BMJ Open

Setting Priorities for Research in Medical Nutrition Education: A Global Approach

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-013241
Article Type:	Research
Date Submitted by the Author:	28-Jun-2016
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Primary Subject Heading:	Medical education and training
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	NUTRITION & DIETETICS, MEDICAL EDUCATION & TRAINING, STATISTICS & RESEARCH METHODS, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Title Page

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Journal: BMJ Open

Running Head: Research Priorities in Medical Nutrition Education

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Keywords: nutrition education, medical training, research planning

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ABSTRACT

Objectives: To identify the research priorities for medical nutrition education worldwide.

Design: 5-step stakeholder engagement process based on methodological guidelines for identifying research priorities in health.

Participants: 277 individuals were identified as representatives for 30 different stakeholder organisations across 86 countries. The stakeholder organisations represented the views of medical educators, medical students, doctors, patients, and researchers in medical education.

Interventions: Each stakeholder representative was asked to provide up to three research questions for medical nutrition education deemed as a priority.

Main outcome measures: Research questions were critically appraised for answerability, sustainability, effectiveness, potential for translation and potential to impact on disease burden. A blinded scoring system was used to rank the appraised questions, with higher scores indicating higher priority (range of scores possible 36-108).

Results Thirty-seven submissions were received, of which 25 were unique research questions. Submitted questions received a range of scores from 62-106 points. The highest scoring questions focused on (i) the confidence of medical students and doctors in providing nutrition care to patients, (ii) the essential nutrition skills doctors should acquire, (iii) the effectiveness of doctors at influencing dietary behaviours and (iv) medical students' attitudes towards the importance of nutrition.

Conclusions: These research questions can be used to ensure future projects in medical nutrition education directly align with the needs and preferences of research stakeholders. Funders should consider these priorities in their commissioning of research.

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ARTICLE SUMMARY (Strengths and Limitations)

- A research priority setting project was conducted using a 5-step stakeholder engagement process.
- The project utilised a management team to provide informed, objective input throughout the stakeholder engagement process.
- The research scope, context and criteria for prioritising research questions was drafted and confirmed by the management team through iterative written and verbal discussions.
- Categories of potential stakeholders were identified by the management team to include medical students, medical educators, medical practitioners, nutrition organisations and patient representative bodies.
- Research questions were provided by stakeholders and initially reviewed for alignment with scope before being scored and ranked using the criteria developed by the management team.

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Introduction

Good nutrition is essential for human wellbeing, yet nutrition-related health conditions such as malnutrition, obesity and chronic disease affect nearly all countries worldwide.[1] As a result, poor dietary behaviours contribute significantly to the global burden of disease. Many countries are making progress in improving the nutrition outcomes of individuals and population groups,[1] which provides opportunity for supporting similar improvements in other countries. Health care systems aim to utilise strategies to support patients to have healthy dietary behaviours,[2] and this highlights an emerging priority for optimising health outcomes.[3]

The World Health Organization has previously recommended that medical professionals should be supported to take an active role in promoting healthy dietary behaviours.[2] Authoritative medical bodies have also confirmed that it is within the responsibility of doctors to address nutrition-related issues concerning patients and the public.[4] To best support doctors in the development of nutrition knowledge and skills, nutrition education should be integrated into undergraduate and postgraduate medical training.[2] Advancements in nutrition curriculum guidelines have occurred internationally,[5] and stem from widespread reports of insufficient nutrition education during medical training.[6-8]

There is considerable variability in the quantity and quality of nutrition education provided to medical students and graduates worldwide.[5] Notable differences include the specificity of nutrition content areas, recommended teaching approaches and extent of mandatory enforcement.[5, 9] As such, nutrition topics that have been decided as important for inclusion in medical education are not always sufficiently taught and may not result in a change of medical practice. Furthermore, many studies in medical

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nutrition education use self-reported changes in practices as a proxy indicator of effectiveness at enhancing nutrition care provided to patients,[9-11] and do not investigate whether interventions translate into improved dietary behaviours or health outcomes of patients. Clearly, future research should be carefully planned to overcome these challenges and to advance understanding that supports other countries to make similar improvements.

Research priority setting is a key component of research planning, particularly when research options far exceed available resources.[12] The objective of research priority setting is to use a fair, transparent and systematic approach to identify the most important research projects to conduct.[12] Research prioritisation is a valuable strategy used to ensure that future research projects are directly aligned with the needs and preferences of research end-users, such as stakeholders. This prioritisation process is important because it increases the likelihood that research projects elicit a meaningful impact and can be implemented in a sustainable, feasible and acceptable manner. Research priorities have been developed for specific aspects of nutrition research, such as micronutrient intake for child health,[13] and artificial feeding in hospitals.[14] This process has not yet been applied to other contexts, such as such as medical nutrition education.

The aim of this study was to identify global research priorities for medical nutrition education. The findings are essential for strengthening future research, and will demonstrate a thorough understanding of priority research questions. The study will guide future research projects to be aligned with the needs and preferences of research end-users.

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Methods

Overview

A 5-step stakeholder engagement process was undertaken to identify priorities for research in medical nutrition education worldwide. The stakeholder engagement process was informed by guidelines for setting research priorities.[12, 15] An overview of the stakeholder engagement process is shown in Figure 1. The study was approved by the relevant institutional Human Research Ethics Committee (reference number 2015/900).

INSERT FIGURE ONE ABOUT HERE

Step 1: Select Management Team

The project utilised a management team to provide informed, objective input throughout the stakeholder engagement process. The management team was formed through professional contacts of the researchers and comprised five researchers. Team members were from the UK, Canada, Australia and New Zealand. All members of the management team had extensive experience in medical nutrition education and research, including obtaining research funding support, developing research proposals, conducting studies, disseminating findings and translating evidence into changes in practice.

Step 2: Confirm scope and context

The research scope and context was drafted and confirmed by the management team through iterative written and verbal discussions. This process confirmed the population of interest, health conditions of interest, goals for translation and relevant

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stakeholders. An explanation of the research scope and context was developed to distribute to stakeholders, and reads as follows:

> *"The research we are focusing on examines the best way to support medical students to become competent at incorporating nutrition care into their future routine practices as doctors. Medical nutrition education facilitates students to have adequate nutrition knowledge, skills and attitudes to feel confident at providing nutrition care, as well as advocating for nutrition for improved public health. For the purpose of this project, medical nutrition education encompasses undergraduate, postgraduate and continuing medical education experiences for doctors in all countries; and does not include nutrition education for other health professionals. Outcomes could be measured by self-perceived or actual nutrition knowledge; demonstrated nutrition skills, attitudes towards nutrition, frequency of nutrition care, effectiveness of nutrition care on patients' health outcomes, and advocacy activities related to nutrition."*

Step 3: Engage with Stakeholders

Categories of potential stakeholders were identified by the management team to include medical students, medical educators, medical practitioners, nutrition organisations and patient representative bodies. A list of stakeholder contact details was developed using publicly available information from English websites. Preference was given to national and international bodies in order to capture informed opinions from the broadest possible audience. Figure 2 outlines the global reach of national stakeholder bodies involved in the stakeholder engagement process. Table 1 shows the global representation of the major stakeholder groups invited to participate. In addition to national bodies, international bodies for medical students, medical educators and medical practitioners were invited to provide input. Each stakeholder organisation was contacted via email to explain the aim and ethical approval of the project. In addition, the email outlined the scope and context of the research and asked representatives to provide up to three research questions deemed as a priority.

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Two reminder emails were sent to each stakeholder organisation over a period of two months.

INSERT FIGURE TWO ABOUT HERE

INSERT TABLE ONE ABOUT HERE

Step 4: Confirm Criteria for Appraising and Prioritising Research

The criteria for prioritising research questions were drafted and confirmed by the management team through blinded ranking. Fifteen possible criteria and their explanations were proposed and ranked in order of relevance and importance for the scope and context of research.[12] The four highest ranked criteria (i) answerability, (ii) sustainability, (iii) effectiveness and (iv) potential for translation and impact on disease burden were used to score each research option proposed by the stakeholders. Between two and four assessment questions were drafted and confirmed by the management team to adequately assess each criterion. Box 1 outlines the criteria and assessment questions applied when appraising each research question.

INSERT BOX ONE ABOUT HERE

Step 5: Score of Research Options

The research questions provided by stakeholders were initially reviewed for alignment with scope and ability to be scored using the five criteria. Minor edits were made to the wording of research questions to enable structured scoring by the management team. The submitted research questions were independently scored by each member of the management team using the assessment questions for each criteria, with answers: "Yes" (3 points), "Unsure" (2 points) or "No" (1 point). The

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total number of points awarded to each research question was summed in order to provide an overall score for each criterion, ranging from 36-108 given the assessment criteria and size of the management team. Finally, the appraised questions were ranked from highest to lowest score to provide a list of prioritised research questions.

Results

Thirty-seven research questions from 19 stakeholder organisations were obtained from the stakeholder engagement process over the two month data collection period. Twelve questions were collapsed with others due to considerable overlap, resulting in 25 unique research questions for appraisal. Table 1 outlines each of the research questions as well as the score achieved for each criterion. The questions achieved a mean±SD total score of 86±16 points (range 62-106 points).

INSERT TABLE TWO ABOUT HERE

The appraisal process allowed a total ranking for each question, with clear separation between scores. The highest scoring question overall related to the confidence of medical students and doctors in providing nutrition care to patients. Other high scoring questions focused on the essential nutrition skills for doctors, the effectiveness of doctors at influencing dietary behaviours and medical students' attitudes towards the importance of nutrition.

The ranking of questions differed for each criterion. For example, Table 2 indicates that the seventh highest scoring question overall (translation of nutrition education into improved nutrition care), achieved the highest score in terms of sustainability, the

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12th highest for answerability, third highest for effectiveness and highest for the potential for translation.

Discussion

Medical nutrition education is an important component for the translation and sustainability of multi-faceted interventions within health care. As such, the incorporation of medical nutrition education into current interventions should be considered collaborative rather competitive. This study aimed to identify the global research priorities for medical nutrition education. The process for developing these priorities was consultative and consensus-based. The stakeholder engagement process resulted in a wide variety of research questions being critically appraised and prioritised. This suggests that the aim of developing a fair, transparent and systematic approach to identifying the most important research priorities was satisfied.[12] This work can inform future research projects that align with the needs and preferences of research end-users in medical nutrition education. Funding bodies and health service providers are encouraged to use these research priorities in decision-making about future projects.

The highest scoring questions focused on the confidence of medical students and doctors in providing nutrition care to patients; the essential nutrition skills doctors should acquire; the effectiveness of doctors at influencing dietary behaviours and medical students' attitudes towards the importance of nutrition. Interestingly, most of these topics have been previously researched to variable extents.[8, 16-31] This indicates that previous research activities are generally aligning with the needs and preferences of stakeholders. The extent to which current research projects align with the prioritised research questions when planning projects should be reviewed, with

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particular emphasis on incorporating indicators of effectiveness and translation into practice. Furthermore, the priorities identified in this study align with grand/global challenges schemes underway in several countries including Canada, the UK and USA in terms of improving global health through prevention and management of infectious and non-communicable diseases.

The ranking of research questions differed for each criterion. This suggests that a different list of priority research questions may have been produced using different criteria. An iterative approach was used in the present study to determine the most appropriate criteria for appraising the research questions. These criteria could be used to strengthen potential research questions by enhancing answerability, or altering study designs to increase the potential for translation to practice. To overcome this limitation, providing stakeholder organisations with instructions on the optimal development of research questions may help align future submissions to the criteria.

The attributes of the submitted research questions require consideration prior to future research. For example, the submitted research questions differed in scope and focus, and achieved variable scores for each appraisal criterion. The stakeholder organistions typically represented the views of clinicians, with less direct representation of patients. Furthermore, the research questions that were more specifically worded appeared to achieve higher scores than generally worded questions. This suggests that the appraisal by the management team may have been more favourable when the questions were easily understood and clearly described, rather than whether or not the question was an important priority. Specific questions may also score higher in the feasibility criteria compared to general questions because the translation to study design may be clear. These limitations suggest that future research planning should

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use the prioritised research questions as a source of guidance, whilst also considering other relevant factors such as translating general questions into study designs, acknowledging existing projects, patients' preferences, international priorities in nutrition and whether the intervention translates into improved dietary behaviours or health outcomes of patients.

In conclusion, this study has identified the global research priorities for medical nutrition education. The process used provides a consultative, transparent, and consensus-based model that could be applied elsewhere. The stakeholder engagement process resulted in a wide variety of research questions being critically appraised and prioritised. As a result, future research projects that align with the prioritised research questions are likely to meet the needs and preferences of research stakeholders in medical nutrition education.

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Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing Interests: The authors declare no competing interests.

Author's contribution: LB and KB took a lead role in the concept and design of the study. LB, KB, CL and SR advised on data collection and analysis. JC assisted with the writing of the manuscript. All authors contributed to the manuscript development and approved the final version prior to submission.

Data Sharing: There is no additional data available.

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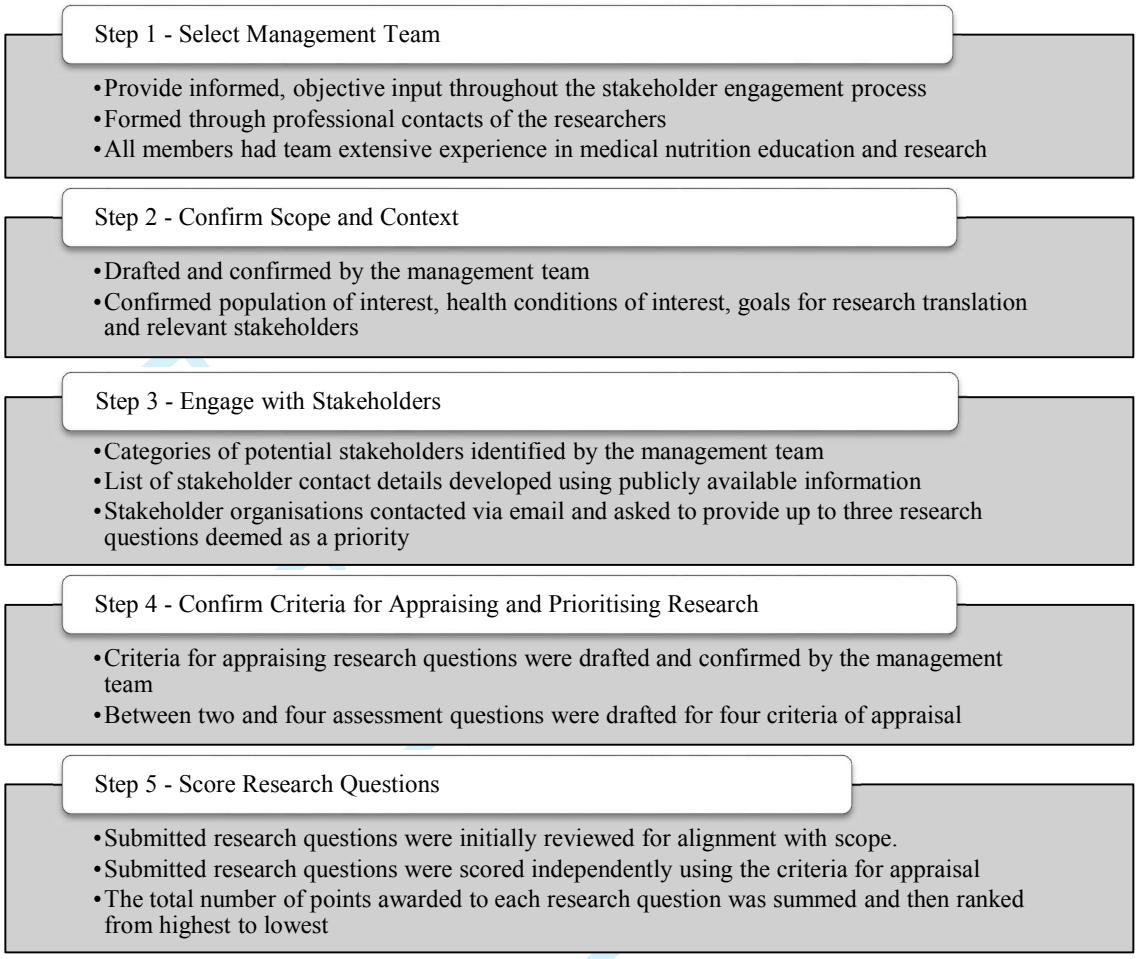

Figure 1: Overview of the stakeholder engagement process.

Figure 2: Reach of stakeholder input across the world. Shaded areas highlight countries with opportunity to participate in the stakeholder consultation process.

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Table 1: List of countries invited to participate, in order of stakeholder group.

Stakeholder group	Global, Region or Country invited to participte
Medical eudcators	Global (worldwide), USA, Canada, Asia, Vietnam, Oceania, Europe, United Kingdom
Medical Practitioners	Global (worldwide), Africa, Nigeria, Ethiopia, Egypt, Tanzania, South Africa, Kenya, Sudan, Uganda, Mozambique, Malawi, Zambia, Zimbabwe, Rwanda, Namibia, Lesotho, The Bahamas, Curacao, USA, Canada, Brazil, Tinidad & Tobago, China, India, Pakistan, Bangladesh, Japan, Vietnam, Thailand, Myanmar, South Korea, Malaysia, Nepal, Taiwan, Sri Lanka, Hong Kong, Singapore, Russia, Phillipines, Australia, New Zealand, Spain, Ukraine, Poland, Romania, Czech Republic, Hungary, Bulgaria, Serbia, Slovakia, Croatia, Armenia, Albania, Lithuania, Macedonia, Slovenia, Latvia, Estonia, UK, Italy, Netherlands, Portugal, Sweden, Austria, Denmark, Finland, Norway, Ireland, Iceland, Liechtenstien, Kazakhstan, Turkey, Uzbekistan, Azerbaijan, Jordan, Kuwait, Georgia, Cyprus, Malta, Israel, Fiji, Samoa
Medical Students	Global (worldwide), Canada, Africa, Egypt, Kenya Ghana, Tunisia, The Americas, Brazil, Chile, Asia/Pacific, China, India, Pakistan, Bangladesh, Japan, Thialand, Myanmar, South Korea, Malaysia, Nepal, North Korea, Taiwan, Cambodia, Hong Kong, Singapore, Mongolia, Indonesia, Phillipines, Australia, New Zealand Europe, Ukraine, Poland, Romania, Bulgaria, Serbia, Croatia, Lithuania, Macedonia, Slovenia, Latvia, Italy, Belgium, Portugal, Austria, East Medditeranean, Turkey, Greece, Georgia, Malta, Iran, Iraq,
Patient advocacy	USA, Canada, Australia, Europe, UK.

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Box 1: Assessment questions used to appraise each research question.

Criterion 1: ANSWERABILITY

1.1 Is the research question clear, including well defined study outcomes?

1.2 Can a study be feasibly designed to answer the research question?

1.3 Do you think that a study needed to answer the research question would feasibly obtain ethical approval?

1.4 Taking into account the level of difficulty to answer the questions (e.g. required design, safety, infrastructure, need to modify health professional behaviours), do you believe the research question can be answered in the current local, national, or global context?

Criterion 2: SUSTAINABILTY

2.1 Taking into account the resources required to answer the research question, do you think the benefits from the research would be long lasting (ie. >5years)?

2.2 Do you think that the research question would be relevant and well justified for governmental, industry or nationally competitive funding?

Criterion 3: EFFECTIVENESS

3.1 Do you believe the research could provide rationale to inform a future intervention, OR, do you believe there is enough rational to support the development of an intervention to answer the research question?

3.2 Do you believe an intervention that answers the research question will have equitable outcomes for all population groups?

3.3 Do you believe an intervention that answers the research question could be cost effective?

Criterion 4: POTENTIAL FOR TRANSLATION AND IMPACT ON DISEASE BURDEN

4.1 If the research question was answered, would the new knowledge be able to be used by other stakeholders in the current context of medical education?

4.2 If the research question was answered, could the new knowledge facilitate improvements in nutrition care provided by doctors within a local, national or international context?

4.3 If the research question was answered, could the new knowledge support local, national or international improvements in health care service delivery?

4.4 If the research question was answered, is there potential to improve the nutrition care provided to patients by an amount that would cause a reduction in the burden of over- or under-nutrition at a population level?

All questions were answered in the format "Yes" (3 points), "Unsure" (2 points) or "No" (1 point).

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Table 2: Summary of Scores for Appraised Research Questions from highest to lowest ranked priority (n=25).

Submitted Research Questions	Criterion Scores				Total Score *(out of 108)*
	Answerability *(out of 36)*	**Sustainability** *(out of 18)*	**Effectiveness** *(out of 27)*	**Potential for Translation and Impact on Disease Burden** *(out of 27)*	
How confident are medical students and doctors in providing nutrition care to patients?	36	17	27	26	106
What are the essential nutrition medical skills for physicians and physician-to-be to obtain?	36	16	27	26	105
How effective are doctors at influencing nutritional health of patients?	36	17	26	26	105
What level of importance is placed on nutrition care by medical students?	36	15	26	26	103
What is the cost benefit of educating medical students and doctors in nutrition?	36	15	24	26	101
Is CME/CPD education on nutrition available, and if yes, what proportion of doctors participate in this education?	31	18	26	26	101
To what extent does medical nutrition education translate into improved nutrition care of doctors?	29	18	26	27	100
How do we best support doctors and medical students to appropriately manage malnutrition?	35	12	23	25	97
What nutrition related competencies are being developed in medical students in different countries?	29	18	24	26	95
How can simple nutrition questionnaires be best used to support doctors and medical students to provide nutrition care?	32	16	22	25	95
What level of knowledge does the average medical graduate have of nutrition prescription?	32	16	21	26	95
What are the key nutrition messages that doctors should provide patients discharged from a rehabilitation centre?	34	13	22	24	93

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How well do medical students and doctors recognise the role of other health professionals in nutrition?	32	16	20	24	92
What is the most effective way to develop nutrition related competencies in medical students/physicians in different countries?	29	17	19	26	91
Does medical nutrition education currently cover dietary supplementation?	34	8	18	22	82
What is the prevalence of different nutrition related conditions of patients in different countries?	30	12	20	18	80
What are the most important laboratory tests to assess malnutrition in peadiatrics?	25	10	18	17	70
How does nutrition effect dyslipidaemia and diabetes?	24	11	17	18	70
How does nutrition effect brain degeneration?	24	8	16	20	69
How does nutrition influence the outcomes of patients with psychiatric disorders?	23	8	17	19	68
What is the ideal role of supplements in managing over and under nutrition?	23	8	15	21	67
What is the effect of dietary supplementation in healthy patients?	22	12	18	17	67
What are the most common food allergies of patients in different countries?	27	9	15	16	67
What is the best way for doctors to manage hypervitaminosis?	21	8	16	18	63
How does nutrition influence the outcomes of patients with rheumatic diseases?	18	8	18	18	62
Mean (SD)	**29 (5.5)**	**13 (3.8)**	**21 (4.0)**	**23 (3.9)**	**86 (15.7)**

440

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Setting Priorities for Research in Medical Nutrition Education: An International Approach

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-013241.R1
Article Type:	Research
Date Submitted by the Author:	02-Sep-2016
Complete List of Authors:	Ball, Lauren; Griffith University, Menzies Health Institute Queensland Barnes, Katelyn; Griffith University, Menzies Health Institute Queensland Laur, Celia; Need for Nutrition Education Programme group Crowley, Jennifer Ray, Sumantra; MRC Human Nutrition Research,
Primary Subject Heading:	Medical education and training
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	NUTRITION & DIETETICS, MEDICAL EDUCATION & TRAINING, STATISTICS & RESEARCH METHODS, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Title Page

Title: Setting Priorities for Research in Medical Nutrition Education: An International Approach

Journal: BMJ Open

Running Head: Research Priorities in Medical Nutrition Education

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Keywords: nutrition education, medical training, research planning

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Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing Interests: The authors declare no competing interests.

Author's contribution: LB and KB took a lead role in the concept and design of the study. LB, KB, CL and SR advised on data collection and analysis. JC assisted with the writing of the manuscript. All authors contributed to the manuscript development and approved the final version prior to submission.

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ABSTRACT

Objectives: To identify the research priorities for medical nutrition education worldwide.

Design: A 5-step stakeholder engagement process based on methodological guidelines for identifying research priorities in health.

Participants: 277 individuals were identified as representatives for 30 different stakeholder organisations across 86 countries. The stakeholder organisations represented the views of medical educators, medical students, doctors, patients, and researchers in medical education.

Interventions: Each stakeholder representative was asked to provide up to three research questions that should be deemed as a priority for medical nutrition education.

Main outcome measures: Research questions were critically appraised for answerability, sustainability, effectiveness, potential for translation and potential to impact on disease burden. A blinded scoring system was used to rank the appraised questions, with higher scores indicating higher priority (range of scores possible 36-108).

Results Thirty-seven submissions were received, of which 25 were unique research questions. Submitted questions received a range of scores from 62-106 points. The highest scoring questions focused on (i) increasing the confidence of medical students and doctors in providing nutrition care to patients, (ii) clarifying the essential nutrition skills doctors should acquire, (iii) understanding the effectiveness of doctors at influencing dietary behaviours and (iv) improving medical students' attitudes towards the importance of nutrition.

Conclusions: These research questions can be used to ensure future projects in medical nutrition education directly align with the needs and preferences of research

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stakeholders. Funders should consider these priorities in their commissioning of research.

ARTICLE SUMMARY (Strengths and Limitations)

- The research priority setting project was conducted using a well established protocol previously used by international organisations and funding bodies.
- Participating stakeholder organisations were limited to English speaking groups, which may have excluded some organisations from providing input.
- The stakeholder organisations typically represented the views of clinicians, with less direct representation of patients.
- The project utilised a management team to provide informed, objective input throughout the stakeholder engagement process, thereby enhancing the quality of the project.

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Introduction

Good nutrition is essential for human wellbeing, yet nutrition-related health conditions such as malnutrition, obesity and chronic disease affect nearly all countries worldwide.[1] As a result, poor dietary behaviours contribute significantly to the global burden of disease. Many countries are making progress in improving the nutrition outcomes of individuals and population groups,[1] which provides opportunity for supporting similar improvements in other countries. Health care systems aim to utilise strategies to support patients to have healthy dietary behaviours,[2] and this highlights an emerging priority for optimising health outcomes.[3]

The World Health Organization has previously recommended that medical professionals should be supported to take an active role in promoting healthy dietary behaviours.[2] Authoritative medical bodies have also confirmed that it is within the responsibility of doctors to address nutrition-related issues concerning patients and the public.[4] Within this context, nutrition care refers to any practice undertaken by a doctor to facilitate improved dietary behaviours and subsequent health outcomes of patients.[5] To best support doctors in providing nutrition care, optimal nutrition knowledge and skills, including when to consult a nutrition professional such as a Registered Dietitian or Registered Nutritionist should be developed throughout undergraduate and postgraduate medical training.[2] Advancements in nutrition curriculum guidelines have occurred internationally,[6] and stem from widespread reports of insufficient nutrition education during medical training.[7-9]

There is considerable variability in the quantity and quality of nutrition education provided to medical students and graduates worldwide.[6] Notable differences include the way nutrition is incorporated into the medical curricula, the specificity of nutrition

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content areas, recommended teaching approaches and extent of mandatory enforcement.[6, 10] As such, nutrition topics that have been decided as important for inclusion in medical curricula are not always sufficiently taught and may not result in a change of medical practice. Furthermore, many studies in medical nutrition education use self-reported changes in practices as a proxy indicator of effectiveness at enhancing nutrition care provided to patients.[10-12] These studies do not investigate whether interventions translate into improved dietary behaviours or health outcomes of patients. Clearly, future research should be carefully planned to overcome these challenges and to advance understanding that supports other countries to make similar improvements.

Research priority setting is a key component of research planning, particularly when research options far exceed available resources.[13] The objective of research priority setting is to use a fair, transparent and systematic approach to identify the most important research projects to conduct.[13] Research prioritisation is a valuable strategy used to ensure that future research projects are directly aligned with the needs and preferences of research end-users, such as stakeholders. This prioritisation process is important because it increases the likelihood that research projects elicit a meaningful impact and can be implemented in a sustainable, feasible and acceptable manner. Guidelines for setting research priorities exist and are deemed superior to other methodologies such as Delphi due to its ability to assure confidentiality of stakeholders.[13, 14] Research priorities have been developed for specific aspects of nutrition research, such as micronutrient intake for child health,[15] and artificial feeding in hospitals.[16] This process has not yet been applied to other contexts, such as such as medical nutrition education.

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The aim of this study was to identify international research priorities for medical nutrition education. The findings are essential for strengthening future research, and will demonstrate a thorough understanding of priority research questions. The study will guide future research projects to be aligned with the needs and preferences of research end-users.

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Methods

Overview

A 5-step stakeholder engagement process was undertaken to identify priorities for research in medical nutrition education worldwide. The stakeholder engagement process was informed by guidelines for setting research priorities.[13, 14] An overview of the stakeholder engagement process is shown in Figure 1. The study was approved by the relevant institutional Human Research Ethics Committee (reference number 2015/900).

INSERT FIGURE ONE ABOUT HERE

Step 1: Select Management Team

The project utilised a management team developed in accordance with published guidelines. [13, 14] The rationale of using a management team was to provide informed, objective input throughout the stakeholder engagement process. The management team was comprised five researchers with expertise in medicine, nutrition, education and evaluation. Team members were from the UK, Canada, Australia and New Zealand. All members of the management team had extensive experience in medical nutrition education and research, including obtaining research funding support, developing research proposals, conducting studies, disseminating findings and translating evidence into changes in practice.

Step 2: Confirm scope and context

The research scope and context was drafted and confirmed by the management team through iterative written and verbal discussions. This process confirmed the population of interest, health conditions of interest, goals for translation and relevant

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stakeholders. An explanation of the research scope and context was developed to distribute to stakeholders, and reads as follows:

> *"The research we are focusing on examines the best way to support medical students to become competent at incorporating nutrition care into their future routine practices as doctors. Medical nutrition education facilitates students to have adequate nutrition knowledge, skills and attitudes to feel confident at providing nutrition care, as well as advocating for nutrition for improved public health. For the purpose of this project, medical nutrition education encompasses undergraduate, postgraduate and continuing medical education experiences for doctors in all countries; and does not include nutrition education for other health professionals. Outcomes could be measured by self-perceived or actual nutrition knowledge; demonstrated nutrition skills, attitudes towards nutrition, frequency of nutrition care, effectiveness of nutrition care on patients' health outcomes, and advocacy activities related to nutrition."*

Step 3: Engage with Stakeholders

Categories of potential stakeholders were identified by the management team based on their involvement with the activities described in the scope and context statement. Key words such as "medical", "nutrition", "education", "doctors", "patients, and "public health" were used to identify the following potential stakeholder groups: medical students, medical educators, medical practitioners, nutrition organisations and patient representative bodies. A list of stakeholder contact details was developed using publicly available information from English websites. Preference was given to national and international bodies in order to capture informed opinions from the broadest possible audience. Figure 2 outlines the global reach of national stakeholder bodies involved in the stakeholder engagement process. Table 1 shows the international representation of the major stakeholder groups invited to participate. In addition to national bodies, international bodies for medical students, medical educators and medical practitioners were invited to provide input. Each stakeholder

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organisation was contacted via email with an information sheet that outlined the aim and ethical approval of the project. In addition, the email outlined the scope and context of the research and provided a link to an anonymous online survey where representatives could provide up to three research questions deemed as a priority. Stakeholders providing questions via the online survey system inferred consent. Two reminder emails were sent to each stakeholder organisation over a period of two months.

INSERT FIGURE TWO ABOUT HERE

INSERT TABLE ONE ABOUT HERE

Step 4: Confirm Criteria for Appraising and Prioritising Research

The criteria for prioritising research questions were drafted and confirmed by the management team through blinded ranking. Fifteen possible criteria and their explanations were proposed based on published guidelines[13] and ranked in order of relevance and importance for the scope and context of research. The four highest ranked criteria (i) answerability, (ii) sustainability, (iii) effectiveness and (iv) potential for translation and impact on disease burden were used to score each research option proposed by the stakeholders. Between two and four assessment questions were drafted and confirmed by the management team to adequately assess each criterion. Box 1 outlines the finalised criteria and assessment questions applied when appraising each research question.

INSERT BOX ONE ABOUT HERE

Step 5: Score of Research Options

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The research questions provided by stakeholders were initially reviewed for alignment with scope and ability to be scored using the four criteria. Minor edits were made to the wording of research questions to enable structured scoring by the management team. The submitted research questions were independently scored by each member of the management team using the assessment questions for each criteria, with answers: "Yes" (3 points), "Unsure" (2 points) or "No" (1 point). The total number of points awarded to each research question was summed in order to provide an overall score for each criterion, ranging from 36-108 given the assessment criteria and size of the management team. Finally, the appraised questions were ranked from highest to lowest score to provide a list of prioritised research questions.

Results

Thirty-seven research questions from 19 stakeholder organisations were obtained from the stakeholder engagement process over the two month data collection period. Twelve questions were collapsed with others due to considerable overlap, resulting in 25 unique research questions for appraisal. Table 1 outlines each of the research questions as well as the score achieved for each criterion. The questions achieved a mean±SD total score of 86±16 points (range 62-106 points).

INSERT TABLE TWO ABOUT HERE

The appraisal process allowed a total ranking for each question, with clear separation between scores. The highest scoring question overall related to increasing the confidence of medical students and doctors in providing nutrition care to patients. Other high scoring questions focused on the clarifying the essential nutrition skills for

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doctors, understanding the effectiveness of doctors at influencing dietary behaviours and improving medical students' attitudes towards the importance of nutrition.

The ranking of questions differed for each criterion. For example, Table 2 indicates that the seventh highest scoring question overall (translation of nutrition education into improved nutrition care), achieved the highest score in terms of sustainability, the 12th highest for answerability, third highest for effectiveness and highest for the potential for translation.

Discussion

This study aimed to identify the international research priorities for medical nutrition education. The process for developing these priorities was consultative and consensus-based. The stakeholder engagement process resulted in a wide variety of research questions being critically appraised and prioritised. This suggests that the aim of developing a fair, transparent and systematic approach to identifying the most important research priorities was satisfied.[13] This work can inform future research projects that align with the needs and preferences of research end-users in medical nutrition education. Funding bodies and health service providers are encouraged to use these research priorities in decision-making about future projects.

The highest scoring questions focused on increasing the confidence of medical students and doctors in providing nutrition care to patients; clarifying the essential nutrition skills doctors should acquire; understanding the effectiveness of doctors at influencing dietary behaviours and improving medical students' attitudes towards the importance of nutrition. Interestingly, most of these topics have been previously researched to variable extents. [5, 9, 17-30] This indicates that previous research activities

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are generally aligning with the needs and preferences of stakeholders. Furthermore, the priorities identified in this study align with grand/global challenges schemes underway in several countries including Canada, the UK and USA in terms of improving global health through prevention and management of infectious and non-communicable diseases.

The ranking of research questions differed for each criterion. This variation suggests that a different list of priority research questions may have been produced using different criteria. An iterative approach was used in the present study to determine the most appropriate criteria for appraising the research questions. These criteria could be used to strengthen potential research questions by enhancing answerability, or altering study designs to increase the potential for translation to practice. To overcome this limitation, providing stakeholder organisations with instructions on the optimal development of research questions may help align future submissions to the criteria.

The attributes of the submitted research questions require consideration prior to future research. For example, the submitted research questions differed in scope and focus, and achieved variable scores for each appraisal criterion. Furthermore, the research questions that were more specifically worded appeared to achieve higher scores than generally worded questions. This suggests that the appraisal by the management team may have been more favourable when the questions were easily understood and clearly described, rather than whether or not the question was an important priority. Specific questions may also score higher in the feasibility criteria compared to general questions because the translation to study design may be clear. These limitations suggest that future research planning should use the prioritised research questions as a source of guidance, whilst also considering other relevant factors such as translating

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general questions into study designs, acknowledging existing projects, patients' preferences, international priorities in nutrition and whether the intervention translates into improved dietary behaviours or health outcomes of patients.

The present study had some notable limitations. For example, 37 submissions were obtained from a possible 277 individuals who represented stakeholder organisations. The anonymity of responses precluded any description of the responding stakeholder organisations. Furthermore, it is unclear whether greater responses would have led to a wider variety in questions appraised. However, given that 12 of the 37 submissions (32%) overlapped significantly, it is evident that stakeholders had some consistent questions deemed worthy of consideration.

In conclusion, this study has identified the international research priorities for medical nutrition education. The process used provides a consultative, transparent, and consensus-based model that could be applied elsewhere. The stakeholder engagement process resulted in a wide variety of research questions being critically appraised and prioritised. As a result, future research projects that align with the prioritised research questions are likely to meet the needs and preferences of research stakeholders in medical nutrition education.

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Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing Interests: The authors declare no competing interests.

Author's contribution: LB and KB took a lead role in the concept and design of the study. LB, KB, CL and SR advised on data collection and analysis. JC assisted with the writing of the manuscript. All authors contributed to the manuscript development and approved the final version prior to submission.

Data Sharing Statement: There is no further data that has not been published. Raw data can be accessed by emailing l.ball@griffith.edu.au.

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Figure 1: Overview of the stakeholder engagement process.

PLEASE SEE ATTACHED JPG

Figure 2: Reach of stakeholder input across the world. Shaded areas highlight countries with opportunity to participate in the stakeholder consultation process.

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Table 1: List of countries invited to participate, in order of stakeholder group.

Stakeholder group	**Global, Region or Country invited to participate**
Medical educators	Global (worldwide), USA, Canada, Asia, Vietnam, Oceania, Europe, United Kingdom
Medical Practitioners	Global (worldwide), Africa, Nigeria, Ethiopia, Egypt, Tanzania, South Africa, Kenya, Sudan, Uganda, Mozambique, Malawi, Zambia, Zimbabwe, Rwanda, Namibia, Lesotho, The Bahamas, Curacao, USA, Canada, Brazil, Trinidad & Tobago, China, India, Pakistan, Bangladesh, Japan, Vietnam, Thailand, Myanmar, South Korea, Malaysia, Nepal, Taiwan, Sri Lanka, Hong Kong, Singapore, Russia, Philippines, Australia, New Zealand, Spain, Ukraine, Poland, Romania, Czech Republic, Hungary, Bulgaria, Serbia, Slovakia, Croatia, Armenia, Albania, Lithuania, Macedonia, Slovenia, Latvia, Estonia, UK, Italy, Netherlands, Portugal, Sweden, Austria, Denmark, Finland, Norway, Ireland, Iceland, Liechtenstein, Kazakhstan, Turkey, Uzbekistan, Azerbaijan, Jordan, Kuwait, Georgia, Cyprus, Malta, Israel, Fiji, Samoa
Medical Students	Global (worldwide), Canada, Africa, Egypt, Kenya Ghana, Tunisia, The Americas, Brazil, Chile, Asia/Pacific, China, India, Pakistan, Bangladesh, Japan, Thailand, Myanmar, South Korea, Malaysia, Nepal, North Korea, Taiwan, Cambodia, Hong Kong, Singapore, Mongolia, Indonesia, Philippines, Australia, New Zealand, Europe, Ukraine, Poland, Romania, Bulgaria, Serbia, Croatia, Lithuania, Macedonia, Slovenia, Latvia, Italy, Belgium, Portugal, Austria, East Mediterranean, Turkey, Greece, Georgia, Malta, Iran, Iraq,
Nutrition Organisations	USA, UK
Patient Representatives	USA, Canada, Australia, Europe, UK.

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Box 1: Assessment questions used to appraise each research question.

Criterion 1: ANSWERABILITY

1.1 Is the research question clear, including well defined study outcomes?

1.2 Can a study be feasibly designed to answer the research question?

1.3 Do you think that a study needed to answer the research question would feasibly obtain ethical approval?

1.4 Taking into account the level of difficulty to answer the questions (e.g. required design, safety, infrastructure, need to modify health professional behaviours), do you believe the research question can be answered in the current local, national, or global context?

Criterion 2: SUSTAINABILTY

2.1 Taking into account the resources required to answer the research question, do you think the benefits from the research would be long lasting (ie. >5years)?

2.2 Do you think that the research question would be relevant and well justified for governmental, industry or nationally competitive funding?

Criterion 3: EFFECTIVENESS

3.1 Do you believe the research could provide rationale to inform a future intervention, OR, do you believe there is enough rational to support the development of an intervention to answer the research question?

3.2 Do you believe an intervention that answers the research question will have equitable outcomes for all population groups?

3.3 Do you believe an intervention that answers the research question could be cost effective?

Criterion 4: POTENTIAL FOR TRANSLATION AND IMPACT ON DISEASE BURDEN

4.1 If the research question was answered, would the new knowledge be able to be used by other stakeholders in the current context of medical education?

4.2 If the research question was answered, could the new knowledge facilitate improvements in nutrition care provided by doctors within a local, national or international context?

4.3 If the research question was answered, could the new knowledge support local, national or international improvements in health care service delivery?

4.4 If the research question was answered, is there potential to improve the nutrition care provided to patients by an amount that would cause a reduction in the burden of over- or under-nutrition at a population level?

All questions were answered in the format "Yes" (3 points), "Unsure" (2 points) or "No" (1 point).

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462 Table 2: Summary of Scores for Appraised Research Questions from highest to lowest ranked priority (n=25).

Submitted Research Questions	Criterion Scores				Total Score *(out of 108)*
	Answerability *(out of 36)*	**Sustainability** *(out of 18)*	**Effectiveness** *(out of 27)*	**Potential for Translation and Impact on Disease Burden** *(out of 27)*	
How confident are medical students and doctors in providing nutrition care to patients?	36	17	27	26	106
What are the essential nutrition skills for physicians and physicians-to-be to obtain?	36	16	27	26	105
How effective are doctors at influencing nutritional health of patients?	36	17	26	26	105
What level of importance is placed on nutrition care by medical students?	36	15	26	26	103
What is the cost benefit of educating medical students and doctors in nutrition?	36	15	24	26	101
Is CME/CPD education on nutrition available, and if yes, what proportion of doctors participate in this education?	31	18	26	26	101
To what extent does medical nutrition education translate into improved nutrition care of doctors?	29	18	26	27	100
How do we best support doctors and medical students to appropriately manage malnutrition?	35	12	23	25	97
What nutrition related competencies are being developed in medical students in different countries?	29	18	24	26	95
How can simple nutrition questionnaires be best used to support doctors and medical students to provide nutrition care?	32	16	22	25	95
What level of knowledge does the average medical graduate have of nutrition prescription?	32	16	21	26	95
What are the key nutrition messages that doctors should provide patients discharged from a rehabilitation centre?	34	13	22	24	93

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How well do medical students and doctors recognise the role of other health professionals in nutrition?	32	16	20	24	92
What is the most effective way to develop nutrition related competencies in medical students/physicians in different countries?	29	17	19	26	91
Does medical nutrition education currently cover dietary supplementation?	34	8	18	22	82
What is the prevalence of different nutrition related conditions of patients in different countries?	30	12	20	18	80
What are the most important laboratory tests to assess malnutrition in peadiatrics?	25	10	18	17	70
How does nutrition affect dyslipidaemia and diabetes?	24	11	17	18	70
How does nutrition affect brain degeneration?	24	8	16	20	69
How does nutrition influence the outcomes of patients with psychiatric disorders?	23	8	17	19	68
What is the ideal role of supplements in managing over and under nutrition?	23	8	15	21	67
What is the affect of dietary supplementation in healthy patients?	22	12	18	17	67
What are the most common food allergies of patients in different countries?	27	9	15	16	67
What is the best way for doctors to manage hypervitaminosis?	21	8	16	18	63
How does nutrition influence the outcomes of patients with rheumatic diseases?	18	8	18	18	62
Mean (SD)	**29 (5.5)**	**13 (3.8)**	**21 (4.0)**	**23 (3.9)**	**86 (15.7)**

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Figure 1: Overview of the stakeholder engagement process.

42x36mm (300 x 300 DPI)

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Figure 2: Reach of stakeholder input across the world. Shaded areas highlight countries with opportunity to participate in the stakeholder consultation process.

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