Original Article

Development of nutrition science competencies for undergraduate degrees in Australia

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Background and Objectives: The need for updated competencies for nutrition scientists in Australia was identified. The aim of this paper is to describe the process of revising of these competencies for undergraduate nutrition science degrees in Australia. **Methods and Study Design:** An iterative multiple methods approach comprising three stages was undertaken: 1. Scoping study of existing competencies; 2. Exploratory survey; and, 3. Modified Delphi process (2 rounds) involving 128 nutrition experts from industry, community, government and academia. A ≥70% consensus rule was applied to Rounds 1 and 2 of the Delphi process in order to arrive at a final list of competencies. **Results:** Stage 1: Scoping study resulted in an initial list of 71 competency statements, categorised under six core areas. Stage 2: Exploratory survey-completed by 74 Nutrition Society of Australia (NSA) members; 76% agreed there was a need to update the current competencies. Standards were refined to six core areas and 36 statements. Stage 3: Modified Delphi process-revised competencies comprise five core competency areas, underpinned by fundamental knowledge, skills, attitudes and values: Nutrition Science; Food and the Food System; Nutrition Governance, Sociocultural and Behavioural Factors; Nutrition Research and Critical Analysis; and Communication and Professional Conduct; and three specialist competency areas: Food Science; Public Health Nutrition; and Animal Nutrition. **Conclusions:** The revised competencies provide an updated framework of nutrition science knowledge for graduates to effectively practice in Australia. They may be used to benchmark current and future nutrition science degrees and lead to improved employability skills of nutrition science graduates.

Key Words: competency areas, workforce development, Delphi, nutrition science, Australia

INTRODUCTION

The nutrition profession comprises a variety of career pathways and workplace applications that converge on food, nutrition and health. Nutrition roles in the workplace may include nutrition scientists, nutritionists (animal or human), nutrition educators and/or researchers, biochemists, public health nutritionists and dietitians.[1] Although they may each have vastly different roles in the health and medical sector, training in the nutrition discipline has focused on the biological and biomedical domains. In recent years this traditional focus has been challenged as nutrition related problems have become more complex, including recognition of the need to consider sustainability in nutrition solutions.[2-4] The New Nutrition Science (NNS) project over a decade ago recommended that a broader, social and environmental dimension be incorporated into the biological construct of the discipline of nutrition science to address the multiple and complex

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determinants of health.[2,5] Indeed the United Nations' Sustainable Development Goals (SDGs) in 2015[6] introduced a new paradigm that poses major challenges to nutrition practice that may affect the way in which nutrition science is taught.[7]

To encompass the broader focus within nutrition science,[2,5] and to include skills and knowledge in the societal and environmental sciences, a comprehensive set of competencies is required. Competency is the ability to adequately demonstrate integrated multiple attributes such as knowledge, skills, values and attitudes within a specific occupation.[8] Competencies are the broader professional standards that inform the development of tertiary nutrition degree learning outcomes, which in turn direct teaching and learning practices with regard to pedagogy, generic skills development, and assessment techniques. Suggested within the literature, competencies evolve and are highly influenced by workplace change and experiences. Further, competencies align with Yorke's definition of graduate employability, namely "a set of achievements – skills, understandings and personal attributes - that make an individual more likely to secure employment and be successful in their chosen occupations to the benefit of themselves, the workforce, the community and the economy".[9] Competencies for professional practice are thus essential for the development of the current and future nutrition science workforce.[10,11]

Existing Australian nutrition science competencies were published by the NSA in 2006,[1] and were originally adapted from those established by the Nutrition Society of the United Kingdom.[12] Given the changes in expectations of industry, health, community and the tertiary education sector, these competencies are now out of date. The existing competencies do not adequately encompass the NNS recommendations,[2,5] nor do they include many of the emerging skills now required by contemporary nutrition science graduates to meet workplace requirements as described by Yorke.[9] In Australia, a readiness for change in nutrition has seen competency standards developed for entry-level dietitians,[13] and public health nutritionists[14] and nutrition competencies have been developed for medical graduates.[15-17] Revised competencies for the general nutrition science field are needed to encompass the broader focus within nutrition science,[2,5] address nutrition workforce challenges and to direct the education of future nutrition professionals.

Revised competencies will redefine the scope of practice for the nutrition science profession and enable recognition of those who have received an appropriate level of nutrition science training. These competencies will provide minimum requirements for practice, and provides a benchmark and guide existing programmes on inclusion of contemporary nutrition issues or to identify programme gaps. It is also envisaged in the future that these competencies could provide standards for: design and augmentation of curricula; audit of student outcomes; and consistency between programmes of study.

The aim of this paper is to describe the revision of nutrition science competencies necessary to effectively practice in nutrition science. These competencies will guide program design for undergraduate nutrition science degrees and ensure graduates are prepared for the Australian workforce context.

METHODS

In 2014, the Australian Nutrition Trust (ANT) convened a workshop at the 2014 NSA Annual Scientific Meeting inviting all Australian nutrition science degree coordinators to participate in a discussion on course curriculum. The workshop identified the need for updated nutrition competencies in Australia. A national Working Party was established consisting of degree leaders and senior academics from six Universities across Australia (University of Canberra, University of South Australia, Edith Cowan University, Deakin University, Curtin University, University of Wollongong) to oversee the process of developing competency statements. Working Party members had an average tertiary education experience of 12 years, covering competency, learning outcome and course development. A Reference Group was also established, which comprised experts with experience in tertiary teaching and learning development, translation of education to workforce practice and nutrition workforce development, from government, industry and academia to provide advice on the review process.

Study design

An iterative multiple methods approach was undertaken to develop the nutrition science competencies, comprising three stages: Stage 1: Scoping study of existing competencies; Stage 2: Exploratory survey; and Stage 3: Modified Delphi process (completed in two rounds). The methodological framework, as shown in Figure 1, was informed by similar Australian work conducted in the development of dietetic[13,18] and public health nutrition competency standards.[14] Ethics approval was obtained from the University of Canberra Human Research Ethics Committee (HREC –15:255 and 16:136). This study conforms to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000). All participants provided informed consent prior to commencing the online surveys.

For Stage 1, the initial list of nutrition competencies were compiled from existing Australian and international standards including those from the World Public Health Nutrition Association,[19] Association for Nutrition (UK),[12,20] Queensland Health,[21] Dietitians Association of Australia (DAA),[22] Public Health Nutrition,[10,11] Deakin University[23] and NSA.[1] The list was refined by removing duplicate competencies (n=15), those irrelevant to the Australian context for example, reference to non-Australian accreditation, legislative requirements or profession ethics, and those considered outside the scope of an undergraduate nutrition scientist program such as clinical-related practice. This refined competency statement list was the basis of the Stage 2 online survey (Qualtrics LLC Provo, Utah USA), asking stakeholders about their views of the competency criteria. A modified Delphi process[24,25] was utilised for Stage 3 using Qualtrics. Traditionally, the Delphi process allows the interaction of group members through a series of three survey rounds, to provide collective feedback of emerging consensus.[25] Due to the extensive respondent feedback in Round 1, the protocol was modified to integrate the respondent

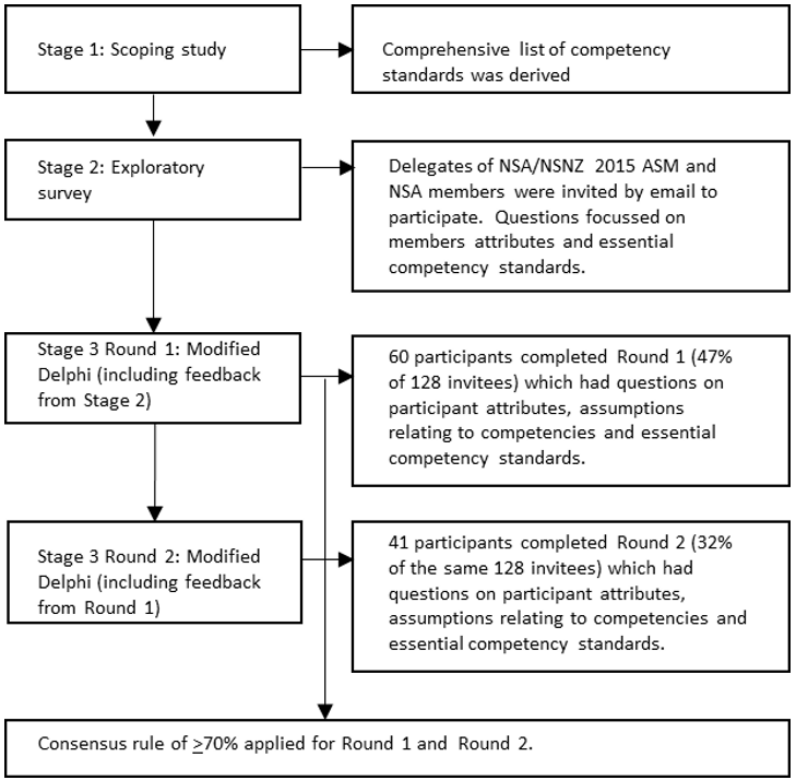

Figure 1. Schematic overview of the study design.

feedback into the competency structure and statements before progressing to the next round. This meant that two survey rounds were conducted and, rather than using the same competency statements in both rounds, statements were modified for Round 2 in response to emerging consensus in respondent feedback. Due to these modifications all participants were invited to comment on the revised competency list in Round 2 and not just those who responded in Round 1.

Study participants

Stage 1 scoping study was conducted by members of the Working Party. For Stage 2, delegates at the 39th NSA 2015 Annual Scientific Meeting (ASM) held in New Zealand (December 2015) (n~297 delegates) were invited to participate in the online survey. A promotional flyer was used at the NSA information stand (n=31 participated). An invitation in the NSA fortnightly newsletter was also extended to all NSA members to complete the online survey (n=1171). The survey remained open between February and March 2016.

In Stage 3, the expert list for the Delphi process was derived through a process of purposive sampling. Individuals were selected based on their role, length of time working in a nutrition-related role, experience in curriculum development and/or level of influence in the nutrition and nutrition science profession, for example academic course directors, industry program managers or community nutritionists/dietitians who are involved in the application of nutrition and recruitment of nutrition science graduates. The expert list comprised 128 nutrition experts from government, industry, community and academia. The Delphi participants were formally invited to participate by email in which they were provided with an online copy of the participant information sheet which explained the project, the diversity of nutrition programs in Australia, the competencies and the need for a revision of the current nutrition science competencies. Participants were also provided with the link to the online survey.

Data collection

The Stage 2 survey was open between December 2015-March 2016 and comprised: a series of demographic questions; open ended questions relating to the need for revised nutrition science competencies; questions about the definitions of a nutritionist and nutrition scientist; as well as asking agreement with 71 competency statements grouped under six core competency areas using a Likert scale (1=Not Important, 3=Neutral, 5=Extremely Important). The Stage 3 (Delphi Rounds 1 and 2) surveys comprised demographic questions and level of agreement with competency statements through the same 5-point Likert scale as used in Round 1. Delphi participants were also given the opportunity to comment on the composition of each competency area. The Round 1 survey was open between February to March 2017, and Round 2 during August 2017.

Data analysis

Data was transferred from Qualtrics (LLC Provo, Utah USA) to Microsoft Excel® for analysis where the proportion of respondents for each competency statement were calculated. A consensus rule was set at ≥70% and was applied in Stages 2 and 3. Consensus for each statement was determined when combined responses for the categories "Important" and "Extremely important" were ≥70%. The consensus rule of ≥70% was chosen as it was: firstly, similar to that applied in the derivation of the dietetic and public health nutrition competency standards;[10,11] and, secondly considered appropriate due to the wide diversity

of nutrition expertise, and the potential bias that could be introduced when individuals' ranked importance of competency items. For example, during Stage 2 (exploratory stage), public health nutritionists were found to rank food science competencies lower compared to competencies with a public health focus, and vice versa. Content analysis was used to analyse the qualitative feedback.

RESULTS

Stage 1: Scoping study

Seventy-one competency statements were generated from existing international and national competencies. These statements were categorised under six core competency areas which reflected the key learning areas within nutrition and those commonly used in the standards audited for this stage of the project:[1,10-12,19-23] Nutrition Science; Food Supply and Production; Research; Sociocultural and Policy; Professional Conduct and Development; and, Nutrition Project Management Skills.

Stage 2: Exploratory survey

Stage 2 was completed by 74 NSA members, however, only 58 of these respondents completed all sections of the survey. Of these, 65% (n=48) worked in the tertiary education sector, 11% (n=8) in the food industry, 11% (n=8) in private practice, 9% (n=7) were employed in various levels of government research and the remainder worked in a variety of other areas. The time spent working in the nutrition industry varied from 1.5 years to over 50 years with an average of 17 years (SD = 10.5). Overall, participants agreed that there was a need to update the current nutrition science competencies (76%, n=56) and that the competencies should comprise a mix of skills, knowledge and attributes of the workforce (95%, n=70), (Table 1). Despite this, only 38% (n=28) of participants agreed and 47% (n=34) were neutral in terms of the current competencies not addressing the skills, knowledge and attributes required for graduates to be competitive in the workforce.

Overall, there was a high level of consensus relating to all of the competencies included in the exploratory survey. In three of the competency areas, all statements achieved ≥70% consensus, namely Nutrition Science (range 77-97%), Food supply and production (75-90%), and Research (81-97%). Within the competency areas Sociocultural and Policy (range 37-88%), Professional Conduct and Development (range 69-93%), and Nutrition Project Management Skills (60-81%) one statement in each did not achieve consensus of ≥70%. These statements were: 'Ability to design / formulate a diet for a specific target group' (67%); 'Inform and influence individuals and communities by using appropriate media, community resources and social marketing techniques' (69%); and 'Ability to acquire project funds' (60%), respectively. The competency statements with a high level of agreement were reviewed in consultation with the Reference Group, and repetitive statements were filtered and removed. The resulting competency areas were refined to six core areas and 36 statements. Each competency area comprised two tiers: Tier 1 (Core Statements), defined as the minimum competencies that graduates from all nutrition science degrees achieve at the completion of the degree; and Tier 2 (Secondary Statements), defined as the competencies that some degrees may include if they had a specific focus area including animal nutrition, public health nutrition or food technology.

Stage 3: Modified Delphi process

In Round 1 of the modified Delphi process, 60 of 128 invited participants completed the survey; response rate of 47% (Table 2). Of these, 68% (n=41) worked in the tertiary education sector, 16% (n=9) in the Government sector (Local, State and National) and 5% (n=3) in Food Industry. In relation to the role of participants within these sectors, 47% (n=28) worked as an academic, 22% (n=13) public health nutritionist, 13% (n=8) a nutrition scientist.

All core statements for each of the six competency areas achieved ≥70% consensus in Round 1 of the Delphi process (n=28/28, Supplementary Table 1). Of those competency areas with Tier 2 (secondary) competency statements, most (n=5/8) were below 70% consensus. Respondents also gave considerable feedback regarding the structure and content of the competency statements. In particular that the separation of the statements in Tier 1 and Tier 2 may not lend themselves to the diversity of nutrition science degrees offered in Australia. A number of comments suggested the competencies include the following topics: genetics; immunology; political science; economic; environmental and social dimensions; food security; food environment; food biotechnology; sustainability; social justice and cultural influences. Furthermore, commentary regarding the large amount of information in

Table 1. Stage 2 - Participant views on need for updated nutrition science competencies

Statement	% important + extremely important	Mean (Likert scale)[†]
There is a need to update the current competency requirements for nutritionists and nutrition scientists (n=74)	76%	4.2
The competencies need to comprise a mix of skills, knowledge and attributes of the diverse nutritionist and nutrition scientist workforce (n=74)	95%	4.5
Updating the competencies requires the input of industry, community and academic sectors (n=74)	91%	4.5
Current competencies do not address the skills, knowledge and attributes required for nutritionist and nutrition science graduates to be competitive in the workforce (n=72)	39%	3.4
There is a need to separate the combined disciplines of nutrition and nutrition science from the other professions (n=74)	50%	3.5

[†]Likert Scale: 1=Not Important, 3=Neutral, 5=Extremely Important.

each statement, and the explicit knowledge required to underpin areas was voiced. Some respondents felt that more emphasis was needed in the statements about practical skills to support theory and an emphasis on the focus on food, dietary patterns and health rather than a reductive approach of nutrients alone.

Based on feedback from participants in Round 1 of Stage 3, content analysis of the comments, and in consultation with the Reference group, the nutrition science competencies were reframed to include five core competency areas which better summarised the key learning areas for an undergraduate nutrition science course (comprising 50 competency statements) and three specialist competency areas (comprising 6, 5 and 18 statements, respectively). The five core competency areas describe core functions and are each underpinned by fundamental knowledge, skills, attitudes and values:

- Nutrition Science;
- Food and the Food System;
- Nutrition Governance and Sociocultural and Behavioural Factors;
- Nutrition Research and Critical Analysis; and,
- Communication and Professional Conduct.

The three specialist areas of competence encompassed focus areas that are included in undergraduate nutrition science degrees, namely:

- Food Science;
- Public Health Nutrition; and,
- Animal Nutrition.

In Round 2 of the Delphi process, 41 of 128 invited participants completed the survey; response rate of 32%. Of these (Table 2), 70% (n=29) worked in the University sector, 7% (n=3) in the Food Industry sector, 7% (n=3) in non-Government organisations and 5% (n=2) in the Government sector (National only). In relation to the role of participants within these sectors, 56% (n=23) were an academic, 10% (n=4) a researcher, 10% (n=4) a dietitian, 5% (n=2) public health nutritionist, 7% (n=3) a nutritionist/nutrition scientist. Four of the five core competency areas achieved ≥70% consensus for all statements (Tables 3a). Core competency area 2-Food and the Food System achieved ≥70% compliance for 8/10 statements. One statement, 'Impact of food technologies, food sustainability and food supply on food security/insecurity levels at the individual, household, community, national and global levels and subsequent influence on health and disease states' was retained in the core competencies despite only achieving 68.6% consensus. This was deemed to be a priority area by the working party and reference group for which to produce future-proof university nutrition graduates. The statement 'New food science technologies and their use, including but not limited to, food biotechnology, food engineering and nutrition quality control' attained 51.4% consensus and with qualitative feedback, deemed a better fit in the Food Science Specialist Competency Area rather than the Core Area. The resulting five Core Competency Areas comprise 49 competency statements.

Both the Food Science and Public Health Nutrition specialist competencies achieved ≥70% consensus for all statements, while 17/18 statements in the Animal Science specialist competency achieved consensus (Table 3b). The statement 'Derivation and use of Least Cost Formulation and an understanding of the parametric formulation programs' attained 65.2% consensus, and was removed from the Animal Science competency list.

DISCUSSION

This study reports on the process undertaken to revise the national competencies for nutrition science in Australia. These competencies reiterate the scope of practice for the nutrition science profession and enable recognition of those who have received an appropriate level of nutrition

Table 2. Demographic information for modified Delphi Rounds 1 and 2 (Stage 3)

	Delphi-Round 1 (%)	Delphi-Round 2 (%)
n	60	41
Response rate	46.8	32.0
Sector		
University	68.3	70.1
Food industry	5.0	7.3
Private practice	1.7	2.4
Local government	1.7	0
State government	3.3	0
Federal government	10.0	4.9
Non-government organisation	3.3	7.7
Not for profit organisation	1.7	0
No response provided	5.0	7.3
Role		
Nutritionist	5.0	4.9
Nutrition scientist	8.3	2.4
Public health nutritionist	21.6	4.9
Dietitian	1.7	9.8
Food scientist	1.7	4.9
Researcher	5.0	9.8
Academic	46.7	56.1
Health manager	1.7	0
Other	3.3	0
Not provide a response	5.0	7.3

Table 3a. Nutrition science core competencies

Competency areas and statements	% consensus[†]
Core competency 1: Nutrition science	
A nutrition science / nutrition degree graduate should be able to demonstrate an understanding, evaluate and/or apply their knowledge in relation to the:	
Biochemistry and physiology of the human body and its functions at the molecular, cellular and whole body levels, in particular the digestive, neuro-endocrine, cardiovascular, haematological, respiratory, musculo-skeletal, reproductive, urinary and immune systems	97.2
Homeostatic and metabolic mechanisms, including acid-base regulation, fluid and electrolyte balances, thermoregulation, hormone balance/control and gaseous exchange	83.3
Metabolic demand for nutrients and consequences of excess and deficiency at the molecular, cellular and whole of body	97.2
Roles of components in foods and drink, including the macro and micronutrients, alcohol, water and non-nutrients in the human body	100.0
Relationships between nutrients, nutrients-food, food-meals, meals-diets, diets-dietary patterns in maintaining health, disease development and treatment/prevention of disease	97.2
Common nutrition related conditions such as, but not limited to: obesity, diabetes, cancers, metabolic diseases, cardiovascular disease, digestive and malabsorption problems	97.2
Variations in nutrient interactions, food, diets and dietary patterns relating to age, gender, physical activity, lifestyle for a variety of population groups (for example non-Indigenous and Indigenous) in health and disease conditions	97.2
Principles of nutrient and dietary analysis, including calculating nutrient content of foods and diets of population groups or individuals, and justifying the choice of methods used	97.2
Principles and methods of measurement of energy balance; energy expenditure, physical activity and fitness; body mass and body composition	94.4
Legislation, regulation, policies and guidelines which underpins the Australian Dietary Guidelines, the Australian Guide to Healthy Eating, the Nutrient Reference Values and other standards	77.8
Application of the principles of the Australian Dietary Guidelines, the Australian Guide to Healthy Eating and the Nutrient Reference Values to the nutrients, food, diets and dietary patterns of individuals and groups of individuals	88.9
Core competency 2: Food and the food system	
A nutrition science / nutrition degree graduate should be able to demonstrate an understanding and apply *foundational* knowledge in relation to the (higher level competency standards under this area are listed under Specialist Competency: Food Science):	
Chemical composition, properties, and reactions of nutrients (macro, micro and non-nutrients) and foods and their effect on:	
- the food supply chain, including food production, preparation, preservation, packaging, transport, consumer usage and wastage	75.8
- fortification and reformulation	82.4
- cooking and storage methods	82.4
- nutritional quality of food	93.9
- food supplements	76.5
- consumer food choice	79.4
- sustainable food production systems, including agricultural systems and technology and farming	70.6
Food commodities including staple foods, processed food, main sources of key nutrients and novel foods within Australia and internationally	82.9
Impact of food technologies on health and disease states, for example, processed food and fortification versus fresh food, normalisation of discretionary foods	74.3
Importance of food safety and food preservation practices for the control of key/common pathogens and spoilage microorganisms in food	77.1
Impact of the environment, climate change and global events on the food supply chain	80.0
Impact of food technologies, food sustainability and food supply on food security/insecurity levels at the individual, household, community, national and global levels and subsequent influence on health and disease states	68.6
Regulation, legislation, policy and standards to ensure nutrition quality and the safety of food across the food supply system nationally and internationally	77.1
General principles and evidence associated with determining the efficacy, health attributes, health claims, safety and legal aspects of foods, drinks and supplements	91.2
Graduates should also be able to demonstrate:	
Basic practical skills relating to food science, chemistry and biochemistry including the wet and dry lab environments	70.0
Core competency 3: Nutrition governance and, sociocultural and behavioural factors	
A nutrition science / nutrition degree graduate should be able to demonstrate an understanding and apply *foundational* knowledge in relation to the:	
Legislation, regulation, policies and guidelines which underpin food, nutrition and health strategic documents at the national and global levels	80.0

[†]≥70% consensus rule was applied to combined Likert Scale responses 4= Important and 5=Extremely Important.

Table 3a. Nutrition science core competencies (cont.)

Competency areas and statements	% consensus†
Core competency 3: Nutrition governance and, sociocultural and behavioural factors continued..	
Historical and current factors, including the social, economic, environmental, institutional and political contexts that influence the food supply, food sustainability and food choices of individuals and populations groups	71.4
Social determinants of health that influence food supply, food sustainability, food choices, dietary patterns, health and well-being of healthy, non-healthy and priority population groups	85.7
Impact of social justice, religion and cultural factors on food, nutrition and health	74.3
Nutrition related health issues for priority population groups, including those which are specific to Aboriginal and Torres Strait Islander population and culturally linguistically diverse groups, at risk of food insecurity, refugees and pregnant women	91.4
Principles and types of interventions to address sociocultural and behavioural factors influencing individual and population group food choices	85.7
Importance of evaluation – from historical and current contexts, nutrition surveillance and interventions - to improve health and well-being status of individuals and populations	88.6
Graduates will also be able to demonstrate:	
Cultural competency, that is, understand, communicate and interact with individuals and population groups across a variety of cultures	94.1
Core competency 4: Nutritional research and critical analysis	
A nutrition science / nutrition degree graduate should be able to demonstrate an understanding and apply *foundational* knowledge to be able to:	
Analyse and interpret the principles and methods of nutrition research in the context of, one or more of the following: nutrition science, food science (wet and dry lab), public health nutrition and clinical studies	97.1
Plan, collect, present, analyse and interpret nutrition data using appropriate qualitative and/or quantitative statistical methods and nutrition status assessment methods, for example: anthropometric data, nutrient composition analysis using nutrient databases, biochemical analysis, and physiological and functional methods	88.6
Critique the strengths and weaknesses of nutrition-related research methods, in order to understand limitations of the scientific basis and rigour of nutritional evidence	97.1
Conduct and interpret basic statistical analysis in terms of nutrition related data	85.7
Interpret epidemiological concepts and data relating to the nutritional status of populations	91.4
Critically evaluate the scientific literature to make academic judgements regarding scientific rigour, methodology, reported outcomes and conduct of nutritional research	97.1
Consider the ethical requirements of undertaking research involving humans and animals when critically analysing the research literature and planning a research project	85.7
Core competency 5: Communication and professional conduct	
A nutrition science / nutrition degree graduate should be able to:	
Communicate scientifically, truthfully and professionally with a range of stakeholders using appropriate resources, techniques and technologies, including social media and social marketing techniques	97.1
Communicate in a culturally sensitive, ethical and honest manner to maintain integrity of the nutrition profession and the individual	97.1
Translate scientific evidence and concepts to simple and safe messages, following legislative requirements for safe practice, that can be understood by a variety of consumer and non-science groups	97.1
Recognise and adhere to relevant (Australian) professional Standards of Ethics (for example Nutrition Society of Australia, Public Health Association of Australia, Australian Institute of Food Science Technology, Dietitians Association of Australia)	91.4
Maintain professional currency, through regular and appropriate engagement in professional development activities	97.1
Recognise own limitations to relevant nutrition profession scope of practice and values and have the foresight to refer to other professionals	91.4
Promote and contribute to reflective practice and an active learning environment	91.4
Identify and act on overt conflicts of interest, for example, the use of inappropriate funding sources	90.9

†≥70% consensus rule was applied to combined Likert Scale responses 4= Important and 5=Extremely Important

science training. The competencies are organised into five core and three specialist competency areas and are applicable to graduates that have undertaken either undergraduate degrees in nutrition science, for example a Bachelor of Nutrition Science or Bachelor of Human Nutrition, as well as those with nutrition majors such as a Bachelor of Science, Bachelor of Health Sciences or Bachelor of Public Health.

The structure of the competencies was based on those given by the World Public Health Nutrition Association,[19] Association for Nutrition (UK),[12,20] and others,[1,10,11,21-23] where related competencies are organised into key competency areas. Each competency area incorporates knowledge-based theoretical foundations along with behavioural practices. The structure was informed by consultation processes with a reference group, as well as engagement with key stakeholders and the final outcomes reflected a high level of consensus by the majority of Delphi survey participants.

These new competencies are more comprehensive than the previous nutrition science competencies used in Australia.[1] Importantly results of the revision process enabled the competencies to better align with contemporary issues raised by the Australian Academy of Science Decadal Plan for Nutrition,[3,4] the United Nations SDGs (2015-2030)[6] and the NNS.[2,5] In particular social and environ-

Table 3b. Nutrition science specialist competencies

Specialist competency areas and statements	% consensus[†]
Specialist competency: Food science	
In addition to the above core competencies, graduates from an undergraduate university nutrition/nutrition science degree with a focus in food science should be able to demonstrate an understanding, evaluate and apply their knowledge in relation to:	
Nutrient and ingredient behaviours under different processing, cooking and storage conditions	90.9
Complexities of sustainable food production (agricultural science and technology), reformulation, production, processing, manufacturing, distribution, fortification and food technology	81.8
Limits on the food supply arising from changes in environmental conditions, global events and political science	84.8
Research and development of new food products	75.0
New food science technologies and their use, including but not limited to, food biotechnology, food engineering and nutrition quality control	65.2 (moved from core)
Graduates will also be able to competently perform:	
Practical skills relating to food science, chemistry and biochemistry including the wet and dry lab environments	87.5
Practical food science skills in the methods such as but not limited to, food reformulation, analysis of food composition, food contaminants, food spoilage	81.3
Specialist competency: Public health nutrition	
In addition to the above core competencies, graduates from an undergraduate university nutrition/nutrition science degree with a focus in public health nutrition should be able to demonstrate an understanding, evaluate and apply their knowledge to a high level in relation to:	
Investigate new and emerging issues relating to health and, food and nutrition in the global, national and local level context	90.9
Use appropriate health, nutrition and behaviour change theories, education and health promotion in order to improve nutrition outcomes for groups that are equitable and sustainable	88.2
Investigate psychological, sociological and political factors that influence food choice in a variety of population groups globally, nationally and locally	84.8
Design a program or project; selecting appropriate methods for monitoring and evaluating effectiveness and efficiency, including delivery of milestones	91.2
Analyse and interpret epidemiological concepts and data relating to: the nutritional status of populations and aetiology of nutritional related disease	100.0
Specialist competency: Animal nutrition	
Graduates from an undergraduate university animal nutrition science/science degree with a focus in animal nutrition should be able to demonstrate an understanding, evaluate and apply their knowledge to a high level in relation to:	
All core competencies listed under Core Standard 4: Nutrition Research and Critical Analysis, and Core Stand ard 5: Communication and Professional Conduct – with an animal nutrition focus, as well as, the:	
Physiology, anatomy and biochemistry of a variety of animal species and their functions at the molecular, cellular and whole body levels	91.7
Feeding behaviour of animal species in relation to season, reproductive status and competition for resources	91.7
Feeding behaviour of animals, throughout the life-course, (specified by course) in relation to nutrient requirements, digestion, natural behaviour and welfare	95.8
Feeding and nutrition disorders of digestion and metabolism in animals	100.0
Nutrient requirements for growth, egg production, lactation, pregnancy, development, maintenance, production and performance (including sport) in a variety of species of animals	95.7
Physiological and pathological effects of deficiencies (and excesses) of specific nutrients and food on a variety of animal species	95.5
Knowledge of feedstuffs and ingredients, their chemical composition, nutritive value, potential anti-nutrients and toxins	91.3
Use of nutrient requirements to design practical feeding solutions for animals (specified by course) to nutritionally support maintenance, production, health and performance	100.0
Impact of animal feeding and management on risks of animal diseases	91.3
Human health risks resulting from animal feeding practices, for example antibiotic resistance	91.3
Effects of different processing techniques on animal products for human consumption on nutrition and health in the human subject	95.7
Legislation relating to the animal feed industry, including feeding standards, and nutritional requirements for a variety of animal species	87.0
Impact of animal farming systems on the environment, in particular energy use, emissions and greenhouse gases	82.6
Relationship between trends in human health and nutrition and the consumption of food of animal origin	91.3
Human behaviour and perception and their influence on feed choice for animals	78.3
Knowledge of complete and balanced nutrition versus supplementation and the impact on feed, performance and life-course of the animal	100.0
Development and application of animal nutrition and feed guidelines for a variety of animal species and groups	87.0

[†]≥70% consensus rule was applied to combined Likert Scale responses 4= Important and 5=Extremely Important

mental concepts are embedded in competency areas 2 and 3, Food and the Food System, and Nutrition Governance and Sociocultural and Behavioural Factors. These competencies include the knowledge and skills required to understand the broad food and nutrition system: that is the food supply system from farm to plate; the agricultural

and environmental context of food and nutrition; and the sociological factors that influence food, nutrition and food choice. These theoretical foundations are absent in the existing NSA competencies. Survey respondents also highlighted a shift in the evidence from specific nutrients and nutrient interactions to the nutrients-food-diets-dietary patterns continuum and the relevant interactions and practice implications. This paradigm is acknowledged throughout the revised competency statements. In addition, survey findings indicated that greater emphasis be placed on professional behaviours of communication and conduct beyond graduation. This result is reflected in Core Competency 5, Communication and Professional conduct whereby higher order values and behaviours are outlined and are underpinned by knowledge-based statements. The underpinning is such that effectiveness in Core Competency 5 can only occur when nutrition scientists and nutritionists demonstrate appropriate knowledge in the other competency areas. For example, Core competency 5.2 'communicate in a culturally sensitive, ethical and honest manner to maintain integrity of the nutrition science profession' depends on proficiency in, for example, knowledge contained in Core Competency 3.3 'social determinants of health that influence food supply, sustainability, dietary patterns, health and well-being of healthy, non-healthy and priority population groups'. Rather than stand alone, these competencies are intended to be relational.

Nutrition science is complex, multi-dimensional and continually evolving,[2,3,5] as are the degrees of study in Australia. Diversity between the university nutrition programs reflects varying strengths that may be driven either by the research or collaborative direction of the Faculty or department. Based on the outcomes of this revision process, it is not expected that the competencies will standardise the flavour of Australian nutrition science courses and reduce diversity. The suggestions to include the specialist competency areas of food science, public health and animal nutrition in addition to the five core competency areas would enable the competencies to be relevant to courses across the spectrum of nutrition science in Australia.

Professional competencies will enable recognition of those who have received an appropriate level of nutrition science training. It is therefore anticipated that results of this project will provide a benchmark against which to map existing university degrees and nutrition majors, in order to augment curricula for enhanced graduate outcomes. The revised competencies also provide an opportunity for benchmarking graduates from different nutrition programs who seek voluntary registration with the NSA.[26] Since nutrition science degrees are not accredited in Australia, it is suggested that use of competencies in nutrition education will enhance credibility in training and skills. These may also help to address the wider problem of public confusion in Australia about the difference between a university trained nutritionist and one who is not. Since the title 'nutritionist' is not legally protected in Australia, a graduate from a nutrition short course may practice as a 'nutritionist' with either a diploma or even certificate level qualification.[1,26,27] These revised nutrition science competencies are intended for those with a minimum of Australian Qualifications Framework (AQF) level 7 nutrition education.[28]

Like those described by the World Public Health Nutrition Association,[19] these nutrition science competencies outline the essential (minimum) requirements for practice. Each of the knowledge and skill statements within the set of competencies is prefixed with a verb to facilitate its use in education, for example, to inform the learning outcomes, program development and content, skills development and assessment of courses of study.[8,29,30] Having descriptive and measurable verbs will enable educators to set assessment tasks to evaluate whether the competency has been met. In the current project assigning these verbs created many challenges as there were conflicting views from survey respondents (Stages 2 and 3) and members of the Working Party. The variation in the expected performance level of learners from an education taxonomy point of view and the linking of essential knowledge statements and higher order practice behaviours and outcomes was considered.[8,31,32] It is the role of universities to assess student's higher order thinking according to the learning outcomes of their particular course. Since different courses would have a different focus, use of the verbs 'demonstrate an understanding and apply' would give guidance to the minimum requirements for nutrition science curricular[4] and to meet the requirements of the AQF.[28,33] It might be suggested that the nutrition science competencies would also serve to complement those of other related professions, such as the outcome based competencies recently published by the DAA.[22] These dietetic competencies are critical as they underlie the professional course accreditation and credentialing of individuals, and in Australia most dietitians train as a nutritionist before their dietetic training.[34]

An important function of competencies is to delineate the scope of practice of a profession. There is widespread acknowledgement that interprofessional teams can be more effective in solving complex nutrition and health problems compared to discrete professions working in silos.[35-37] Interprofessional education is therefore a focus of contemporary health education.[38] Nutrition scientists will feasibly work in cross-disciplinary teams with related scientists or allied health professionals, whose differences in training and expertise can be leveraged to maximise outcomes. Role clarification is critical within interprofessional teams, and the revised nutrition science competencies will better facilitate this.

The strength of this study includes the use of a rigorous iterative multiple methods approach comprising a scoping study of existing competencies, exploratory survey and modified Delphi process. The scoping study considered a wide range of previously published nutrition competencies both nationally and internationally to capture the changing context of nutrition science globally. An advantage of a Delphi process is to obtain anonymous, collective expert opinion via a series of survey rounds,[25] in the case of this study an expert panel of key stakeholders from industry, community, government and academia. The Delphi process usually involves three survey rounds.[25] In the present study the modified approach included two Delphi rounds (Stage 3) as a consensus of ≥70% occurred in the second round in four of the five

core competency areas for all statements, indicating high agreement among the expert panel. The ≥70% consensus threshold is consistent with other similar studies that have developed competencies for Australian nutrition related professions, such as public health nutrition and dietetics.[13,14] One potential limitation may be the lack of diversity in Delphi participants, with the majority coming from the University sector, and a broader range of participants may have provided more divergent views from different perspectives.[25] However, despite the potential oversampling and thus representation from the University sector in Stages 2 and 3, the Delphi process does not state equal representation is required to reduce respondent bias.[25] Even though the lower representation of stakeholders from food industry and private practice was apparent, the representative mix of the Reference group and consultation process ensured competencies for these career paths were addressed. Inclusion and engagement in the Delphi process, as with similar studies,[11,13] was based upon the qualities and expertise of those on the expert panel, particularly in relation to the education and employment of nutrition science graduates.

Conclusion

An iterative, multiple methods approach was used to revise competencies that describe professional expectations of entry level nutrition scientists for effective practice in the Australian workforce. The revised nutrition science competencies will contribute to an enhanced professional identity for nutritionists and nutrition scientists in a changing landscape of allied health professionals and a broadening scope of nutrition-related work. The competencies will guide those setting nutrition science curriculum to ensure that nutrition graduates are adaptive and competitive in the global environment. In addition, it is anticipated that Australian Universities will offer more competitive and world-class nutrition science programs which are student-centred, engaging and innovative and result in increased student enrolments, retention and research capacity.

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AUTHOR DISCLOSURES

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Supplementary table 1. Summary of round 1 modified Delphi results

Core standard	Core statements			Secondary statements		
	N	N achieved ≥70 consensus	Range (%)	N	N achieved ≥70 consensus	Range (%)
1. Nutrition science	8	8	89-100	0	0	0
2. Food chain and food science	5	5	77-88	4	1	56-73
3. Nutrition governance and sociocultural factors	4	4	88-90	3	2	65-90
4. Advocacy, translation of research into practice and communication	3	3	81-92	0	0	0
5. Nutrition research and critical analysis	4	4	94-100	1	0	60
6. Professional conduct and ethical practice	4	4	78-98	0	0	0

N: the number of core statements; N achieved: the number of statements that achieved/complied with consensus rule. The range is shown as percent (%) agreement from the respondents.