided opportunities for superiors to model nutrition care; removed barriers to nutrition care in health systems; provided participants with local, practically relevant tools and messages; and incorporated non-traditional, innovative teaching strategies. Operating in contexts where student and qualified healthcare professionals provided nutrition care in developed and developing countries, these interventions yielded health outcomes by triggering a range of mechanisms, which included feeling competent, feeling confident and comfortable, having greater self-efficacy, being less inhibited by barriers in healthcare systems and feeling that nutrition care was accepted and recognised.

Conclusions: These findings show how important it is to move education for nutrition care beyond the simple acquisition of knowledge. They show how educational interventions embedded within systems of healthcare can improve patients' health by helping health students and professionals to appreciate the importance of delivering nutrition care and feel competent to deliver it.

Strengths and limitations of this study

- Application of the principles of realist synthesis to nutrition and education research is novel.
- The characteristics and conditions of educational interventions that can improve the delivery of nutrition care, identified by this review, are important to the work of policymakers, researchers, health professions educators and course developers.
- Few reports of failed educational interventions were found, indicating a risk of positive publication bias.
- Until our conceptual model is tested and refined in the real world, we consider it to be an indefinite candidate theory, presenting elements worth considering by those concerned with the design, implementation and evaluation of educational interventions to improve the delivery of nutrition care by doctors and other healthcare professionals.
- We cannot assume that the research evidence we identified represents 'real-world' practices, and therefore our claims for the transferability of this research must be guarded.

INTRODUCTION

Nutrition is an important component of healthcare. It plays a critical role in the prevention and treatment of most cardiovascular and cerebrovascular diseases, which are leading causes of morbidity and mortality throughout the world.^{1–3} Nutrition is even more important in sub-Saharan Africa because malnutrition is a major cause of morbidity and mortality, particularly among children.⁴

Several landmark reports^{5 6} have identified the delivery of nutrition care as one of the core responsibilities of doctors. Research has also shown that nutrition counselling delivered by them has positive influence on patients' clinical outcomes. They and other

healthcare professionals whose primary role is not nutrition care, however, often miss opportunities to advise patients on diet and health.^{7 8} Health workers in primary care settings are particularly important providers of nutrition care because they can motivate even healthy individuals to adopt healthier lifestyles.⁹ The care expected from primary care health workers includes nutrition assessment, education and counselling interventions, monitoring and evaluation. Lack of knowledge,¹⁰ skills and confidence,^{11 12} as well as negative attitudes towards delivery of nutrition care and low outcome expectancy,¹³ are barriers to healthcare professionals providing nutrition care. In addition to these individual-related factors, several system-related factors such as lack of time, office space, payment, materials and education¹⁴ also prevent the delivery of nutrition care by these healthcare professionals.

Many educational interventions have been designed and implemented to improve nutrition care, but their effects have been inconsistent and often weak.^{15–17} There remains a need, therefore, for interventions that can change healthcare professionals' behaviour in practice.^{15–17} It is imperative to identify contextual factors, which mediate or inhibit their competence and delivery of nutrition care.^{18 19} In order to meet those needs, researchers have to identify components of effective educational interventions and processes.

To date, only one secondary research investigation has synthesised conclusions from existing evidence about nutrition care.²⁰ The authors of that review concluded that in-service nutrition training improved healthcare professionals' knowledge, nutrition-related counselling skills and malnutrition management skills. The main limitation was that this was a traditional systematic review, which only considered in-service nutrition training programmes. Its authors found that the evidence base was very heterogeneous; studies had widely varying study designs with heterogeneous outcome measures; and there were wide differences in the competence, experience and backgrounds of participating healthcare professionals. As the authors acknowledged, systematic review methodology limited their ability to recognise and account for the complexity of interactions within such interventions.

We reasoned that we could move the field forward by conceptualising nutrition education interventions as complex ones within a realist research approach. As noted in our published review protocol,²¹ we recognised that educational interventions involve multiple actors operating at different levels with a range of artefacts in varied material environments.²² We assumed that these components operate in non-linear ways to yield context-dependent outcomes. Realist synthesis explores 'what is it about this intervention that works, for whom and in what circumstances?' and is therefore an appropriate way to study complex interventions.²³ It is an iterative, theory-driven approach, which aims to unpack the theories that inform decisions and actions adopted in the

design and implementation of interventions.²⁴ Realist synthesis begins with the development of an initial programme (or candidate) theory about how interventions work, the contexts in which they do and do not work, and the differentiated patterns of outcomes that they generate.²⁵ As the review progresses, researchers test the initial programme theory and refine it as more evidence becomes available.²⁶

Thus, the aim of this realist review was to determine what, how, for whom, why and in what circumstances educational interventions improve the delivery of nutrition care by doctors and other healthcare professionals work.

METHODS

VM is a nutritionist working in sub-Saharan Africa, which provided a context for the research. Other members of the team included scholars of medical education, evidence synthesis, social science, nutrition and an experienced clinician.

Alteration from protocol

The review question above is broader than in the published protocol²¹ because the search showed important findings from research in health professions other than medicine, which the team felt could make a valuable contribution.

Search methods

Search terms pertaining to nutrition, care, healthcare professionals, training etc were scoped on two electronic databases. Resulting articles were reviewed, and refinement of search terms was not considered necessary. Further explanation and a full list of the search terms can be found in our published protocol.²¹ A search strategy was created for Ovid MEDLINE (available in online supplementary appendix 1) and adapted for the rest of the databases. These databases were CINAHL, ERIC, EMBASE, PsycINFO, Sociological Abstracts, Web of Science, Science Direct and Google Scholar, the latter of which was used to search for grey literature. Email alerts were set for journals and RSS feeds for databases to ensure that we identified new papers as soon as they became available.

Inclusion criteria

- ▶ *Study participants:* Medical students, students of other health professions and practising healthcare professionals (eg, nurses, physician assistant).
- ▶ *Focus of intervention:* Developing participants' competencies in any aspect of nutrition practice behaviour.
- ▶ *Study design:* All.
- ▶ *Context of intervention:* Medical schools, residency and fellowship programmes, and interventions at community and hospital settings.
- ▶ *Publication language:* English.

► **Publication date.** January 1994 to December 2014 inclusive. This date range was chosen because preliminary searches indicated that educational interventions to improve nutrition care competencies and delivery among doctors and other healthcare professionals gained prominence within published literature around 1994.

Exclusion criteria

We sought to understand generalists' delivery of nutrition education, and therefore we excluded research that only considered the education of dietitians and/or nutritionists since nutrition is their main responsibility. While we excluded conference proceedings, opinion pieces, case studies and abstracts, we used them to

develop the initial candidate theories reported in our protocol.²¹ We also excluded systematic reviews, although they informed the design of our data extraction form and provided an insight into context, mechanism outcome (CMO) configurations and additional references. Papers were also excluded if they lacked evaluation or outcome data and not being about improvement in nutrition care competencies.

Study selection

Figure 1 shows the flow chart of the search and selection processes. The final search yielded 4500 hits. VM and TD initially screened the titles of 100 hits independently and compared their findings. There was almost complete agreement, and VM continued with the screening.

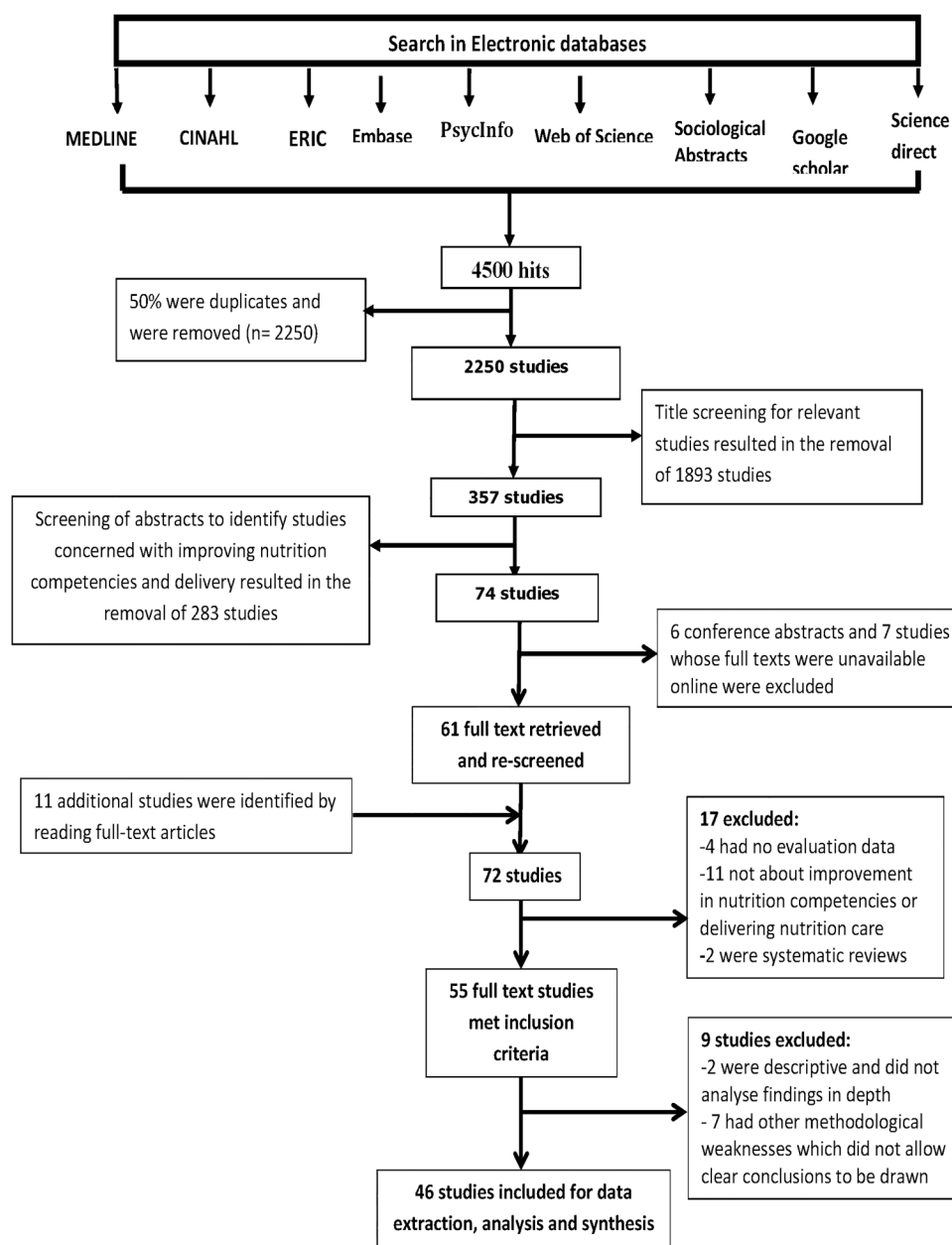


Figure 1 Search and selection process.

After eliminating duplicates, 357 studies were selected. Having obtained their abstracts, VM, TD and MGC determined independently whether each study was concerned with improving nutrition care competencies and delivery of nutrition care. At a face-to-face discussion, we compared our choices, for which the κ statistic of agreement was 0.9. This yielded 74 studies, 6 of which were excluded because they were conference abstracts. Seven studies could not be obtained despite repeated attempts. VM read the reference lists of the remaining 61 studies, and all identified systematic reviews, identifying 11 more studies.

Quality assessment

It is regarded as acceptable in realist synthesis to include part(s) or whole studies for analysis and synthesis, provided that the methods employed for collecting such data are robust.²⁷ As recommended by Pawson,²⁵ the appraisal of primary studies was informed by their relevance as well as their rigour.²⁵ Our judgements of a study's relevance were informed by the extent to which the whole study or parts of it were relevant to our published initial programme theory.²¹ Our assessment of rigour was informed by the trustworthiness of studies' design, sample size and data collection tools in relation to the outcomes reported. The Mixed Methods Appraisal Tool²⁸ helped us assess rigour.²⁸ Based on the exclusion and inclusion criteria, VM selected 55 of the 72 studies for quality assessment. Quality assessment was conducted by AS, TD, FS and MGC. This process resulted in the exclusion of nine studies from which clear conclusions could not be drawn because of methodological weaknesses. The remaining 46 studies were included into our data analysis. We kept notes of our reasons for including or excluding each study and resolved doubts about our judgements of study quality by discussing between ourselves. The processes of quality assessment and data extraction proceeded concurrently.

Data extraction, analysis and synthesis

For the purpose of data extraction, we followed guidance from previous related systematic reviews^{20 22 29-31} and iteratively refined our procedures in accordance with the focus of the review. VM initially extracted data from a sample of 10 studies, discussed the findings with the other members of the team and used those discussions to guide further data extraction. Data extracted included the following:

- ▶ Study design, sample size and outcome data
- ▶ Educational levels of study participants (students vs practising health workers)
- ▶ How course material had been developed
- ▶ Topics covered
- ▶ Methods of teaching and learning
- ▶ Methods of evaluating outcomes including data collection tools
- ▶ Intervention type (eg, workshops, curriculum designs)
- ▶ Durations of intervention

- ▶ Contexts of intervention (eg, practising healthcare professionals, students)
- ▶ Mechanisms generated
- ▶ Learning outcomes
- ▶ Impacts (if any) of intervention on clinical outcomes
- ▶ Any theories or mechanisms postulated by author(s) explaining the effects of interventions

We read all 46 included studies twice, transferring relevant data into our data extraction form. We identified the CMOs and interactions between them for each study as well as the theory informing each intervention. To do that, we assumed that the design of each study was informed by a theory, which the authors stated explicitly or implicitly. Identifying those theories helped us understand how interventions worked to generate outcomes. We discussed and reflected on all the data we had identified for each study, sometimes using extracts of publication narratives to foster reflection.

The next stage was to identify themes that were common to different studies. Using an interpretative and narrative approach, we discussed and synthesised initial conclusions, which we used to refute or refine the candidate theories in our published protocol.²¹ We chose this process of synthesis in preference to a meta-analysis, which would not have been possible given the diversity in study populations, designs, interventions and outcomes.³²

RESULTS

General characteristics of the studies

Table 1 provides a summary of the 46 studies. Twenty-seven (59%) came from the USA, 7 (19%) from Europe, 4 each from South America (all from Brazil) and Asia, 2 from Canada and 1 each from Africa (ie, South Africa) and Australia. In total, 4816 participants participated in them (median=76 participants; IQR: 47, 178). Interventions that had healthcare professionals as participants had somewhat larger numbers (median=98; IQR: 46, 163) than those having students as participants (median=54 participants; IQR: 32, 152).

The studies had varied study designs (shown in table 2) with a preponderance (n=39, 85%) of quasi-experimental designs. Twenty-one studies had follow-up evaluations after the pre-test and post-test evaluations. The time period between post-test and follow-up evaluations ranged between 2 weeks and 12 months.

Most studies (n=32, 70%) evaluated outcomes using surveys of knowledge, attitudes, self-reported practice behaviours, self-efficacy, confidence and feedback. A large proportion of these surveys were developed by the authors, who did not usually report the psychometric properties of their instruments. All the interventions that set out to improve knowledge used multiple-choice questions (ranging between 1 and 78 questions). Changes in attitude before and after interventions were

Table 1 Summary of findings of studies reviewed (n=46)

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|---|---|----------------|--|--|---|--|
| Levy <i>et al</i> , 2011 ³³ | Workshop | USA | Primary healthcare professionals (doctors, nurses, physician assistants) | Pre-test and post-test without control group | Training programme to provide information, tools and technical assistance to primary care practices to improve delivery of preventive services and the management of chronic diseases | Training well received by all participants Self-reported improvement in knowledge between pre-test and post-test Self-reported satisfaction with intervention |
| Carson, 2003 ³⁴ | Part of an ambulatory clerkship | USA | Fourth year medical students | Cross-sectional | Training medical students on assessment of body composition using tape measure Facilitating the identification and treatment of metabolic syndrome | Increased self-reported knowledge Probable changes in practice behaviour |
| Taren <i>et al</i> , 2003 ³⁵ | Required course | USA | Preclinical medical students | Pre-test and post-test with control group | Evaluation of an integrated nutrition education programme Nutrition intervention for disease prevention and therapy | Significant increase in nutrition OSCE scores between pre-test and post-test Increased self-reported satisfaction in nutrition content of the curriculum |
| Buckley, 2003 ³⁶ | Varied formats (web-based, web-enhanced and traditional lectures) | USA | Fourth year nursing students | Cross-sectional | Evaluating the effect of various formats of training on the nutrition knowledge of participants | No significant changes in knowledge between the three formats More positive perception of web-enhanced than the web-based and traditional |
| Ray <i>et al</i> , 2012 ³⁷ | Lectures, demonstrations and interactive practical sessions | UK | Third and fourth year clinical students | Pre-test and post-test without control group | Evaluating the effectiveness of a nutrition education intervention in a cohort of tomorrow's doctors using knowledge, attitude and practice scores related to clinical nutrition Covering topics relating to hospital malnutrition | Significant improvement in knowledge scores between pre-test and post-test Significant changes in attitude scores Students reported satisfaction with the course Applied acquired knowledge to patients |
| Ke <i>et al</i> , 2008 ³⁸ | Workshop | Taiwan | Nurses in ICU, GI and GS | RCT | The effects of educational intervention on nurses' knowledge, attitudes and behavioural intentions regarding supplying artificial nutrition and hydration Coverage of topics such as normal nutrient metabolism, | Significant improvement in knowledge between pre-test and post-test Significant changes in mean attitude scores Significant changes in behaviour intentions |

Continued

Table 1 Continued

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|---|--|-----------------|-----------------------------|--|---|---|
| Buchowski <i>et al</i> , 2002 ³⁹ | A computer-based and a required course | USA | First year medical students | Pre-test and post-test without control group | nutrient metabolism for terminal patients with cancer and appropriateness of supplying ANH to terminal patients with cancer The efficacy of two modules (nutrition anaemias and diabetes and weight management) used by first year medical students Coverage of topics such as nutritional anaemias, diabetes and weight management | Increase in knowledge scores between pre-test and post-test Developed positive attitudes towards nutrition after intervention Mixed results with regard to confidence to counsel patients on nutrition Positive change in attitudes towards malnourished children after intervention Change in perceptions about malnourished children after training Reduction in case fatalities |
| Puoane <i>et al</i> , 2006 ⁴⁰ | Workshop | South Africa | Nurses | Pre-test and post-test without control group | Assessing the attitudes and perceptions towards severely malnourished children and their mothers/caregivers pre-test and post-intervention Coverage of topics such as principles of care set out by the WHO for managing severe malnutrition | Intervention improved the knowledge of paediatric residents about breastfeeding Confidence increased after the intervention Limited changes in participants' practice behaviour after intervention Improvement in knowledge scores after intervention Changes in practice behaviour |
| Hillenbrand and Larsen, 2002 ⁴¹ | Workshop | USA | Paediatric residents | Pre-test and post-test without control group | The effect of an educational intervention on paediatric residents' knowledge about breastfeeding, their confidence in addressing lactation issues and their management skills during clinical encounters with breastfeeding mothers | Improvement in knowledge scores after intervention Changes in practice behaviour |
| Maiburg <i>et al</i> , 2003 ⁴² | Computer-based instruction | The Netherlands | GP trainees | Pre-test and post-test with control group | The impact of a computer-based instruction on nutrition knowledge and practice behaviour of GP trainees Covered a wide range of nutrition including food pyramid, obesity, diabetes mellitus, hypercholesterolaemia, hypertension and irritable bowel syndrome | Improvement in knowledge scores after intervention Changes in practice behaviour |

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Table 1 Continued

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|---|----------------------------|----------------|--|--|--|---|
| Ockene <i>et al</i> , 1995 ⁴³ | Workshop | USA | Internists | RCT | Impact of a training programme on physicians' lipid intervention knowledge, attitudes and skills Improved skills on brief dietary risk assessment and patient-centred counselling | No significant changes in self-reported knowledge scores Limited changes in attitudes Counselling scores increased between pre-test and post-test |
| Zaman <i>et al</i> , 2008 ⁴⁴ | Workshop | Pakistan | Healthcare workers | RCT | Impact of training health workers in nutrition counselling in enhancing their communication skills and performance, improving feeding practices and reducing growth faltering in children aged 6–24 months | Improved communication skills Improved consultation performance Mothers able to recall recommendations of health workers |
| Eisenberg <i>et al</i> , 2013 ⁴⁵ | Workshop | USA | Doctors and other healthcare professionals | Pre-test and post-test without control group | Improving healthcare professionals nutrition behaviour, personal habits and their perceived ability to advise overweight or obese patients through the inclusion of 'culinary education' in the form of cooking demonstrations and participatory hands-on cooking workshops, combined with more traditional didactic and nutrition-related presentations | Self-reported significant positive changes in ability to counsel obese patients Changes in participants' nutrition behaviours |
| Roche <i>et al</i> , 2007 ⁴⁶ | Computer-based instruction | USA | Paediatric residents | RCT | A computer-based compact disc instructional programme covering the nutrition topics of oral rehydration therapy, calcium and vitamins | Modest improvement in self-reported knowledge scores after intervention Positive attitudes towards computer instruction after intervention Participants believed intervention enhanced their knowledge in nutrition |
| Gance-Cleveland <i>et al</i> , 2009 ⁴⁷ | Workshop | USA | Nurse practitioners | Pre-test and post-test without control group | Four-hour training session on HEAT CPG to improve provider behaviour and efficacy Topics covered included obesity prevention, behaviour modifications and family | Post-training results revealed significant improvement in practitioner knowledge Post-training results revealed significant |

Continued



Table 1 Continued

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|--|--|----------------|--|--|---|--|
| | | | | | counselling, family collaboration and advising | improvement in practitioners' intent to improve behaviour Post-training results revealed significant improvements in practitioners' report of increased confidence in ability to address barriers |
| Ray <i>et al</i> , 2014 ⁴⁸ | Workshop | UK | Junior doctors | Pre-test and post-test without control group | Nutrition assessment in hospitalised patients | Significant improvement in knowledge, attitudes and practice scores |
| Bassichetto and Réa, 2008 ⁴⁹ | Workshop | Brazil | Paediatricians and nutritionists | RCT | Training intervention to equip junior doctors to run a hospital nutrition awareness week to contribute to the improvement in nutrition care Topics covered included clinical and public health nutrition, organisational management and leadership strategies | Significant improvement in knowledge scores after intervention Improvement in dietary counselling after intervention |
| Dacey <i>et al</i> , 2013 ⁵⁰ | Workshop | USA | Doctors and other healthcare professionals | Pre-test and post-test without control group | The impact of two types of live face-to-face CME programmes aiming to alter participants' thinking and behaviour and comfort with the use of lifestyle medicine Topics included the history and rationale for lifestyle medicine, exercise medicine initiative and lifestyle medicine competencies | Improvement in the perception of barriers to lifestyle medicine Improvement in self-reported knowledge Increased confidence to counsel |
| Ritenbaugh <i>et al</i> , 1996 ⁵¹ | 4-year integrated nutrition curriculum | USA | All levels of medical students | Cross-sectional | Evaluation of an integrated nutrition curriculum | Changes in knowledge Students satisfied with curriculum |
| Tziraki <i>et al</i> , 2000 ¹⁴ | Workshop | USA | Primary care doctors | RCT | Training to improve the adoption of a manual to guide primary care practices in structuring their office environment and routine visits to improve nutrition screening, advice/referral and follow-up for cancer prevention Compared the effect of training on | Greater adoption of manual recommendations among practices in the training group Training group adhered closer to diet screening recommendations in the manual |

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Table 1 Continued

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|---|----------------------------|----------------|-----------------------------|--|--|--|
| Edwards and Wyles, 1999 ⁵² | Workshop | UK | Healthcare professionals | Pre-test and post-test without control group | the manual with mailing the manual to practices Effectiveness of training sessions for health professionals concerning folic acid in pregnancy | Changes in office environment were conducive to nutrition screening and dietary advice Improvement in knowledge after training Participants enjoyed most parts of the training |
| Castro <i>et al</i> , 2013 ⁵³ | Workshop | Brazil | Doctors in the ICU | Pre-test and post-test with control group | A multifaceted nutritional educational intervention on the quality of nutritional therapy and clinical outcomes of critically ill patients | Significant improvement in participants' knowledge after the intervention Reduction in patients' length of stay of in the ICU Adequacy of nutritional therapy improved significantly Initiating enteral nutrition earlier than 48 hours more commonly |
| Pelto <i>et al</i> , 2004 ⁵⁴ | Workshop | Brazil | Doctors | RCT | Training to improve the nutrition counselling behaviour of physicians and caregiver retention of nutrition advice using the nutrition component of the WHO/UNICEF strategy of IMCI Reducing growth faltering in children by means of the nutrition training programme | Modest changes in physician behaviour in practice Mother's uptake of physician advice improved Reduction in malnutrition cases |
| Kohlmeier <i>et al</i> , 2000 ⁵⁵ | Computer-based instruction | USA | First year medical students | Pre-test and post-test without control group | Evaluating students' attitudes and self-efficacy in nutrition and cancer and acceptability of a computer-based instruction | Significant improvement in attitudes and self-efficacy after intervention Students generally accepted computer-based instruction |
| Bjerrum <i>et al</i> , 2012 ⁵⁶ | Workshop | Denmark | Nurses | Pre-test and post-test without control group | Improving nurses knowledge in nutrition and their attitudes towards their responsibility to providing nutrition care in relation to assessment and management Coverage of basic nutrition education, malnutrition in the hospital setting | Changes in knowledge and attitudes Participants felt more secure in their ability to provide nutrition care Participants were satisfied with the intervention |

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Table 1 Continued

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|---|-------------------|----------------|------------------------------|--|---|--|
| Pedersen <i>et al</i> , 2012 ⁵⁷ | Workshop | Denmark | Nurses | Pre-test and post-test without control group | Training programme to implement nutritional guidelines to change nurses' nutrition practice behaviour relating to the identification of patients' eating habits, improving patients' knowledge about appropriate food choices and number of snacks eaten between meals to risk of undernutrition in hospitalised patients | Modest changes in nutrition practice behaviour Improvement in the eating difficulties of patients Patients' knowledge of appropriate food choices improved |
| Conroy <i>et al</i> , 2004 ⁵⁸ | Required course | USA | Second year medical students | Pre-test and post-test without control group | Impact of an innovative preventive medicine and nutrition curriculum on students' confidence about addressing patients' diet and exercise patterns and on their own health habits | Personal dietary, exercise patterns of participants improved Confidence in their ability to address diet and exercise in patients increased |
| Endevelt <i>et al</i> , 2006 ⁵⁹ | Workshop | Israel | Second year medical students | Cross-sectional | Identification of time slots for nutrition training for medical students Impact of a nutrition education programme on students' knowledge Topics covered included nutrition and dietary recommendations for healthy people. Health risks of obesity | Changes in knowledge Students considered nutrition curriculum to be effective |
| de Fine Olivarius <i>et al</i> , 2005 ⁶⁰ | Seminar | USA | Primary care doctors | Pre-test and post-test with control group | Improving the quality of diet recording and instruction in primary care Diet counselling for diabetes patients using one's own diet | Improvement in personal dietary behaviours of participants Changes in attitudes towards dietary counselling |
| Sclair <i>et al</i> , 2012 ⁶¹ | Workshop | USA | First year medical students | Pre-test and post-test without control group | The feasibility and impact of a brief nutrition counselling curriculum on medical students' nutrition knowledge, confidence, attitudes and practices and their own affect the students' own nutrition behaviour and attitudes Topics covered were nutrition-related counselling confidence for patients with obesity | Significant changes in self-efficacy scores Significant changes in attitudes Improvement in nutrition counselling competence Improvement in personal dietary habits |

Continued

Table 1 Continued

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|---|----------------------------|----------------|------------------------------------|--|--|---|
| Scolapio <i>et al</i> , 2008 ⁶² | Workshop | USA | Doctors, dieticians and pharmacist | Pre-test and post-test with control group | and chronic disease and understanding of simple nutrition messages Impact of a live continuing medical education nutrition course on participants' nutrition knowledge and practice behaviour Coverage of a variety of topics including identifying methods to feed patients with acute pancreatitis, parenteral nutrition, management of obesity and others | Significant changes in knowledge Confidence in counselling patients on nutrition improved Modest changes in practice behaviours |
| Kennelly <i>et al</i> , 2010 ⁶³ | Workshop | Ireland | GPs and nurses | Pre-test and post-test without control group | The impact of a dietetics intervention on healthcare professionals' knowledge in nutrition and practice behaviour related to the management of malnutrition in hospitalised patients and the acceptability of the educational intervention | Significant changes in knowledge Modest changes in practice behaviours Level of acceptance for the intervention increased |
| Lewis <i>et al</i> , 2014 ⁶⁴ | Internet-based instruction | USA | Paediatric residents | Cross-sectional | Evaluating paediatric trainees' engagement, knowledge acquisition and satisfaction with nutrition modules delivered in interactive and non-interactive format Coverage of breastfeeding practices | Significant change in knowledge Engagement with course content increased Level of satisfaction with intervention increased |
| Acuña <i>et al</i> , 2008 ⁶⁵ | Workshop | Brazil | Medical and nursing students | Pre-test and post-test without control group | Evaluating the effect of an intensive education course given to healthcare professionals and students Topics covered related to hospital malnutrition | Ability to diagnose malnutrition improved |
| Powell-Tuck <i>et al</i> , 1997 ⁶⁶ | Required course | USA | Second year medical students | Pre-test and post-test without control group | Development and inception of a 7-day curriculum on diet and health | Students' feedback was positive Significant changes in knowledge |
| Afaghi <i>et al</i> , 2012 ⁶⁷ | Workshop | Iran | Clinical year 4 and 5 students | Pre-test and post-test without control group | Clinical-based case study teaching to enhance clinical skills regarding the role of nutrition in chronic disease | Student perceptions of the adequacy of the instruction were positive |

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Table 1 Continued

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|--|---|----------------|--|--|---|--|
| Carson <i>et al</i> , 2002 ⁶⁸ | Required course | USA | Fourth year medical students | Pre-test post-test with control group | Topics covered included the role of nutrition in chronic diseases, assessment of dietary intake and weight management The outcomes of an integrated cardiovascular nutrition in the fourth year of medical school at the University of Texas | Significant changes in knowledge Significant changes in knowledge Significant changes in attitude Self-efficacy in addressing nutrition issues improved |
| Vanderpool <i>et al</i> , 2014 ⁶⁹ | Continuous medical education | USA | Paediatric gastroenterology residents and paediatric gastroenterologists | Pre-test and post-test without control group | Improving nutrition knowledge acquisition and dissemination Topics covered included paediatric nutrition and paediatric nutrition assessment | Changes in knowledge Changes in behaviour Changes in patient outcomes |
| Duerksen, 2002 ⁷⁰ | Clinical rotation | Canada | Second year medical students | Pre-test and post-test without control group | Assessment of hospitalised patients' nutrition using the SGA | Students correctly identified malnourished patients Increased confidence in nutritional assessment |
| Engel <i>et al</i> , 1997 ⁷¹ | Computer-based training as part of family practice clerkship rotation | USA | Third year medical students | Pre-test and post-test without control group | Knowledge and self-efficacy in prescribing diets for patients with diabetes | Improved changes in knowledge Improved changes in self-efficacy |
| Richards and Mitchell, 2001 ⁷² | Presentation by a dietitian to individual participants | Australia | GPs | Pre-test and post-test without control group | Presentation of a nutrition manual and behaviour modification strategies | Improved confidence to provide specific nutrition information and dietary recommendations Increase in the use of the nutrition manual Nutrition counselling of patients improved |
| Kipp, 1997 ⁷³ | Computer-based instruction | USA | First year medical students | Pre-test and post-test without control group | Evaluation of a CAI module on food guide pyramid and dietary guidelines | Students considered CAI as appropriate learning tool for nutrition concepts Students satisfied with format |
| Cooksey <i>et al</i> , 2000 ⁷⁴ | Computer-based instruction | USA | Preclinical medical students | Cross-sectional | Evaluation of series of interactive, multimedia educational programmes (nutrition in medicine) | Changes in knowledge Advantages of accessibility, self-paced study, interactivity, immediate |

Continued

Table 1 Continued

| Author(s) and year | Intervention type | Study location | Participants | Study design | Focus of intervention/topics covered | Outcomes |
|--|-------------------------|----------------|--|--|---|--|
| Cheatham <i>et al</i> , 2002 ⁷⁵ | Computer-based tutorial | USA | Nursing, physician assistant and physical therapy students | Pre-test and post-test without control group | that teach the basic principles of nutritional science and application to cases Development and use of a computer-based tutorial on nutritional assessment | feedback and tracking students' performance were noted Significant changes in knowledge scores Students felt amount of content was adequate |
| Kolasa <i>et al</i> , 1996 ⁷⁶ | Workshop | USA | Dietetic students, family medicine residents and third year medical students | Cross-sectional | Encouraging effective communication with media and consumer through article preparation | Participants found the intervention to be an interesting way to learn about current food and nutrition issues |
| Fox, 2009 ⁷⁷ | Required course | Canada | Community nutrition graduate students | Pre-test and post-test without control group | Incorporation of arts as strategies for understanding and addressing community health issues | Students recognised the incorporation of arts as a mechanism of conducting health research, advocacy, education, healing and capacity-building initiatives |

ANH, artificial nutrition and hydration; CME, continuous medical education; CPG, clinical practice guideline; GI, gastroenterology; GP, general practitioner; computer-assisted instruction; GS, general surgery; HEAT, healthy eating and activity together; ICU, intensive care unit; IMCI, integrated management of childhood illness; OSCE, objectively structured clinical examination; RCT, randomised controlled trial; SGA, subjective global assessment; UNICEF, United Nations Children's Fund.

Table 2 Study designs and data collection methods

| Characteristic | Frequency (%) |
|---|---------------|
| Study design | |
| Randomised control trials | 7 (15) |
| Quasi-experimental | |
| Pre-test–post-test with control group | 6 (13) |
| Pre-test–post-test without control group | 26 (57) |
| Cross-sectional | 7 (15) |
| Methodological approach | |
| Qualitative | 5 (10) |
| Quantitative | 32 (70) |
| Qualitative and quantitative | 9 (20) |
| Data collection method | |
| Questionnaires/surveys only | 32 (70) |
| Observations only | 2 (4) |
| Focus group discussions only | 2 (4) |
| Questionnaires/survey with other methods (eg, interviews, observations) | 10 (22) |
| Format of intervention | |
| Training programmes | 12 (26) |
| Workshops | 9 (20) |
| Required courses | 7 (15) |
| Technology based (computer based, internet based) | 11 (24) |
| Ambulatory clinical rotations | 2 (4) |
| Seminars | 1 (2) |
| Continuing medical education programmes | 4 (9) |
| Healthcare professionals (n=22, 48%) | |
| Doctors (GPs/primary care) | 8 (36) |
| Nurses | 5 (23) |
| Multidisciplinary participants (eg, nurses, doctors, pharmacists) | 9 (41) |
| Students (n=24, 52%) | |
| Undergraduate, preclinical | 14 (58) |
| Undergraduate, clinical | 5 (21) |
| Postgraduate | 5 (21) |

GPs, general practitioners.

assessed using the Likert scales, anchored with statements describing attitudes.

Most questionnaires measuring behaviour changes used self-reported changes in nutrition practice behaviour. A few studies observed clinical behaviour to measure changes in nutrition practice. For example, one study in the Netherlands⁴² used incognito standardised patients to assess the impact of an intervention on the nutrition practice behaviour of general practitioner (GP) residents. Another study in Brazil⁵⁴ measured nutrition indices (ie, wasting, stunting and underweight) of children to determine the impact of an educational intervention that aimed to improve the provision of nutrition counselling to mothers and/or caregivers by doctors.

Intervention focus, types, teaching and learning formats, duration of interventions and expected learning outcomes

Only 11 studies (24%) explicitly stated the theoretical underpinning of their interventions. These included

experiential, social and cognitive learning theories as well as cognitive theory of multimedia learning. The purpose of most interventions was to improve participants' competencies (ie, knowledge, skills and attitudes) in a variety of nutrition topics (shown in table 1). Studies originating from developing countries tended to cover topics related to infant and young child feeding practices, whereas those from developed countries covered topics related to hospital malnutrition and nutritional management of chronic diseases. Most studies in which students participated aimed to increase curriculum contact hours and nutrition content. Studies involving practitioners were usually continuous medical education (CME) programmes aiming to improve knowledge, attitudes, skills and practice behaviour in specific topics such as breastfeeding practices and dietary counselling. Teaching and learning formats included lectures, problem-based learning tutorials, nutrition slogans, demonstrations, role plays, group discussions, games and video presentations. All interventions used more than one teaching and learning format except six, which were either lecture based or computer based only.^{38 42 46 55 64 69} Almost all of the interventions used innovative teaching and learning methods. Interventions involving students were usually obligatory and lasted from 2 weeks to 4 years. Those involving professionals were generally shorter. The shortest intervention was a 1-hour intensive session for GPs and other healthcare professionals on the benefits of giving folic acid to women of child bearing age,⁵² the longest were two 4-year integrated nutrition curricula for medical students.^{35 51} Inconsistent reporting of the length of interventions (including use of terms like credit hours) made it difficult to determine their average lengths.

Context–mechanisms–outcomes configurations

Table 3 lists the CMOs identified from the included studies. We describe here how those interacted to yield CMO configurations.

Emphasising skills development instead of knowledge outcomes ('Let me be skilful')

Researchers were often triggered to design interventions by professionals' lack of knowledge about nutrition. This was particularly true of undergraduate education,^{36 39 59 64 66 67} where all but one⁵² of the interventions primarily targeting knowledge took place. Yet interventions that only aimed to improve knowledge were less likely to change practice behaviour. In four studies, for example, significant gains in knowledge did not predict practice scores,³⁷ improve students' assessment of the nutrition status of overweight patients,³⁴ influence behaviour change intentions³⁸ or affect dietary counselling for mothers/caregivers of children aged 12–24 months.⁴⁹ Furthermore, there were interventions, which did not significantly increase knowledge yet changed behaviour. For example, a significant improvement in diet counselling during audiotaped

Table 3 Context, mechanism and outcome configurations

| Context | Intervention characteristics | Mechanisms triggered | Outcomes |
|--|--|---|---|
| <ul style="list-style-type: none"> ▶ Participants lacking nutrition counselling skills ▶ Participants having inadequate knowledge ▶ Participants being future and practising healthcare professionals | Emphasizing skills building instead of knowledge outcomes ('let me be skilful') | <ul style="list-style-type: none"> ▶ Being more confident ▶ Feeling adequately prepared | <ul style="list-style-type: none"> ▶ Use of dietary counselling steps ▶ Self-reported confidence to counsel patients and change in counselling behaviour |
| <ul style="list-style-type: none"> ▶ Lack of faculty to provide nutrition training at preclinical and clinical settings ▶ Participants being future and practising healthcare professionals | Superiors role modelling the delivery of nutrition care ('I look up to you') | <ul style="list-style-type: none"> ▶ Being more confident ▶ Sense of acceptance ▶ Sense of credibility ▶ Anticipation of being valued | <ul style="list-style-type: none"> ▶ Better delivery of nutrition care in clinical settings ▶ Greater confidence in nutrition counselling |
| Participants being future and practising healthcare professionals | Meeting the needs of potential participants of an intervention ('Ask me what I want') | <ul style="list-style-type: none"> ▶ Interest ▶ Sense of knowing the needs of participants | <ul style="list-style-type: none"> ▶ Greater satisfaction with educational intervention ▶ Significant gains in knowledge outcomes |
| <ul style="list-style-type: none"> ▶ Participants lacking time to provide nutrition care ▶ Lack of payment for providing preventive care ▶ Participants having limited access to referral sources and materials for nutrition care ▶ Poor investment into nutrition care ▶ Lack of supportive office systems to deliver nutrition care ▶ Separation of prevention and curative services in the healthcare system | Addressing structural and systemic factors to make an enabling environment ('Is my consulting room enabling?') | <ul style="list-style-type: none"> ▶ Feeling comfortable to deliver nutrition care ▶ Sense of acceptance ▶ Perceiving fewer barriers to the delivery of nutrition care ▶ Sense of recognition | <ul style="list-style-type: none"> ▶ Structured office environment conducive to providing nutrition-related services ▶ Strategies to address lack of support systems ▶ Encountering fewer barriers to lifestyle medicine |
| <ul style="list-style-type: none"> ▶ Inadequate instruction and syllabi for nutrition training in curricula ▶ Busy healthcare professionals lacking time to attend continuing education programmes in nutrition | Incorporating technology-based education ('My computer is a learning tool') | <ul style="list-style-type: none"> ▶ Convenience and self-paced study ▶ Interactivity ▶ Instant feedback ▶ Accessibility | <ul style="list-style-type: none"> ▶ Significant gains of knowledge ▶ More positive attitudes towards nutrition care ▶ Changed real-time practice behaviour ▶ Greater confidence in skills of nutrition counselling |
| <ul style="list-style-type: none"> ▶ Practising healthcare professionals ▶ Participants lacking appropriate tools to deliver nutrition care ▶ Participants' personal dietary and lifestyle habits ▶ Participants having inadequate training in nutrition | Providing participants with local, practical relevant tools and messages ('Give me tools') | <ul style="list-style-type: none"> ▶ Removal of perceived barriers ▶ Feeling comfortable | <ul style="list-style-type: none"> ▶ Better counselling skills ▶ Facilitating the uptake of nutrition messages ▶ Changed nutrition practice behaviour ▶ Engaging in specific rather than general discussion with patients |

Continued



Table 3 Continued

| Context | Intervention characteristics | Mechanisms triggered | Outcomes |
|---|---|---|--|
| <ul style="list-style-type: none"> ▶ Participants not routinely addressing patients' nutrition problems ▶ Existence of structural barriers to providing nutrition care to patients ▶ Poor interest in nutrition education | Use of non-traditional teaching strategies ('Using the right strategy for the right job') | <ul style="list-style-type: none"> ▶ Capture interest of participants ▶ Meet the learning needs of participants ▶ Active participation and uptake of knowledge and skills ▶ Relevance of learning | <ul style="list-style-type: none"> ▶ Giving relevant advice and recommendations to patients ▶ Simplifying complex messages ▶ Engaging the management of malnutrition ▶ Engaging in exercise and dietary counselling ▶ Ability to counsel overweight/obese patients ▶ Significant changes in knowledge gains ▶ Positive personal health habits of participants |
| <ul style="list-style-type: none"> ▶ Lack of confidence to deliver nutrition care ▶ Among future and practising healthcare professionals | Improving self-efficacy ('I feel that I can do it, so I will do it') | <ul style="list-style-type: none"> ▶ Feeling motivated ▶ Feeling confident | <ul style="list-style-type: none"> ▶ Self-reported changes in practice behaviours ▶ Intentions to change behaviour |
| <ul style="list-style-type: none"> ▶ Participants having inadequate knowledge ▶ Among future and practising healthcare professionals ▶ Participants lacking training in diet counselling ▶ Lack of patient motivation to change dietary pattern ▶ Lack of time ▶ Low priority given to nutrition ▶ Inadequate time dedicated to nutrition ▶ Healthcare students ▶ Reported inadequate knowledge in nutrition | Improving the personal health habits of healthcare professionals ('Do as I do') | <ul style="list-style-type: none"> ▶ Being more confident ▶ Sense of being a role model ▶ Sense of relatedness to patients | <ul style="list-style-type: none"> ▶ Greater counselling confidence ▶ Intentions to change behaviour ▶ Positive healthy lifestyles ▶ Engaging in dietary assessment ▶ More favourable attitudes towards nutrition counselling |
| <ul style="list-style-type: none"> ▶ Multidisciplinary nature of healthcare delivery ▶ Cross-disciplinary nature of nutrition | Integrating nutrition content ('Add nutrition to my learning') | <ul style="list-style-type: none"> ▶ Accepting nutrition education ▶ Reduction in perception of time limitations | <ul style="list-style-type: none"> ▶ Greater recognition of the relevance of nutrition education ▶ Increased in the number hours dedicated to nutrition ▶ Greater gains in cognitive outcomes |
| | Adopting a multidisciplinary approach in intervention design and implementation ('Working with others') | <ul style="list-style-type: none"> ▶ Sense of belonging ▶ Acceptance ▶ Recognising the multidisciplinary nature of nutrition healthcare delivery | <ul style="list-style-type: none"> ▶ Multidisciplinary designed programme ▶ Meets the needs of all participants ▶ Greater satisfaction |

physician–patient interactions^{43 50} and increased self-reported counselling behaviour and confidence⁵⁰ took place without any significant increase in knowledge. In one study, Ockene *et al*⁴³ noted that ‘a large proportion (1.5 hour) of the entire 3 hour CME training program was devoted to the learning of counselling and dietary assessment skills’. These findings show that it is important to train skills and create learning environments that encourage the acquisition of skills in order to change healthcare professionals’ nutrition care behaviour.^{78 79}

Superiors role modelling the delivery of nutrition care (‘I look up to you’)

A candidate theory in our published protocol,²¹ that healthcare professionals would be more likely to deliver nutrition care if they saw their superiors model the same behaviour, was apparent in the evidence. Seeing superiors model nutrition care led research participants to feel more confident, accepted and credible. They anticipated their actions being valued, which led them towards changing their nutrition practice. Virtual physician mentors,³⁹ simulation of GP consultations using video clips,⁴² physicians describing how they addressed nutrition in practice⁶⁸ and role modelling by physicians in classes⁶⁸ were among the interventions that provided positive role modelling.

Meeting the needs of potential participants of an intervention (‘Ask me what I want’)

Most interventions were modelled on the theory that education will be most successful when it is designed to meet participants’ needs.^{33 34 37 48 50 52 59 62 63 67–69} Assessment of needs identified gaps in learners’ knowledge or practice behaviour,⁶² and how they learnt best. It informed the content, format and design of curricula. It helped select teaching and learning methods to which participants were receptive, which they found interesting and satisfying, and which led them to value their education.

Addressing structural and systemic factors (‘Is my consulting room enabling?’)

As well as education, interventions that improved working environments influenced participants’ behaviour and helped maintain changes that had been achieved.⁵⁷ Eight studies helped participants address lack of support^{33 47 48 69} and systematic barriers.^{14 50 54 57} They restructured office environments to make them more conducive to providing nutrition care.¹⁴ Pelto *et al*,⁵⁴ for example, stated that ‘structural conditions in the public health system in Pelotas provided an environment in which physicians could utilize their knowledge’ (p. 360). Other researchers provided nutritional messages that busy primary care providers could deliver to patients.³³ Presentations on change management and leadership⁴⁸ and provision of guidelines on office organisation¹⁴ helped improve nutrition care. Collaboration between education and care delivery leaders helped

remove structural and systemic barriers.³⁰ These created working environments that were conducive to the delivery of nutrition care.

Incorporating technology-based education (‘My computer is a learning tool’)

Seven studies used technology to resolve challenges relating to healthcare professionals having insufficient time to attend continuing education programmes, programmes having inadequate nutrition content and faculty being unavailable to teach.^{39 42 46 55 64 68 74} Computer-based and internet-based interventions allowed easy updating of content,⁴² permitted self-directed and independent study of nutrition information,^{42 46} presented content consistently,⁶⁸ were accessible,⁷⁴ promoted interactivity⁷⁴ and were convenient for participants because they were self-administered^{42 68} and self-paced.⁷⁴ These interventions led to significant gains of knowledge,^{39 46 55 64} positive attitudes,^{42 46} increase in self-assessed nutrition counselling skills^{42 55} and real-time practice behaviour.⁴² The convenience, interest and independent nature of this type of education contributed to those outcomes.

Providing participants with local, practically relevant tools and messages (‘Give me tools’)

Some researchers theorised that making local, practically relevant tools and messages available in practice contexts would change the behaviour of trainee healthcare professionals. The tools they provided included memorable slogans,³³ simple ‘key take home messages’,^{33 37 40 63} personalised nutrition messages³³ and locally relevant examples.⁵⁴ Researchers simplified nutrition messages,³³ provided resource materials and tools to resolve problems in counselling and assessing patients,^{54 63} and adapted advice for local conditions.⁵⁴ Those interventions helped professionals engage in specific rather than generic discussions with patients and provided advice and recommendations that patients found relevant.⁵⁴ The authors of a randomised controlled trial (RCT), which improved physicians’ counselling of mothers with malnourished children aged 12–24 months in Brazil,⁵⁴ attributed children’s improved nutritional status to this provision of locally appropriate messages and tools.

Using non-traditional teaching and learning strategies (‘The right strategy for the right job’)

Another theory, which guided interventions, was that non-traditional teaching and learning strategies would change professionals’ behaviour. For instance, Hillenbrand and Larsen⁴¹ hypothesised that providing a series of interactive educational interventions to paediatric residents would increase their knowledge about breastfeeding and lactation problems and increase their confidence to counsel breastfeeding women. Interventions, which sometimes complemented lectures, included discussions, simulated patient cases, group work, role plays, hands-on demonstrations, group

practice, panel discussions and case-based learning. Other interventions included problem-based learning tutorials, computer-based or web-based cases, student-led debates, self-assessment exercises and clinical case presentations.^{58 62 68} These interventions provided practical experience and promoted active learning. They emphasised the development of skills rather than just knowledge. They engaged participants' interest and helped them assume responsibility for their own learning. These interventions caused significant changes in participants' knowledge, personal health habits, confidence to provide exercise and dietary counselling, ability to counsel obese patients and ability to manage malnutrition. Carson *et al*⁶⁸ attributed the enhanced nutrition counselling skills of students in a 4-week ambulatory care rotation to their innovative combination of teaching strategies.

Improving self-efficacy ('I feel that I can do it, so I will do it')

Self-efficacy is a basic tenet of Bandura's social learning theory.⁸⁰ This term describes individuals' confidence in their ability to perform a task or achieve an outcome. It is a key influence on behaviour.⁸⁰ Eight studies explicitly set out to improve participants' self-efficacy by increasing their confidence. They adopted strategies like role modelling by practising physicians,⁶⁸ role playing using either simulated or real patients,^{41 43 47 58} providing demonstrations and hands-on practice sessions^{33 41 43 45 47 61 68} and viewing then discussing videos and web-based cases.^{43 68} Four each of these interventions were conducted among future healthcare professionals and practising healthcare professionals. They were effective in both settings.

Improving the personal health habits of the healthcare professional ('Do as I do')

Four interventions, which stimulated practising^{45 60} and health professions students^{58 61} to take better care of their own health, had positive outcomes. These included regular consumption of fruits and vegetables, personal awareness of calorie consumption, engagement in regular physical activity and development of culinary skills. In both settings, these led to better self-reported healthy lifestyles and self-reported ability to undertake dietary assessment,⁶¹ counselling confidence,^{45 58 61} self-assessed knowledge⁶⁰ and even treating a higher proportion of diabetic patients with diet alone.⁶⁰ Healthcare professionals, who considered themselves role models for patients, felt more confident to advise patients to do as they had done.^{45 58 61}

Initial and revised programme theory

Our published protocol²¹ presented candidate theories and a theoretical model, which we briefly repeat here. Drawing on social cognitive theory, we postulated the following:

- ▶ Healthcare professionals' ability to deliver nutrition care is influenced by their competence, which is the

outcome of a learning process, which is influenced by factors within academic environments. Those factors include the quantity and quality of nutrition content in curricula, the teaching and learning methods employed, and the extent to which learning is reinforced.

- ▶ Professionals are more likely to care for patients' nutrition if they have high self-efficacy for nutrition care and vice versa.
- ▶ Professionals' delivery of nutrition care is a behaviour demonstrated in the social context of workplaces, which is influenced by observing and modelling the behaviours, attitudes and emotional reactions of others (eg, superiors).⁸¹ It is also influenced by the structural determinants of behaviours such as the workplace settings themselves (eg, hospital/community, emergency/paediatric/general ward), job descriptions/role, time and availability of other staff to undertake particular roles.

The review process described above examined those theories, which led us to revise, add components to and broaden our theoretical model (shown in figure 2). 'Outcomes', in realist terminology, can be short, medium and long terms.⁸² We have added a hierarchy of outcomes to our theoretical model.

The items in the model are inter-related as opposed to operating in isolation from one another. They do not operate in a linear fashion. Several context-mechanism-outcome configurations could be generated from the data. For instance, assessments of needs identify knowledge, skills and attitude gaps and other educational needs of potential participants. The outcome of the needs assessments informs the design of the educational intervention as well as its characteristics. It informs what kind of characteristics or strategies the intervention should adopt in order to realise the desired outcome. These strategies could include improving the personal health habits of healthcare professionals, adopting technology-based education, improving skills development, adopting innovative teaching and learning strategies, role modelling and others. These generate mechanisms (not indicated in the diagram) such as interest, receptivity and acceptance, which generate short-term outcomes such as improved knowledge, attitude, skills, self-efficacy, values and personal habits. The immediate and short-term outcomes may act as mechanisms to bring about change in nutrition practice behaviour (medium-term outcome). Doctors and other healthcare professionals may change their nutrition practice behaviour as a result of having adequate knowledge, skills, attitudes, confidence and self-efficacy. A change in nutrition practice behaviour will mean increased delivery of nutrition care to patients, which may result in the long-term goal of improved clinical outcomes (long-term outcomes) of patients. However, these outcomes can best be enhanced and maintained if there is an enabling healthcare setting (context). This could be realised by enhancing certain

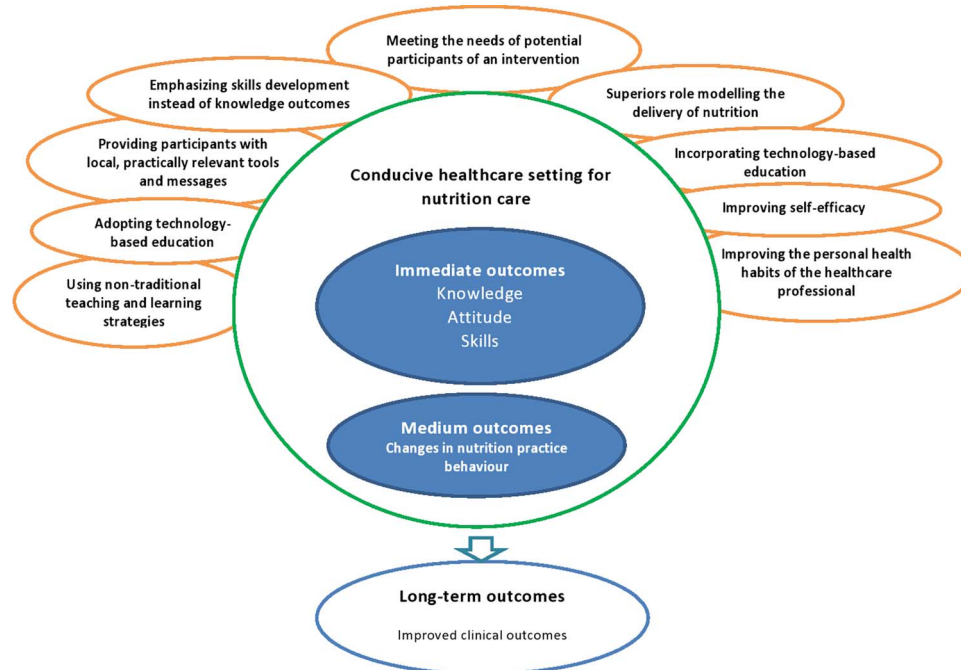


Figure 2 Revised theoretical model or programme theory.

conditions/contexts such as restructuring the healthcare system, removing structural and systemic barriers, adopting favourable policies for nutrition care, providing appropriate tools to deliver nutrition care, investing more in preventive care and providing an office that makes it easier to provide nutrition care. Providing an enabling healthcare setting was central to all of the CMO configurations identified.

We present in [table 4](#) a summary of the characteristics of interventions in accordance with what works, for whom and under what conditions.

Measurement issues

The ultimate aim of health education is to improve health outcomes. Few studies have, however, even tried to show improvements in patients' health because it is very difficult to do. Authors acknowledged that this limited the conclusions they could draw from their evidence,⁶² which meant that they could often only speculate on how their interventions might affect patients' health. The impact of educational interventions is often ranked according to its position in Miller's pyramid of assessment.⁸³ Some studies achieved the highest level—the performance level—which is most likely to impact patient outcomes. They did so by directly observing the delivery of nutrition care in clinical settings,^{14 41 44 49 54} recording videos of doctors counselling patients,¹⁴ auditing charts^{40 65 68} and using incognito simulated patients.⁴² Most studies were at lower levels of the pyramid. For example, they assessed participants' reported changes in practice behaviours by means of self-administered surveys. As observed by the authors of one such study,⁵⁸ reliance on students' self-reported

confidence in counselling rather than an objective measure of counselling skills (such as an objective-structured clinical examination) limits the generalisability of the findings. Schlair *et al*⁶¹ acknowledged the potential for social desirability bias in self-reports. While self-report would be invalid evidence in a systematic review or meta-analysis, it is safer to use it in realist synthesis, which aims to produce progressively more refined theories of change rather than incontrovertible evidence.

For future studies, Scolapio *et al*⁶² suggested that 'harder' data could be obtained using patient surveys and chart reviews, or having participants give specific examples of improved patient outcome that were directly linked to competences they had acquired from educational interventions. Our review shows the need for future studies to explore innovative ways of collecting this information.⁶²

DISCUSSION

There is increasing pressure for medical education to be socially accountable.^{84–86} This research may be seen as socially responsive because it arose out of a pressing health need in sub-Saharan Africa: improvement of the competencies of doctors and other healthcare professionals in order to deliver effective nutrition care. Our study provided practical guidance to educators trying to meet this need in Africa and elsewhere by showing the importance of moving education for nutrition care beyond the simple acquisition of knowledge.

The CMO configurations identified in this realist review are preliminary and non-exhaustive and should be considered as a set of generic hypotheses derived

Table 4 Overview of what works, for whom, under what circumstances and to achieve what

| | |
|--------------------------|--|
| What works | Choosing interventions, which are educationally and clinically relevant to the needs of participants Adopting appropriate teaching and learning techniques Building on self-efficacy and confidence through role modelling Emphasizing skills development rather than pure knowledge gains Improving the personal lifestyle habits of healthcare professionals Removing systemic barriers and restructuring healthcare systems to make healthcare settings more enabling Using practical, relevant tools Using information and communications technology (computer-based education) |
| For whom | Doctors and other practising healthcare professionals Students of the health professions |
| Under what circumstances | Within a multidisciplinary approach to nutrition education and care Supported by educational and care delivery leaders Where nutrition care is recognised as an important component of Care delivery systems Curricula Where healthcare systems are structured to be conducive to the practice of nutrition care |
| To achieve what outcomes | Educational and clinical outcomes |

from the best available evidence. Nonetheless, they provide information to policymakers about what may improve the nutrition practice behaviour of healthcare professionals, how, under what conditions and in what settings. Our review has identified a set of conditions that facilitate the success of interventions in varied contexts.

A key finding of this review is that improving the skills, self-efficacy and attitudes of learners by adopting appropriate teaching and learning strategies is critical to the success of nutrition education interventions. Improving learners' skills and attitudes provides them with confidence and a sense of enactive mastery of the specific tasks they have to perform. Role modelling of the delivery of nutrition care by superiors, providing appropriate physical space in which to deliver nutrition care and adopting favourable policies are important because they increase professionals' sense of being accepted, credibility, relatedness and assurance.

Our analysis shows that planners of educational interventions would be well advised to assess potential participants' needs and interests. Computer-based education presents new opportunities for course designers and planners. Already considered as a potentially efficient form of teaching and learning in the health professions,^{46 87–89} this presents novel ways of incorporating nutrition content into healthcare professional curricula. Given that healthcare professionals say they have too little time to attend training programmes and provide nutrition care, the convenience of computer-based and internet-based education has potential to overcome barriers to learning.

The main strengths of our review were its integrative nature and our use of realist synthesis methodology, which allowed for practical theories to be generated for future testing and implementation. However, the review

had limitations. One is that we did not consult individual experts in the field when we developed our initial model. Had we done that, we might have included more candidate theories. We also acknowledge the interpretive and subjective nature of qualitative research and the likelihood that a different team of researchers might have arrived at different candidate programme theories. We acknowledge that the model shown in [figure 2](#) is but one of several possible interpretations, as is typical of the models that emerge from realist synthesis. We acknowledge limitations in the evidence base. The synthesis that results from any review is only as good as the primary studies it is able to include. Many of the primary studies provided limited, superficial descriptions of their educational interventions. This made it difficult for us to test all components of our candidate theories and to provide rich descriptions of some of the mechanisms that were identified. As has been found by other reviewers in medical education,^{22 29 30} this review was limited by a lack of descriptions of the contexts of the intervention, implementation processes and mechanisms.

Other limitations included the unavailability of the full text of seven studies.^{90–96} While it is a limitation, realist synthesis is less dependent on the inclusion of complete sets of studies than, for example, traditional systematic reviews.⁸² So, it may limit the scope of our findings but does not invalidate them. While the backbone of meta-analysis and traditional systematic review is aggregation, realist synthesis refines theories by obtaining a rich (rather than necessarily complete) evidence base of reports of how interventions generate certain pattern of outcome.⁸² We also consider as a limitation the delay in preparing the review for publication after the end of the search in December 2014. During this period, new studies might have been published, the inclusion of which may enrich further our findings.

Finally, initial screening by just one author might be seen as a limitation, but we found such high consistency between that author's judgement and a second author in a pilot phase of the project that we judged single screening to make the best use of the inevitably limited resources in the country, where the research was conducted.

We conclude that it has been possible to assemble, from a heterogeneous database, some patterns in the links between CMOs that are consistent enough to guide the practice of nutrition education. Our findings have refined some existing candidate theories, which researchers, also, apply to their work on nutrition education.

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Contributors VM and TD were responsible for the conception and design of the study. VM was principally responsible for searching, sourcing and initial screening of studies. VM, MGC and TD further screened studies based on abstracts. Quality assessment was performed by VM, AJJAS, FS and MGC. VM was responsible for data extraction, synthesis and interpretation of the data and drafting of the manuscript. AJJAS, TD, FS, MGC and PA contributed to interpretation of the data and revision of the article. All authors approved the article for publication.

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REFERENCES

- Pearson TA, Blair SN, Daniels SR, *et al.* AHA guidelines for primary prevention of cardiovascular disease and stroke: 2002 update consensus panel guide to comprehensive risk reduction for adult patients without coronary or other atherosclerotic vascular diseases American Heart Association Science Advisory and Coordinating Committee. *Circulation* 2002;106:388–91.
- Bantle JP, Wylie-Rosett J, Albright AL, *et al.*, American Diabetes Association. Nutrition recommendations and interventions for diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2008;31(Suppl 1):S61–78.
- Goldstein LB, Adams R, Alberts MJ, *et al.*, American Heart Association/American Stroke Association Stroke Council; Atherosclerotic Peripheral Vascular Disease Interdisciplinary Working Group; Cardiovascular Nursing Council, *et al.* Primary prevention of ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council: cosponsored by the Atherosclerotic Peripheral Vascular Disease Interdisciplinary Working Group; Cardiovascular Nursing Council; Clinical Cardiology Council; Nutrition, Physical Activity, and Metabolism Council; and the Quality of Care and Outcomes Research Interdisciplinary Working Group: The American Academy of Neurology affirms the value of this guideline. *Stroke* 2006;37:1583–633.
- United Nations Children's Fund. *Improving child nutrition: the achievable imperative for global progress*. New York: United Nations Children's Fund, 2013:1–124.
- Kopelman P, Lennard-Jones J. Nutrition and patients: a doctor's responsibility. *Clin Med (Lond)* 2002;2:391–4.
- Council GM. *Tomorrow's doctors: outcomes and standards for undergraduate medical education*. Manchester, UK: General Medical Council, 2009.
- Abid A, Galuska D, Khan L, *et al.* Are healthcare professionals advising obese patients to lose weight? A trend analysis. *MedGenMed* 2004;7:10.
- Tsai AG, Wadden TA. Treatment of obesity in primary care practice in the United States: a systematic review. *J Gen Intern Med* 2009;24:1073–9.
- Abramson S, Stein J, Schaefele M, *et al.* Personal exercise habits and counseling practices of primary care physicians: a national survey. *Clin J Sport Med* 2000;10:40–8.
- Huang J, Yu H, Marin E, *et al.* Physicians' weight loss counseling in two public hospital primary care clinics. *Acad Med* 2004;79:156–61.
- Laschinger HKS, Tresolini CP. An exploratory study of nursing and medical students health promotion counselling self-efficacy. *Nurse Educ Today* 1999;19:408–18.
- Jay M, Gillespie C, Ark T, *et al.* Do internists, pediatricians, and psychiatrists feel competent in obesity care? *J Gen Intern Med* 2008;23:1066–70.
- Foster GD, Wadden TA, Makris AP, *et al.* Primary care physicians' attitudes about obesity and its treatment. *Obes Res* 2003;11:1168–77.
- Tziraki C, Graubard BI, Manley M, *et al.* Effect of training on adoption of cancer prevention nutrition-related activities by primary care practices: results of a randomized, controlled study. *J Gen Intern Med* 2000;15:155–62.
- McLaren DS. Nutrition in medical schools: a case of mistaken identity. *Am J Clin Nutr* 1994;59:960–3.
- Weinsier RL. National Dairy Council Award for Excellence in Medical/Dental Nutrition Education Lecture, 1995: medical-nutrition education—factors important for developing a successful program. *Am J Clin Nutr* 1995;62:837–40.
- Gershoff SN. National Dairy Council Award for Excellence in Medical/Dental Nutrition Education Lecture, 1996: nutrition education—success or failure? *Am J Clin Nutr* 1996;64:809–12.
- Ball LE, Hughes RM, Leveritt MM. Nutrition in general practice: role and workforce preparation expectations of medical educators. *Aust J Prim Health* 2010;16:304–10.
- Mechanic D. Social research in health and the American sociopolitical context: the changing fortunes of medical sociology. *Soc Sci Med* 1993;36:95–102.
- Sunguya BF, Poudel KC, Mlunde LB, *et al.* Nutrition training improves health workers' nutrition knowledge and competence to manage child undernutrition: a systematic review. *Front Public Health* 2013;1:37.
- Mogre V, Scherpier A, Dornan T, *et al.* A realist review of educational interventions to improve the delivery of nutrition care by doctors and future doctors. *Syst Rev* 2014;3:148.
- Wong G, Greenhalgh T, Pawson R. Internet-based medical education: a realist review of what works, for whom and in what circumstances. *BMC Med Educ* 2010;10:12.
- Pawson R, Greenhalgh T, Harvey G, *et al.* Realist synthesis: an introduction: ESRC Research Methods Programme, University of Manchester RMP: Methods Paper 2, 2004. <http://www.ccsr.ac.uk/methods/publications/documents/RMPmethods2.pdf>
- McCormack B, Rycroft-Malone J, DeCorby K, *et al.* A realist review of interventions and strategies to promote evidence-informed healthcare: a focus on change agency. *Implement Sci* 2013;8:107.
- Pawson R. *Evidence-based policy: a realist perspective*. Thousand Oaks (CA): Sage, 2006.

26. Pawson R, Greenhalgh T, Harvey G, *et al.* Realist review—a new method of systematic review designed for complex policy interventions. *J Health Serv Res Policy* 2005;10(Suppl 1):21–34.
27. Westhorp G, Walker B, Rogers P, *et al.* *Enhancing community accountability, empowerment and education outcomes in low and middle-income countries: a realist review: EPPI-centre, social science research unit, institute of education.* London: University of London, 2014.
28. Pluye P, Robert E, Cargo M, *et al.* *Proposal: a mixed methods appraisal tool for systematic mixed studies reviews.* Montréal: McGill University, 2011.
29. Yardley S, Cottrell E, Rees E, *et al.* Modelling successful primary care for multimorbidity: a realist synthesis of successes and failures in concurrent learning and healthcare delivery. *BMC Fam Pract* 2015;16:23.
30. Jones AC, Shipman SA, Ogrinc G. Key characteristics of successful quality improvement curricula in physician education: a realist review. *BMJ Qual Saf* 2015;24:77–88.
31. Steinert Y, Mann K, Centeno A, *et al.* A systematic review of faculty development initiatives designed to improve teaching effectiveness in medical education: BEME Guide No. 8. *Med Teach* 2006;28:497–526.
32. Shamseer L, Moher D, Clarke M, *et al.*, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ* 2015;349:g7647.
33. Levy J, Harris J, Darby P, *et al.* The primary care nutrition training program: an approach to communication on behavior change. *Health Promot Pract* 2011;12:761–8.
34. Carson JAS. Pocket tape measure for waist circumference: training medical students and residents on a simple assessment of body composition. *J Nutr* 2003;133:547S–9S.
35. Taren DL, Thomson CA, Koff NA, *et al.* Effect of an integrated nutrition curriculum on medical education, student clinical perception, and student perception of medical-nutrition training. *Am J Clin Nutr* 2001;73:1107–12.
36. Buckley KM. Evaluation of classroom-based, web-enhanced, and web-based distance learning nutrition courses for undergraduate nursing. *J Nurs Educ* 2003;42:367–70.
37. Ray S, Udumyan R, Rajput-Ray M, *et al.* Evaluation of a novel nutrition education intervention for medical students from across England. *BMJ Open* 2012;2:e000417.
38. Ke LS, Chiu TY, Hu WY, *et al.* Effects of educational intervention on nurses' knowledge, attitudes, and behavioral intentions toward supplying artificial nutrition and hydration to terminal cancer patients. *Support Care Cancer* 2008;16:1265–72.
39. Buchowski MS, Plaisted C, Fort J, *et al.* Computer-assisted teaching of nutritional anemias and diabetes to first-year medical students. *Am J Clin Nutr* 2002;75:154–61.
40. Puoane T, Sanders D, Ashworth A, *et al.* Training nurses to save lives of malnourished children. *Curationis* 2006;29:73–8.
41. Hillenbrand KM, Larsen PG. Effect of an educational intervention about breastfeeding on the knowledge, confidence, and behaviors of pediatric resident physicians. *Pediatrics* 2002;110:e59.
42. Maiburg BH, Rethans JJ, Schuwirth LW, *et al.* Controlled trial of effect of computer-based nutrition course on knowledge and practice of general practitioner trainees. *Am J Clin Nutr* 2003;77(4 Suppl):1019S–24S.
43. Ockene JK, Ockene IS, Quirk ME, *et al.* Physician training for patient-centered nutrition counseling in a lipid intervention trial. *Pre Med* 1995;24:563–70.
44. Zaman S, Ashraf RN, Martinez J. Training in complementary feeding counselling of healthcare workers and its influence on maternal behaviours and child growth: a cluster-randomized controlled trial in Lahore, Pakistan. *J Health Popul Nutr* 2008;26:210–22.
45. Eisenberg DM, Miller AM, McManus K, *et al.* Enhancing medical education to address obesity: "See one. Taste one. Cook one. Teach one." *JAMA Intern Med* 2013;173:470–2.
46. Roche PL, Ciccarella MR, Gupta SK, *et al.* Multi-school collaboration to develop and test nutrition computer modules for pediatric residents. *J Am Diet Assoc* 2007;107:1586–9.
47. Gance-Cleveland B, Sidora-Arcoleo K, Keesing H, *et al.* Changes in nurse practitioners' knowledge and behaviors following brief training on the healthy eating and activity together (HEAT) guidelines. *J Pediatr Health Care* 2009;23:222–30.
48. Ray S, Laur C, Douglas P, *et al.* Nutrition education and leadership for improved clinical outcomes: training and supporting junior doctors to run "Nutrition Awareness Weeks" in three NHS hospitals across England. *BMC Med Educ* 2014;14:109.
49. Bassichetto KC, Réa MF. Infant and young child feeding counseling: an intervention study. *J Pediatr (Rio J)* 2008;84:75–82.
50. Dacey M, Arnstein F, Kennedy MA, *et al.* The impact of lifestyle medicine continuing education on provider knowledge, attitudes, and counseling behaviors. *Med Teach* 2013;35:e1149–e56.
51. Ritenbaugh CK, Thomson CA, Taren D, *et al.* Nutrition curriculum in medical education: an integrated and comprehensive approach. *Teach Learn Med* 1996;8:102–10.
52. Edwards L, Wyles D. The folic acid message – can training make a difference? *J Hum Nutr Diet* 1999;12:317–26.
53. Castro MG, Pompilio CE, Horie LM, *et al.* Education program on medical nutrition and length of stay of critically ill patients. *Clin Nutr* 2013;32:1061–6.
54. Pelto GH, Santos I, Gonçalves H, *et al.* Nutrition counseling training changes physician behavior and improves caregiver knowledge acquisition. *J Nutr* 2004;134:357–62.
55. Kohlmeier M, Althouse L, Stritter F, *et al.* Introducing cancer nutrition to medical students: effectiveness of computer-based instruction. *Am J Clin Nutr* 2000;71:873–7.
56. Bjerrum M, Tewes M, Pedersen P. Nurses' self-reported knowledge about and attitude to nutrition – before and after a training programme. *Scand J Caring Sci* 2012;26:81–9.
57. Pedersen PU, Tewes M, Bjerrum M. Implementing nutritional guidelines—the effect of systematic training for nurse nutrition practitioners. *Scand J Caring Sci* 2012;26:178–85.
58. Conroy MB, Delichatsios HK, Hafler JP, *et al.* Impact of a preventive medicine and nutrition curriculum for medical students. *Am J Prev Med* 2004;27:77–80.
59. Endevelt R, Shahar DR, Henkin Y. Development and implementation of a nutrition education program for medical students: a new challenge. *Educ Health (Abingdon)* 2006;19:321–30.
60. de Fine Olivarius N, Palmvig B, Andreassen AH, *et al.* An educational model for improving diet counselling in primary care: a case study of the creative use of doctors' own diet, their attitudes to it and to nutritional counselling of their patients with diabetes. *Patient Educ Couns* 2005;58:199–202.
61. Schlair S, Hanley K, Gillespie C, *et al.* How medical students' behaviors and attitudes affect the impact of a brief curriculum on nutrition counseling. *J Nutr Educ Behav* 2012;44:653–7.
62. Scolapio JS, Dibaise JK, Schwenk WF II, *et al.* Advances and controversies in clinical nutrition: the education outcome of a live continuing medical education course. *Nutr Clin Pract* 2008;23:90–5.
63. Kennelly S, Kennedy NP, Rughoobur GF, *et al.* An evaluation of a community dietetics intervention on the management of malnutrition for healthcare professionals. *J Hum Nutr Diet* 2010;23:567–74.
64. Lewis KO, Frank GR, Nagel R, *et al.* Pediatric trainees' engagement in the online nutrition curriculum: preliminary results. *BMC Med Educ* 2014;14:190.
65. Acuña K, Pires C, Santos G, *et al.* Detection of nosocomial malnutrition is improved in Amazon region by a standard clinical nutrition education program. *Nutr Hosp* 2008;23:60–7.
66. Powell-Tuck J, Summerbell C, Holsgrove G, *et al.* Four years' experience of an undergraduate medical nutrition course. *J R Soc Med* 1997;90:67–72.
67. Afaghi A, Hai Agha Mohamadi AA, Ziaee A, *et al.* Effect of an integrated case-based nutrition curriculum on medical education at Qazvin University of Medical Sciences, Iran. *Glob J Health Sci* 2012;4:112–17.
68. Carson JAS, Gillham MB, Kirk LM, *et al.* Enhancing self-efficacy and patient care with cardiovascular nutrition education. *Am J Prev Med* 2002;23:296–302.
69. Vanderpool C, Lin HC, Scheimann A. NASPGHAN Nutrition University as a model for continuing education within pediatric nutrition. *J Pediatr Gastroenterol Nutr* 2014;58:469–71.
70. Duerksen DR. Teaching medical students the subjective global assessment. *Nutrition* 2002;18:313–15.
71. Engel SS, Crandall J, Basch CE, *et al.* Computer-assisted diabetes nutrition education increases knowledge and self-efficacy of medical students. *Diabetes Educ* 1997;23:545–9.
72. Richards D, Mitchell G. Insight. GPs and nutrition: what they want and how they want it. A GP nutrition education project. *Aust J Nutr Diet* 2001;58:56–9.
73. Kipp DE. Technological methods in nutrition education. Developing interactive computerized modules accessible on the World Wide Web for medical students. *Top Clin Nutr* 1997;12:38–44.
74. Cooksey K, Kohlmeier M, Plaisted C, *et al.* Getting nutrition education into medical schools: a computer-based approach. *Am J Clin Nutr* 2000;72:868S–76S.
75. Cheatham M, Boosalis MG, Boissonneault GA. Use of a computer tutorial on nutritional assessment by three different groups of health professions students. *J Allied Health* 2002;31:252–5.

76. Kolasa KM, Elesha-Adams M, Patton DD. When a reporter calls: media training to teach nutrition education. *Top Clin Nutr* 1996;11:75–80.
77. Fox AL. Evaluation of a pilot arts and health module in a graduate community nutrition program. *Can J Diet Pract Res* 2009;70:81–6.
78. Ockene JK, Kristeller J, Goldberg R, *et al*. Increasing the efficacy of physician-delivered smoking interventions. *J Gen Intern Med* 1991;6:1–8.
79. Bandura A, McClelland DC. *Social learning theory*. Englewood Cliffs (NJ): Prentice-Hall, 1977.
80. Bandura A. *Self-efficacy: the exercise of control*. Macmillan, 1997.
81. Bandura A. Social cognitive theory: an agentic perspective. *Annu Rev Psychol* 2001;52:1–26.
82. Westhorp G, Walker B, Rogers P. *Under what circumstances does enhancing community accountability and empowerment improve education outcomes, particularly for the poor? A realist synthesis protocol*. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London, 2012.
83. Miller GE. The assessment of clinical skills/competence/performance. *Acad Med* 1990;65:S63–7.
84. Lindgren S, Karle H. Social accountability of medical education: aspects on global accreditation. *Med Teach* 2011;33:667–72.
85. Boelen C, Woollard R. Social accountability: the extra leap to excellence for educational institutions. *Med Teach* 2011;33: 614–19.
86. Boelen C, Woollard B. Social accountability and accreditation: a new frontier for educational institutions. *Med Educ* 2009;43:887–94.
87. Devitt P, Palmer E. Computer-aided learning: an overvalued educational resource? *Med Educ* 1999;33:136–9.
88. Carr MM, Reznick RK, Brown DH. Comparison of computer-assisted instruction and seminar instruction to acquire psychomotor and cognitive knowledge of epistaxis management. *Otolaryngol Head Neck Surg* 1999;121:430–4.
89. D'Alessandro DM, Kreiter CD, Erkonen WE, *et al*. Longitudinal follow-up comparison of educational interventions: multimedia textbook, traditional lecture, and printed textbook. *Acad Radiol* 1997;4:719–23.
90. Deen D, Karp R, Lowell B. A mini-fellowship in clinical nutrition for primary care physicians. *J Cancer Educ* 2000;15:134–6.
91. Heimburger DC, Ullmann DO, Ramsey MJ, *et al*. Dietary habits of first-year medical students assessed during clinical nutrition course. *Nutrition* 1994;10:214–20.
92. Hodgson CS, Wilkerson L, Go VL. Changes in nutrition knowledge among first- and second-year medical students following implementation of an integrated nutrition curriculum. *J Cancer Educ* 2000;15:144–7.
93. Kolasa KM, Jobe AC, Miller MG, *et al*. Teaching medical students cancer risk reduction nutrition counseling using a multimedia program. *Fam Med* 1999;31:200–4.
94. Edwards M. Nutrition education for medical students: 4th year transition to residency for primary care (1020.3). *The FASEB Journal* 2014;28(1 Suppl):1020.3.
95. Carson JAS. Impact of integrating cardiovascular nutrition in an ambulatory care rotation on the knowledge, attitudes, self-efficacy and patient care practices of fourth year medical students. Doctoral dissertation. University of Texas-Austin, 2000.
96. Baker K, Olfert M. Incorporating nutrition education through applied, hands-on culinary elective in medical school training (1020.2). *FASEB J* 2014;28(1 Suppl):1020.2.