

# Nutrition in medical education: a systematic review

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## Summary

**Background** In many countries, doctors are recommended to provide nutrition care to patients to improve the dietary behaviours of individuals and populations. Here, we present a systematic review that aims to critically synthesise literature on nutrition education provided to medical students.

**Methods** In this systematic review, a literature search was done between May 1 and July 1, 2018, for articles on medical students' nutrition knowledge, skills, and confidence to counsel patients, from Nov 1, 2012, to Dec 31, 2018. Search terms related to medical students included "nutrition in medical education", "medical nutrition education", and "undergraduate medical nutrition education". Search terms for topic of interest included "nutrition", "knowledge", "skills", "nutrition counselling", "confidence", "nutrition care", or "nutrition education". Included studies examined any aspect of recently graduated (ie,  $\leq 4$  years) or current medical students' nutrition knowledge, attitudes, skills, or confidence (or all three) in nutrition or nutrition counselling; evaluated nutrition curriculum initiatives for medical students; or assessed recently graduated or current medical students' perceptions of nutrition education. Quality assessment appraisal of the studies was done using a Mixed Methods Appraisal Tool. Curriculum initiatives were also appraised.

**Findings** 66 studies were identified by the search and 24 were eligible for full-text analysis. 16 quantitative studies, three qualitative studies, and five curriculum initiatives from the USA (n=11), Europe (n=4), the Middle East (n=1), Africa (n=1), and Australasia (n=7) met the inclusion criteria. Our analysis of these studies showed that nutrition is insufficiently incorporated into medical education, regardless of country, setting, or year of medical education. Deficits in nutrition education affect students' knowledge, skills, and confidence to implement nutrition care into patient care. A modest positive effect was reported from curriculum initiatives.

**Interpretation** Despite the centrality of nutrition to healthy lifestyle, medical students are not supported to provide high-quality, effective nutrition care. Medical education can be enhanced by institutional commitment to make nutrition education compulsory in medical training, establishment of nutrition competencies to provide a benchmark for nutrition knowledge and skills to be included in curricula, and supported by funding for innovative curriculum initiatives. These initiatives will improve nutrition in medical training to support future doctors for the 21st century.

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## Introduction

Nutrition is well recognised as a central component of a healthy lifestyle.<sup>1</sup> Over the past 50 years, diets low in key nutrients as found in fruit and vegetables and high in salt and fats have contributed to poor dietary intake and growing burden on health care, population health systems, and, increasingly, on Earth system specialists.<sup>2</sup> The prevalence of poor dietary intake has increased throughout the 21st century, and is underscored by inequities in determinants of health within and between countries.<sup>3</sup> Globally, 11 million deaths annually are attributable to dietary factors, placing poor diet ahead of any other risk factor for death in the world.<sup>4</sup> People in almost every region of the world could benefit from improving their diets by increasing their consumption of key nutrients and foods.<sup>4</sup>

One of the key strategies to support healthy eating in populations is to advocate for healthy eating through

health-care services. In many countries, doctors are recommended by their professional bodies to apply nutrition knowledge in practice to support patients to manage lifestyle-related chronic disease and other diet-related conditions<sup>5</sup> for which poor nutrition is a major risk factor.<sup>6</sup> This support is termed nutrition care, defined as any practice done by a health professional to improve the nutrition behaviour and subsequent health of patients.<sup>7</sup> Nutrition care is fundamental in supporting improved dietary behaviours because of its direct relevance to health care and population health systems.<sup>8</sup> Therefore, doctors require adequate nutrition knowledge, skills, and attitudes to support the integration of nutrition care into routine clinical practice.

A well recognised evidence-practice gap exists between the nutrition knowledge, skills, and attitudes needed for nutrition care and the nutrition education provided to medical students. Internationally, inadequate nutrition

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### Research in context

#### Evidence before this study

Nutrition is well recognised as a central component of a healthy lifestyle. One key strategy to support healthy eating in populations is to advocate for healthy eating through health-care services. In many countries, doctors are recommended to apply nutrition knowledge in practice to support patients to manage lifestyle-related chronic disease and other diet-related conditions for which poor nutrition is a major risk factor. Previous literature has established that an evidence-practice gap exists between the nutrition education provided to medical students and the nutrition knowledge, skills, and attitudes needed for doctors to provide effective and efficient nutrition care. Graduating medical students consistently report that they have insufficient nutrition knowledge and skills required to effectively support dietary behaviour change in their patients. We did a systematic review of studies published since 2012, that investigated nutrition education provided to medical students to provide a new way to approach the evidence-practice gap in medical nutrition education. We searched MEDLINE, PubMed, Cumulative Index of Nursing and Allied Health Literature, and Scopus for quantitative and qualitative studies on medical nutrition education provided to students or recent graduates, or both. Studies that included curriculum initiatives in medical nutrition education were also included. The studies included quantitative studies, qualitative studies, and curriculum initiatives from the USA, Europe, the Middle East, Africa, and Australasia.

#### Added value of this study

The studies included in the review showed consistent findings that nutrition is insufficiently incorporated into medical education, regardless of country, setting, or year of medical education. Deficits in nutrition education affected students' knowledge, skills, and confidence to implement nutrition care into routine clinical practice. Curriculum initiatives achieve modest positive effect; however, the sustainability of this effect was not investigated in any study.

#### Implications of all the evidence available

Despite the centrality of nutrition to a healthy lifestyle, medical students are not supported to provide high-quality, effective nutrition care. Deficits in medical students' knowledge, skills, and confidence to counsel patients are likely to continue into medical practice. To ensure graduating medical students are supported throughout their education to provide optimal nutrition care to patients, it is essential that medical education is enhanced by institutional commitment to make nutrition education compulsory in training, nutrition competencies to provide a benchmark for nutrition knowledge, and skills to be included into curricula are established and supported by funding to research and develop innovative curriculum initiatives. These improvements to medical nutrition education will enable doctors to become more effective health professionals who support positive diet and lifestyle behaviours of their patients and of populations.

education, dissatisfaction with the nutrition education received, and feeling unprepared to counsel in nutrition have been themes that have appeared throughout medical nutrition education literature for more than five decades.<sup>9</sup> Graduating medical students have consistently reported that they have insufficient nutrition knowledge and skills to effectively support dietary behaviour change in their patients.<sup>10</sup> Adequate nutrition knowledge is imperative for doctors to work as effective team members to support the nutrition needs of patients.<sup>11</sup> A new way of approaching the evidence-practice gap in medical nutrition education is required to prevent further escalation of the prevalence of poor dietary intake. This systematic review aims to critically synthesise literature on nutrition education provided to medical students. We will identify new insights into how medical nutrition education can be enhanced to ultimately improve dietary behaviours of individuals and populations across the world.<sup>8</sup>

## Methods

### Search strategy and selection criteria

This systematic review critically synthesises literature on nutrition education provided to medical students. The protocol was not registered; however, all applicable items from the PRISMA guidelines for reporting of systematic reviews were included.<sup>12</sup>

A literature search was done between May 1, and July 1, 2018, which included computerised searches, ancestry searching, and journal hand searching to ensure the inclusion of all eligible studies. On April 10, 2019, this same search strategy was repeated to capture any relevant studies published since July 1, 2018. A health librarian assisted with the computer-based search of MEDLINE, PubMed, Cumulative Index of Nursing and Allied Health Literature and Scopus. Medical subject headings were used in the execution of PubMed and MEDLINE searches. Search terms related to medical students included "nutrition in medical education", "medical nutrition education", and "undergraduate medical nutrition education". Search terms for the topic of interest included "nutrition", "knowledge", "skills", "nutrition counselling", "confidence", "nutrition care", or "nutrition education". Google Scholar was used to obtain additional articles identified by journal hand searching. An example of the search strategy for MEDLINE is provided in the appendix.

The search was restricted to studies published since 2012, because the most recent synthesis of literature on medical nutrition education was published in 2012, with the work of the International Heelsum workshop.<sup>13</sup> All empirical, full-text studies published were included if they met any of the following criteria: examined any aspect of recently graduated or current medical students'

See Online for appendix

nutrition knowledge, attitudes, skills, or confidence in nutrition or nutrition counselling; evaluated nutrition curriculum initiatives for medical students; or assessed recently graduated or current medical students' perceptions of nutrition education. For these studies, data on medical students must have been distinguishable from other subjects, such as students from other health disciplines.

One investigator (JC) screened the title and abstracts of the 120 studies identified through the search using the inclusion criteria. Full-text articles were retrieved for all studies that met the inclusion criteria or required more information than was provided in the abstract to inform a decision. Then, two investigators (JC and LB) independently assessed the full-text articles using the inclusion criteria. A third reviewer was not required to reach consensus about studies to be included. The reason for excluding the studies were documented and shown in the figure.

#### Data analysis

All database search results were imported into EndNote. Duplicate entries were removed before screening.

Data were extracted by JC using a table developed by the research team. Data extracted included author, year, country, aim, research design, sample, participants, and relevant findings. Relevant findings were those that related to the inclusion criteria, including students' nutrition knowledge, attitudes, skills, and confidence to provide nutrition care, as well as perceptions of the nutrition education received during medical training. To ensure accuracy, another investigator (LB) cross-checked the extracted data of all included studies using the full-text study.

The methodological quality of each study was assessed by two investigators (JC and LB) using the Mixed Methods Appraisal tool (MMAT), version 2018.<sup>14</sup> The MMAT allows for simultaneous evaluation of all empirical literature (ie, qualitative, quantitative, and mixed methods studies<sup>15</sup>) making it appropriate for this review. This tool has been shown to be efficient (15 min per study), user friendly, and has high intraclass correlation.<sup>16</sup> Agreement was reached on nearly all (>90%) of the appraisal items. Where scores differed, discrepancies were resolved through discussion. Quality score ranged from meeting none of five criteria (zero) to meeting all five criteria (five).

Quantitative and qualitative studies were included in this systematic review and were analysed thematically using metasynthesis, an integrative interpretation of results to offer a novel finding.<sup>17</sup> Data analysis included iterative comparison of studies to cluster recurrent themes and subthemes.<sup>18</sup> Two investigators (JC and LB) analysed the data. Findings of all the studies were independently read and re-read, coded, and organised into categories, which were then compared across studies to identify relationships and themes.<sup>18</sup>

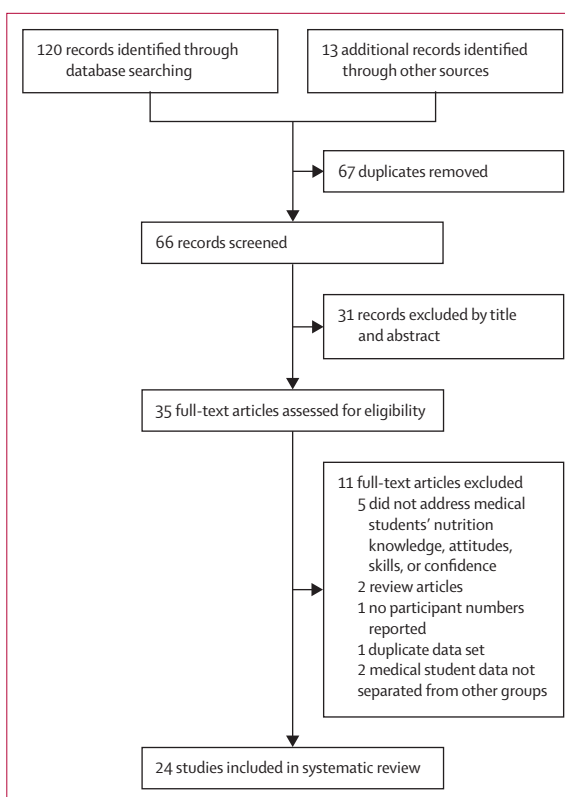


Figure: Study selection process

#### Role of the funding source

No funding was associated with this study. All authors had access to all the data and all authors were responsible for the decision to submit the manuscript.

#### Results

Of the 66 studies originally screened, 35 full-text articles were assessed for eligibility, and 24 were included in the systematic review (figure). The reasons for excluding articles fell within five criteria. The studies encompassed descriptive cross-sectional quantitative surveys ( $n=16$ ),<sup>19–34</sup> qualitative interview studies ( $n=3$ ),<sup>35–37</sup> and evaluations of curriculum initiatives ( $n=5$ ; table).<sup>38–42</sup> Of the 16 quantitative survey studies, eight involved medical students only,<sup>20–22,26–30</sup> three involved recent medical graduates (ie,  $\leq 4$  years),<sup>24,25,32</sup> two involved medical directors only,<sup>31,34</sup> one involved medical students and faculty,<sup>23</sup> and two involved health professional students.<sup>19,33</sup> Participant numbers for the studies ranged widely, from 15 to 3248, and all were between 15 and 1038, with the exception of one larger study ( $n=3248$ ). All studies were published between 2013 and 2018. Studies were done in the USA ( $n=11$ ),<sup>22–25,29,36–38,40–42</sup> Europe ( $n=4$ ),<sup>19,30,31,39</sup> the Middle East ( $n=1$ ),<sup>32</sup> Africa ( $n=1$ ),<sup>35</sup> Asia ( $n=1$ ),<sup>35</sup> Australia ( $n=4$ ),<sup>20,21,26,28</sup> and New Zealand ( $n=2$ ).<sup>27,33</sup> Of the four European studies, one was a Europe-wide study,<sup>31</sup> one was done in Italy,<sup>30</sup> one was from Albania,<sup>19</sup> and one from

	Design and participants	Outcomes assessed	Relevant findings	Quality rating*
<b>Quantitative surveys</b>				
Perlstein et al, 2017; <sup>20</sup> Australia	Surveys of first-year medical students across four consecutive cohorts, 2013–16 (n=555)	Medical students' knowledge of dietary guidelines and self-reported dietary practices	Each year, between 59% and 93% of students correctly identified the recommended daily servings for fruit and between 61% and 84% knew the vegetable recommendations; 40–46% met the guidelines for fruit intake and 12–19% met the guidelines for vegetable intake	2
Schoendorfer et al, 2017; <sup>21</sup> Australia	Survey of first-year to fourth-year medical students (n=928)	Medical students' attitudes towards nutrition, and intention to do nutritional assessment with patients	87% of respondents indicated that "high risk patients should be routinely counselled in nutrition", 70% indicated that "nutrition counselling should be routine practice", and 57% indicated that "routine nutritional assessment and counselling should occur in general practice"; despite overall student support of nutritional counselling (70%) and assessment (86%), students were reluctant to do dietary assessments and only 38% indicated that asking for a food diary or other measure of dietary intake was important	4
Hargrove et al, 2017; <sup>22</sup> USA	Survey of first-year and second-year medical students (n=257)	Medical students' nutrition knowledge and confidence in nutrition	The average nutrition knowledge score was 70%; second-year students (n=118) did better than first-year students (n=139; 74% vs 66%; t=-5.17; p<0.001) and 130 students (51%) scored below the pass rate of 73%; most participants (n=143, 56%) felt comfortable counselling patients on nutrition recommendations, yet only 30 (12%) were aware of the current dietary reference intakes	3
Metcalfe et al, 2017; <sup>23</sup> USA	Surveys of second-year to fourth-year medical students (n=17) and faculty (n=12)	Medical students' familiarity with obesity medicine, and perceptions on current training; faculty's perceptions on important topics to include in curriculum	Medical students' knowledge about basic skills (eg, measuring waist circumference) varied widely; about half of the students did not feel knowledgeable about recommending weight-loss treatments; most students felt it was their role to provide interventions for patients in various categories of overweight or obesity, but did not feel prepared to provide these interventions; faculty-rated patient-centred treatment of weight, bringing up the topic of weight, discussing weight and wellbeing, discussing the relationship between weight and comorbidities, and the doctor's role with overweight or obese patients as topics important to supplement the curriculum	1
Castillo et al, 2017; <sup>24</sup> USA	Survey of fourth-year medical graduates (n=52)	Medical graduates' nutrition knowledge	Graduates answered 52% of questions correctly; most knew the daily recommended number of calories for moderately active females (71%) and males (54%); fewer than 15% knew the recommended percentages for carbohydrate (13%), protein (12%), and fat (8%) in a daily diet	4
Frantz et al, 2016; <sup>25</sup> USA	Survey of recent medical graduates (n=122)	Medical graduates' perceptions on nutrition training received	Few graduates (29%) reported receiving sufficient training in nutrition; on average, graduates who reported being prepared reported a mean of 4 weeks (SD 3.4) of training during medical school, while unprepared interns reported a mean of 2 weeks (2.6) of training (p=0.02); the number of weeks of nutrition training was the only factor associated with perceived preparation (p=0.03)	2
Perlstein et al, 2016; <sup>26</sup> Australia	Survey of first-year to fourth-year medical students (n=197)	Medical students' perceptions of providing nutrition care	Most preclinical students (first to second year) agreed that medical graduates should understand nutritional issues in managing cardiovascular disease (99%), type 2 diabetes (93%), coeliac disease (95%), and renal impairment (97%); students reported limited confidence to show this knowledge (range of confidence 26–41%) for individual conditions; improvement was seen among students in the clinical context (third to fourth year; range 26–81%); few students (third to fourth year) reported knowledge related to medicolegal issues, respiratory disease, nutritional guidelines, and nutritional assessment (each 40%); the majority reported confidence in the dietary management of type 2 diabetes, cardiovascular disease, and coeliac disease, and >60% indicated they would refer onto nutrition professionals	2
Crowley et al, 2015; <sup>27</sup> New Zealand	Survey of fifth-year medical students (n=183)	Medical students' perceptions of providing nutrition care and nutrition training received	Students believed incorporating nutrition care into practice is important, yet were less confident that patients improved their diet after receiving this care; most students (60%) perceived the quantity of nutrition education received to be good or very good, and more (83%) perceived the quality of nutrition education received to be good or very good; students were confident in skills related to nutrition in health and disease but less confident in skills related to general food knowledge; greater quantity and quality of nutrition education was associated with greater self-perceived skills in providing nutrition care to patients, but not with attitudes towards incorporating nutrition care into practice	4
Schoendorfer and Schafer, 2015; <sup>28</sup> Australia	Survey of first-year to fourth-year medical students (n=1037)	Medical students' perceptions of providing nutrition care and blended learning techniques	Less than half of the students (45%) felt they knew enough about nutrition to counsel patients; most students (58%) regularly consulted the internet for information about nutrition and only 163 (16%) used peer-reviewed journals; using clickers, most first-year students (91%) felt that nutrition was important to health care and felt it important in general practice (82%); most students (71%) found using clickers an interesting enhancement and a similar level (70%) noted nutrition content as informative	2
Hyska et al, 2015; <sup>19</sup> Albania	Survey of health professional students (n=347)	Medical and allied health professional students' perceptions of knowledge, attitudes, and practices in public health nutrition	Following assessment of attitudes and practice of public health nutrition in nursing (n=312, 33%), medical (n=280, 27%), pharmacy (n=108, 22%), and dentistry (n=110, 18%) students about one-third of the students were not satisfied with the quality and quantity of nutritional education received; significant gaps were identified in the current curriculum of public health nutrition; medical students perceived that the nutrition teaching curriculum should be more scientifically rigorous	3
Connor et al, 2015; <sup>29</sup> USA	Survey of first-year to fourth-year medical students (n=312)	Medical students' perceptions of competency and use of nutrition resources	Fewer than half of the students (42%) reported that professional nutrition resources were their most commonly used nutrition resources; fewer students (38%) reported using consumer resources, and some students (20%) did not use any nutrition resources; most students (70%) reported feeling competent in their ability to provide basic nutrition education to patients	2

(Table continues on next page)

	Design and participants	Outcomes assessed	Relevant findings	Quality rating*
(Continued from previous page)				
Fiore et al, 2015; <sup>30</sup> Italy	Survey of first-year to sixth-year medical students (n=1038)	Medical students' adherence to the Mediterranean diet	Dietary adherence was reported as poor (21%), average (57%), and good (23%); sex significantly affected adherence scores (female>male; p<0.01); early or late medical school year did not affect results (adjusted OR 0.95; p=0.15)	3
Chung et al, 2014; <sup>31</sup> Europe	Survey of medical education directors at medical schools (n=32)	Number of contact hours for nutrition education	Respondents from ten countries indicated that nutrition education in some form was required in most schools (69%), with an average of 23.68 h provided	2
Gomathi et al, 2014; <sup>32</sup> United Arab Emirates	Survey of medical graduates (n=65)	Medical graduates' perceptions on nutrition training received	Nutrition education was perceived to be very important by the majority of graduates (80%); most (79%) felt that they had not received adequate instruction in nutrition; major areas of deficit included clinical nutrition (45%), nutrition in primary care (40%), and evidence-based nutrition (32%) that did not differ by sex or other groups, such as doctors versus trainee specialists or working within or away from the country of training	1
Crowley et al, 2014; <sup>33</sup> New Zealand	Survey of second-year medical students and medical science students (n=102)	Impact of an undergraduate course on medical students' self-perceived nutrition intake and self-efficacy to improve their own health behaviours and counselling practices	At baseline, medical students described their eating habits to be more healthy than non-medical students (p=0.03); post course, medical students reported a higher frequency of wholegrain food intake (p=0.02); medical students also reported being less comfortable making nutrition recommendations to family and friends post course (p=0.01); most medical students (64%) perceived increased awareness of their own dietary choices, and some (15%) reported an increased likelihood to counsel patients on lifestyle behaviour post course	4
Orimo et al, 2013; <sup>34</sup> Japan	Survey of directors of medical education (n=67)	Number of contact hours for nutrition education	Few medical schools (n=25, 37%) offered dedicated nutrition courses; just over half (n=36, 54%) offered nutrition in other courses; very few schools (n=6, 9%) did not offer any nutrition education; very few schools (n=11, 16%) dedicated more than 5 h to nutrition education	2
<b>Qualitative surveys</b>				
Mogre et al, 2018; <sup>35</sup> Ghana	Qualitative interviews with fifth-year medical students (n=23)	Medical students' perceptions of providing nutrition care	Students felt that doctors have an important role in providing nutrition care to patients; the perceived barriers to nutrition education included personal factors such as the perception that nutrition care is not the responsibility of doctors; interpersonal factors such as poor collaboration with nutrition professionals in medical education; and environmental factors such as lack of faculty to provide nutrition education	4
Cooke et al, 2017; <sup>36</sup> USA	Qualitative interviews with third-year and fourth-year medical students (n=78)	Medical students' perceptions of providing nutrition care for managing childhood obesity	Students requested more training in childhood obesity; students tended to identify others (eg, parents or schools) rather than themselves when asked how childhood obesity should be prevented and treated; students' perceived barriers to childhood obesity prevention and treatment included lack of knowledge, lack of access, and limited time during consultations	4
Danek et al, 2017; <sup>37</sup> USA	Focus groups and qualitative interviews with medical students (n=48), residents (n=14), and doctors (n=10)	Medical students' perceptions on nutrition training received	Students felt nutrition was poorly integrated into the curriculum; they witnessed little nutrition counselling during shadowing experiences and the nutrition information imparted seemed outdated; residents stated they felt ill-prepared to offer nutrition counselling and wanted more education in this area	3
<b>Curriculum initiatives</b>				
Monlezun et al, 2018; <sup>38</sup> USA	Prospective multisite cohort study of students from 20 medical schools, 2012–17 (n=3248)	Medical students' self-reported dietary intake, perceptions on counselling, competencies	Hands-on cooking experience significantly improved students' competencies in patient education (OR 2.14, 95% CI 2.00–2.28; p<0.001), adherence to a Mediterranean-style diet (OR 1.40, 1.07–1.84; p=0.02) and reduced soft drink consumption (OR 0.56, 0.37–0.85; p=0.01) compared with students receiving a traditional medical curriculum	0
Broad and Wallace, 2018; <sup>39</sup> UK	Pilot intervention of a 6-week elective nutrition course for final-year medical students (n=15)	Medical students' confidence in nutrition and relevance to future work	Following the course, students felt more confident about nutrition (paired improvement 0.84, p=0.05) and improved nutrition knowledge (Wilcoxon signed-rank W<0.001); students felt the curriculum was relevant to their future work	0
Jacob et al, 2016; <sup>40</sup> USA	Pilot intervention of a 1-day culinary cooking laboratory for first-year medical students (n=90)	Medical students' perceptions of laboratory experience and confidence in nutrition care	Students found the culinary laboratory provided a feasible educational environment; the experiential, food-based format appeared to stimulate questions central to current nutritional controversies	2

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	Design and participants	Outcomes assessed	Relevant findings	Quality rating*
(Continued from previous page)				
Vargas and Zelis, 2014; <sup>41</sup> USA	Pilot intervention of integrating nutrition into the cardiovascular curriculum for second-year medical students (n=32)	Medical students' self-reported dietary practices	Mean rate your plate nutrition scores at baseline and 1 year later were 57% and 59%, respectively (paired t test p<0.01), indicating students were eating well with respect to heart-healthy choices; in addition to the curriculum impact, students' nutrition-related behaviours and attitudes were positively associated with outcomes	2
Sclair et al, 2012; <sup>42</sup> USA	Evaluation of a 2-h nutrition curriculum intervention for first-year medical students (n=121)	Medical students' reported knowledge, attitudes, and skills in nutrition, and dietary practices	The curriculum intervention significantly improved students' ability to do dietary assessment (2.65 vs 3.05 out of 4; p<0.001) and counselling confidence (1.86 vs 2.22 out of 3; p<0.001), when using a Likert scale	2

OR=odds ratio. \*Quality score ranged from meeting none of five criteria (0) to meeting all criteria (5).

**Table: Description of included studies (n=24), ordered by design and year**

the UK.<sup>39</sup> The study from the Middle East was from the United Arab Emirates (UAE)<sup>32</sup>, the study from Africa was from Ghana, and the Asian study was from Japan.<sup>34</sup>

Each study's design, outcomes and relevant findings are reported in the table. The outcomes assessed in the studies were highly variable.<sup>13</sup> Studies assessed medical students' perceptions about providing nutrition care, including confidence to counsel and attitudes towards nutrition,<sup>20,21,26–29,33,35,36,38–40,42</sup> six assessed medical students' perceptions on nutrition training previously received,<sup>25,28,32,35–37</sup> five assessed medical students' dietary intake,<sup>30,33,38,41</sup> four assessed nutrition knowledge via a test,<sup>22,24,39,41</sup> three assessed self-reported nutrition knowledge,<sup>23,26,28</sup> one reported nutrition knowledge attitudes and practices,<sup>19</sup> and two examined the number of hours dedicated to nutrition during medical training.<sup>31,34</sup>

The methodological quality of studies ranged from very low to high. The most frequent limitations were the absence of control groups (for the curriculum initiatives),<sup>40–42</sup> absence of validated survey instruments,<sup>19,20,22–26,29,39,40,42</sup> poor response rates,<sup>19,27,32,33</sup> small study samples,<sup>23,31,32,33,37</sup> and insufficient representativeness of the study population.<sup>19,23,39,41,42</sup> MMAT scores were lowest for the curriculum initiatives (ranging from zero to two stars). The cross-sectional survey studies were variable, ranging from zero to four stars. The qualitative interview studies were highest quality, ranging from three to four stars.

Nine studies<sup>20–22,26–30</sup> reported on medical students' perceptions of nutrition education in medical training. The studies indicated that the nutrition education received by medical students is insufficient to develop confidence in providing nutrition care. Students perceived that they should understand nutritional issues related to specific conditions and chronic lifestyle diseases<sup>26</sup> and that incorporating nutrition care into practice is important,<sup>27</sup> especially as routine practice among high-risk patients.<sup>21</sup> Students perceived that their nutrition education was inadequate because of their current limited

nutrition knowledge and the ongoing poor integration of nutrition into curricula,<sup>19,36</sup> absence of priority for nutrition education, absence of faculty to provide nutrition education, poor application of nutrition science to clinical practice<sup>35</sup> (such as witnessing little or no nutrition counselling during shadowing experiences),<sup>36,37</sup> absence of scientific rigour in the teaching curriculum,<sup>19</sup> and poor collaboration with nutrition professionals.<sup>35–37</sup> Recent graduates also perceived that nutrition education is vitally important, but they had not received sufficient nutrition education during medical training,<sup>25</sup> especially in the areas of clinical nutrition, nutrition in primary care, and evidence-based nutrition.<sup>43</sup> Medical education directors noted inadequate time devoted to nutrition,<sup>34</sup> and expressed concern over the inadequate amounts of content in nutrition education provided to students.<sup>31</sup> Faculty perceived that supplements to the curriculum were required in prevention and treatment of obesity, including the relationship between diet and wellbeing, patient-centred nutrition counselling, and the role of doctors in providing nutrition care.<sup>23</sup>

Seven studies<sup>19,20,24,26,39,41,42</sup> assessed medical students' knowledge in nutrition at different stages of medical training. The approach to assessment of nutrition knowledge varied among the studies and a lack of validated tools to measure nutrition knowledge was apparent. Nutrition knowledge was investigated via a purposefully developed test in one study of osteopathic medical students with an average nutrition knowledge score of 70%. In this study,<sup>22</sup> second-year students did better than first-year students and half of the students scored below the pass rate. Medical students self-perceived nutrition knowledge improved after inclusion of an interactive nutrition curriculum intervention with self-reports of dietary assessment ability and counselling confidence before and after the intervention.<sup>42</sup> Integrating nutrition into cardiovascular learning activities increased the nutrition knowledge of medical students both before and after the intervention.<sup>41</sup> Similarly, the importance of

developing nutrition knowledge was recognised after assessment of attitude towards nutrition in postgraduate medical students<sup>21</sup> and clinical medical students. By contrast, poor nutrition knowledge affected public health students' understanding of the relationship between diet and long-term health after assessment of attitudes and practice of public health nutrition.<sup>19,28</sup> Poor nutrition knowledge also affected students' awareness of the relationship between diet and long-term health in a study<sup>30</sup> of medical students' adherence to a Mediterranean diet, when the majority of students reported knowing very little about healthy eating and the Mediterranean diet. In this study,<sup>30</sup> results were not affected by early or late medical school year, although women were more likely to have good eating habits than men. Similarly, another study<sup>20</sup> identified the nutrition practices and knowledge of five consecutive cohorts of postgraduate medical students and showed wide variation in nutrition behaviours. In an assessment of recent graduates' perceptions of nutrition education in the undergraduate curriculum, insufficient nutrition knowledge was reported for the topics of clinical nutrition, nutrition in primary care, and evidence-based nutrition, and did not differ by sex or other groups.<sup>32</sup> Insufficient nutrition knowledge also affected students' self-perceived nutrition knowledge and confidence to implement evidence-based nutrition practices in a postgraduate cohort.<sup>26</sup> Insufficient nutrition knowledge affected recent graduates' ability to discuss nutrition with patients,<sup>24</sup> and medical students' self-perceived skills in providing nutrition care.<sup>27</sup> Other studies identified challenges in selecting professional nutrition resources<sup>28</sup> and assessing where medical students obtain their nutrition information.<sup>29</sup> In only one study,<sup>22</sup> low levels of nutrition knowledge was reported as not affecting medical students' confidence to counsel future patients in nutrition.

No study objectively assessed students' competence in nutrition care, but four studies<sup>27,29,33,36</sup> assessed students' confidence to provide nutrition care. Some students felt competent in their ability to provide basic nutrition education<sup>35</sup> and refer to dietary guidelines,<sup>29</sup> yet other students were not confident to counsel patients<sup>33</sup> or that patients would improve their eating behaviours after any provision of nutrition care.<sup>27</sup> Students' confidence in nutrition care increased with progression through their medical training but was limited to a few select diseases.<sup>26</sup> In one study,<sup>36</sup> students rarely recognised their role regarding obesity prevention and treatment, and reported not feeling prepared to provide weight-loss interventions for overweight and obese patients with health-related issues.<sup>23</sup>

Five brief curriculum initiatives were reviewed that all showed modest positive effect.<sup>38–42</sup> A hands on cooking experience compared favourably with a traditional medical school curriculum in terms of student competencies in educating patients, adhering to a Mediterranean diet, believing that nutrition counselling

should be routine clinical practice (odds ratio 2·56, 95% CI 1·95–3·38;  $p=0\cdot001$ ), and improving personal eating behaviours.<sup>38</sup> In another initiative, an elective course in nutrition substantially improved students' confidence about nutrition and nutrition knowledge.<sup>41</sup> Even a very brief nutrition course was shown to improve students' self-reported dietary assessment skills and confidence in nutrition counselling.<sup>42</sup>

## Discussion

This systematic review investigated the nutrition education provided to medical students to gain insight into how nutrition education can be enhanced to meet the needs of future doctors. The reviewed studies showed that nutrition is insufficiently incorporated into medical education, regardless of country, setting, or year of medical education. Collectively, it is clear that despite the centrality of nutrition to healthy lifestyle, graduating medical students are not supported through their education to provide high-quality, effective nutrition care to patients—a situation that has gone on for too long.

The reviewed studies reported that foundation nutrition education provided in medical training should enable graduates to begin conversations with patients and recognise when referral to other health-care professionals is required.<sup>11,44,45</sup> However, medical students reported inadequate nutrition knowledge, whether assessed objectively or subjectively. When nutrition knowledge was assessed in purposely developed tests, half the medical students scored below the school's passing rate,<sup>22</sup> and only half of new medical graduates answered the questions correctly.<sup>24</sup> Other studies have also reported that medical students have inadequate nutrition knowledge.<sup>46,47</sup> The studies included in this review focused on specific aspects of nutrition knowledge and did not assess students' abilities to apply this knowledge. Furthermore, there is no consensus on the required level of nutrition knowledge for medical students,<sup>48</sup> making it challenging to determine the adequacy of this knowledge. Therefore, the required level of nutrition knowledge should be established as a global benchmark for universities.

The reviewed studies consistently showed that medical students want to receive nutrition education to develop their skills in nutrition care. Medical students' perceptions of inadequate nutrition education are consistent with previous literature.<sup>46,49</sup> Medical students do not feel prepared to manage situations in which definitive nutrition therapy has the most potential to affect patient outcomes,<sup>25</sup> and the nutrition knowledge deficits continue into medical practice.<sup>11,49</sup> Medical directors<sup>34</sup> and faculty similarly perceive the nutrition education provided to students as inadequate.<sup>23</sup> Without adequate nutrition education, it is reasonable to assume that doctors are not able to provide the highest quality care to patients. This deficit is relevant to the right to health concept within the *EAT-Lancet* Commission framework, which includes not only access to health care and preventive health measures,

but also addressing emerging social justice, food insecurity, water shortage, and climate change concerns.<sup>50</sup> Further work is required to ensure nutrition education is provided to all medical students in accordance with a global view to nutrition.

Medical students varied in their confidence and perceived competence to provide nutrition care. Lack of confidence to counsel patients in nutrition was reported in several studies,<sup>21,23,26,36,37,39</sup> whereas in two studies<sup>22,29</sup> students reported confidence to counsel patients. As part of understanding both the science and practice related to optimising nutritional status,<sup>44</sup> interventions to improve medical students' health habits and behaviours provide an opportunity to learn the benefits and challenges of adopting or reinforcing health behaviours,<sup>44</sup> and effect on patient counselling practices.<sup>51</sup> Doctors with favourable personal health behaviours are more likely to counsel patients about lifestyle habits than doctors with less favourable lifestyle habits<sup>52</sup> and perceived low self-efficacy in nutrition care.<sup>53</sup> Increasing students' nutrition knowledge and confidence to counsel patients through awareness and appreciation of diet in their personal health status better prepares students to overcome the barriers to consuming a healthy diet that occur in the community,<sup>48</sup> which can then be extended to regional and global levels to address public health nutrition issues.<sup>44</sup> Curriculum initiatives that emphasise medical students' health habits and behaviours are crucial, given that as medical practitioners they will be required to address the increasing prevalence in chronic disease,<sup>45</sup> and can align calls to better standardise learning outcomes of medical education and training.<sup>48</sup> It is paramount that students are supported by learning about their own personal health and diet, and about theory and practice of behaviour change of diet and lifestyles of patients, to improve their ability to apply behaviour change theory as future doctors.<sup>13</sup> The latter includes implementing tools to evaluate performance, such as the Five A's Model (assess, advise, agree, assist, arrange), an analytical framework for behaviour-change counselling designed to facilitate evidence-based, effective patient intervention in a short period of time.<sup>54,55</sup> Such measures are recommended by the US Preventive Services Task Force,<sup>48,56</sup> which can also be used for quality improvement,<sup>54</sup> and the well informed choice of realistic and feasible brief interventions, such as the minimal intervention strategy for overweight and obese adult patients in general practice.<sup>55</sup>

Internationally, advancements in undergraduate curriculum guidelines have occurred in the field of nutrition, following key mandates within countries.<sup>5,57</sup> A range of nutrition curriculum guidelines have been developed that focus on issues of clinical nutrition, undernutrition, and overnutrition across all age groups.<sup>58,59</sup> Others are in statu nascendi: the Dutch Department of Public Health, Well-being and Sports commissioned a report on diet and lifestyle in the medical curriculum,

especially primary care,<sup>60</sup> and the Dutch Organization for Health Research and Development requested a synthesis of knowledge on the important role of diet in the treatment of chronic diseases.<sup>61</sup> However, integration of nutrition into the curriculum is at the discretion of individual medical schools. Factors limiting the integration of nutrition into medical education include curriculum crowding, scarcity of nutrition advocates, and specialist teachers.<sup>45</sup> Previous initiatives to enhance nutrition in medical education focused on approaches to integrate nutrition into medical curricula and modes of delivery,<sup>62</sup> which avoids requirements for increased time within medical curricula. Current recommendations to enhance medical education include emphasis on competency-based curricula, interprofessional and team-based education, information technology-empowered learning, and a shift toward early integration of clinical applications in the basic sciences.<sup>3,48</sup> Enhancements to interprofessional and team-based education recognise the need for doctors and other health professionals to be effective team members<sup>44</sup> and are recognised by organisations such as the American Heart Association.<sup>48</sup> In the context of nutrition education, these reforms highlight movement towards recognising competencies required for effective practice,<sup>48,63</sup> incorporating multidisciplinary teaching approaches to model the contribution of health professionals in addressing nutrition in patient care,<sup>64</sup> including recognising when patients require referral to other health professionals (such as dietitians) for detailed nutritional care and support.<sup>48</sup> Incorporating varied teaching practices to integrate nutrition into existing curriculum with restricted time frames is required,<sup>62</sup> and genuine institutional commitment to providing students with adequate nutrition education.<sup>65</sup> Equally, the importance of medical doctors in a multisectoral approach of preventive nutrition and lifestyle and health promotion needs to be incorporated.<sup>48,66</sup> Students as stakeholders in nutrition education can also provide valuable insights to improve the learning curriculum.<sup>35</sup> Movement towards nutrition competencies has been made in Australia, where a nutrition competencies framework has been developed that includes four nutrition knowledge goals and five nutrition skill goals for medical students.<sup>67</sup> To reinforce medical students' nutrition education, it is imperative that knowledge, attitudes, and practices be comprehensively evaluated, because inadequacies in these areas are known to adversely affect doctors' ability and willingness to perform nutrition counselling,<sup>53</sup> and can align calls to better standardise medical education and training learning outcomes.<sup>48</sup>

It has been previously argued that although doctors have little influence over the myriad structural causes of diet-related disease, a poorly trained medical workforce can be viewed in and of itself as one structural contributor to diet-related disease.<sup>65</sup> Previously, recognition has been given to the need to include education in public health and the environmental determinants of wellbeing, such as diet and



lifestyle, as core elements in medical practice for graduates to deal with these fundamental elements of clinical practice and public health in medical training<sup>68</sup> and have been reiterated in subsequent versions.<sup>5</sup> Therefore, it is of concern that medical students continue to report insufficient nutrition knowledge, skills, and confidence to counsel patients in nutrition.<sup>9,49</sup> There is currently a strong global focus on the need to improve health via better dietary intake, evidenced by the UN Sustainable Development Goals<sup>69</sup> and The Paris Agreement,<sup>70</sup> the *Lancet* Commission on the global syndemic of obesity, malnutrition and climate change,<sup>50</sup> and the EAT-*Lancet* Commission on healthy diets and sustainable food systems.<sup>8</sup> It is therefore time to consider global standards in medical nutrition education to enable doctors to fulfil patients' right to preventive health care. Others endorse the need to make appropriate nutrition training available internationally,<sup>45</sup> to develop professional standards for nutrition education and training, and acknowledge that nutrition education is rarely mandated.<sup>71</sup> The potential for shared learning on advancement in medical nutrition education among countries with comparable tertiary education systems, continuing medical education, language of delivery, and health-care needs of the population suggests that a joint strategic approach to medical nutrition education would promote uniform content and could minimise duplication of effort and resources.<sup>71</sup> Furthermore, alignment of global standards in medical nutrition education and the EAT-*Lancet* Commission would help to address the minimal clear gains in nutrition education made in recent years.

In the reviewed studies, curriculum initiatives showed modest positive effect. Most nutrition initiatives appeared to be opportunistic, rather than reflecting nutrition education integrated throughout medical curricula. Additionally, although many of the studies received poor quality scores, when it comes to survey development there is little consensus on what is necessary, and the development of validated tools is quite prohibitive. The findings of these studies cannot be corroborated without a fundamental shift in the paradigm used. Monlezun and colleagues<sup>72</sup> suggest that generally, previous curriculum interventions are limited by insufficient controls, validated survey instruments, multiyear follow-up, and sample sizes. Evidence-based nutrition education includes using simulations-based medical education with deliberate practice (SBME-DP) and comparative effectiveness research, the latter is important in the USA, related to recommendations for national research funding priorities.<sup>72</sup> Achieving research funding would provide a sound platform for future directions in medical nutrition education. The cooking for optimisation of health initiative links population health with evidence-based nutrition education into training, using SBME-DP, to improve students' eating habits to gain practical nutrition skills, which enable students to see the relevance and application of nutrition care.<sup>38</sup>

To date, use of this model suggests that hands on cooking and nutrition education included in the initiative, which might include use of online resources when nutrition experts are unavailable, can significantly improve students' readiness to enhance patients' health outcomes and provide both short-term and long-term benefits for patients and health systems.<sup>38</sup> Short-term benefits include low-cost nutrition education for patients, which can be taught by medical students to achieve improvements in patient outcomes and reducing health systems costs. Long-term benefits for patients include improvement in quality of care and social equity of health outcomes, and long-term benefits for health systems include strengthening public health and the medical sector's ability to bridge population health measurement with future doctors equipped with culinary skills.<sup>38</sup> Further studies of the long-term outcomes of this initiative on medical students' nutrition knowledge and confidence in nutrition counselling are required, because such measures would help align medical training to the EAT-*Lancet* Commission recommendations for a healthy diet and illustrate how curriculum initiatives can be an integral part of improving students' nutrition knowledge, skills, and confidence to counsel in medical training.

A strength of this systematic review is the wide variety of studies that used a range of methods and objectives to provide a broad overview of nutrition education provided to medical students. The integration of qualitative and quantitative findings can be complex and can introduce bias. Only one investigator screened the title and abstracts of the studies identified through the search; however, two independent researchers screened all full-text articles against the inclusion and exclusion criteria, and a third reviewer was available for discussion if needed for any discrepancies. Data extraction and quality assessment were also done by two investigators to ensure consistency. Although the methodological quality did not influence inclusion or exclusion of studies, the results of the systematic review should be interpreted with caution related to the low quality of some studies. Another strength of this review is that the studies included views of students and medical educators to develop a comprehensive understanding of nutrition in medical training and provide insights into how it could be improved. Future research related to curriculum initiatives could inform planning and design of interventions to improve nutrition education.

This systematic review of medical nutrition education found that despite wanting to receive nutrition education to develop knowledge, skills, and confidence to counsel patients, graduating medical students are not adequately supported to provide high-quality, effective nutrition care to patients. Medical education will be enhanced by institutional commitment to make nutrition education compulsory in training, the establishment of nutrition competencies to guide a benchmark for nutrition knowledge and skills to be included into curricula and

supported by funding for innovative curriculum initiatives. These enhancements are essential to ensure graduating medical students are supported through their education to provide high-quality, effective nutrition care to patients.

#### Contributors

JC did the literature search, review, and extraction. LB contributed to the review and extraction. JC, LB, and GJH made substantial contributions to the conception and design of the review and interpretation of the findings. All authors participated in regular meetings about interpretation studies and Article writing. All authors were involved in the drafting of the Article, and read and approved the final Article. All authors have agreed they are accountable for all aspects of the work.

#### Declaration of interests

We declare no competing interests.

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