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A Systematic Literature Review of Interventions Aimed to Improve Dietary Intake and/or Nutrition Knowledge in Higher Education Students

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Abstract

Background: The importance of a healthy balanced diet throughout life is well-established. The transition to higher education has been associated with poor dietary behaviors. This systematic review aimed to provide the most recent literature on nutrition interventions, focused on improving nutrition education and/or dietary intake in higher education students to help inform future implementation.

Methods: A systematic search was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) guidelines. All studies included an outcome measuring dietary intake and/or nutrition knowledge, were in the English language and published from 2000-2022. Studies were excluded if only qualitative results were reported, weight was the only outcome, or the sample was not solely students. All studies were screened and rated for risk of bias independently by two authors following Cochrane guidelines on quality assessment. Any discrepancies were resolved through discussion with the third author.

Results: Fifty-five studies from thirteen countries, with 14,979 participants met eligibility criteria. Many were of moderate (n=25, 45.5%) or strong quality (n=21, 38.2%). Most reported at least one significant improvement in nutrition knowledge or dietary intake with several studies (n=52, 85.2%) having multiple significant outcomes. Among single interventions, point-of-purchase nutrition information and color-coded indicators in canteens positively influenced dietary intake and awareness of eating a healthful diet. Most studies were educational interventions (n=42, 76.4%) and improved nutrition knowledge and/or dietary intake (n=39, 92.9%).

Conclusion: Third level students are at risk of developing unhealthy dietary behaviors but respond positively to nutrition education and dietary interventions that (i) are underpinned by a theoretical foundation, (ii) are interactive and delivered online, (iii) provide information aimed at improving nutrition knowledge and dietary intake at point-of-purchase settings in higher education environments.

Keywords: Nutrition education, interventions, students, university, higher education, diet

1. BACKGROUND

The importance of following a healthy balanced diet throughout lifeis essential for the prevention of diet related non-communicable diseases.[1] Poor dietary intake and physical inactivity are two main lifestyle factors that increase the risk of developing non-communicable diseases.[2] A poor diet is characterized by a low consumption of fruit and vegetables and a high consumption of salt, saturated fat and trans fatty acids.[3] Research has shown that adherence to dietary guidelines among higher education students is poor and is associated with an increased risk of developing negative physiological long term health effects such as obesity, cardiovascular disease, hypertension and type 2 diabetes.[4-6] It has been estimated that up to 30% of students in higher education are living with over-weight and obesity, with a higher rate among males.[7,8] Factors attributing to this include cost, changes in living arrangements, poor meal planning techniques, unhealthy food options available on site and an increased intake of high energy snacks and fast food.[9,10] There is also reported increases in alcohol consumption and physical inactivity among higher education students.[11] It has been reported that students can gain up to 4kg in the first two years of higher education. [12,13] Barriers to healthy eating among high education students can affect food choices and dietary habits. Hilger et al reported that the two main barriers of healthy eating amongst German higher education students was a lack of time to prepare healthy meals, mainly due to study commitments and lack of healthy foods available in canteens.[14] There is an increasing need for interventions to counteract the effects of poor dietary intake in higher education institutions as eating habits developed during this stage of life can continue into adulthood.[15,16] The higher education environment provides an ideal setting for the implementation of health promoting interventions due to the wide range of health facilities, cost effective resources and qualified health professional staff available to implement and evaluate these interventions.[10] Recently, the Department of Health in Ireland published a national healthy campus charter[17]. While some evidence has stated that nutrition education interventions and strategies to promote healthy eating environments such as cost incentives and point of purchase labels in higher education settings can be successful,[18-22]the most effective way of carrying out these interventions to target dietary intake and nutrition education is not clearly identified.[23] Therefore, the aim of this review is to provide the most recent literature on nutrition interventions, focused on improving nutrition education and/or dietary intake in higher education students. This will provide direction for the future implementation of these programs.

2. METHODS

This systematic review was registered in PROSP-ERO, an International prospective register of systematic reviews, ID:PROSPERO 2020 CRD42020209859: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020209859. This review was conducted following guidelines from the PRISMA 2020 checklist which can be viewed as Supplementary Material 1.

Eligibility criteria

The PICO (Population, Intervention, Comparison, and Outcome)[24] components for this study are outlined in Table 1. Articles that examined the effect of interventions aiming to improve dietary intake and/or nutrition knowledge among a general healthy population of higher education students were included in this review. Studies that included staff were excluded if the student data could not be extracted. Studies that included solely athletic student populations were excluded. Studies published between 2000–2022 and available in the English language were included. All studies included an aim to improve dietary intake and/or nutrition knowledge and an outcome measuring them. Any studies without these outcomes were excluded. Studies that aimed to prevent weight gain but included improving/altering dietary intake or nutrition knowledge as an aim and an outcome measure were included however, studies with weight as the only outcome were excluded. Studies that only included an abstract and did not include a full text were again excluded. Lastly, studies that reported only qualitative results and studies with a sample not solely higher education students were further removed in the search.

Table 1. Population, Intervention, Comparison and Outcomes (PICO)

Population	Students attending higher education.
Intervention	Interventions with the aim of improving dietary intake and/or nutrition knowledge among higher education students.
Comparator	No comparison groups.
Outcome	Changes in dietary patterns by assessing reported food group intake and/or changes in nutrition knowledge from pre to post intervention. Main outcomes will vary as interventions may focus on improving intake and/ or knowledge of different food groups.

Literature search

Thorough searches were carried out in March 2021 and a secondary search was carried out in March 2022 on the following databases: PubMed, Education Resources Information Centre (ERIC), Web of Science and Science Direct. Further searches were also carried out through citations searches and Google scholar. Keywords appropriate to the title used in the search included: "university" OR "college" OR "campus" OR "third level" OR "students" AND "dietary intake" OR "food intake" OR "diet" OR "eating " OR "nutrition knowledge" OR "nutrition education" OR "health promotion" OR "intervention". An example of the search strategy is provided in Supplementary Material 3.

Study selection

A flow diagram which demonstrates the selection process is shown on Figure 1. The search results from each database were recorded and saved. Duplicates were then removed, and articles were screened based on title and abstract. Full texts were then analyzed by two authors (RK, GW) and compared against inclusion and exclusion criteria. Reasons for exclusion were reported and can be viewed in Supplementary Material 2. Any differences observed between the two authors were discussed with a third author (LK). Microsoft Excel 2016, version 16.0 was used to manage paper selection and references.

Data extraction

Once all appropriate articles for this review were retrieved and discussed among all authors, data was extracted from each of the studies and presented in three tables (Tables 2-4). Interventions were divided into single component interventions, multicomponent interventions and educational interventions as classified previously by Mikkelsen and colleagues.[25] Tables 2-4 present study characteristics including: author and year, country, study objective, participant characteristics, study design, description of the intervention, duration, data collection methods, the theoretical foundation present, outcomes, and quality.

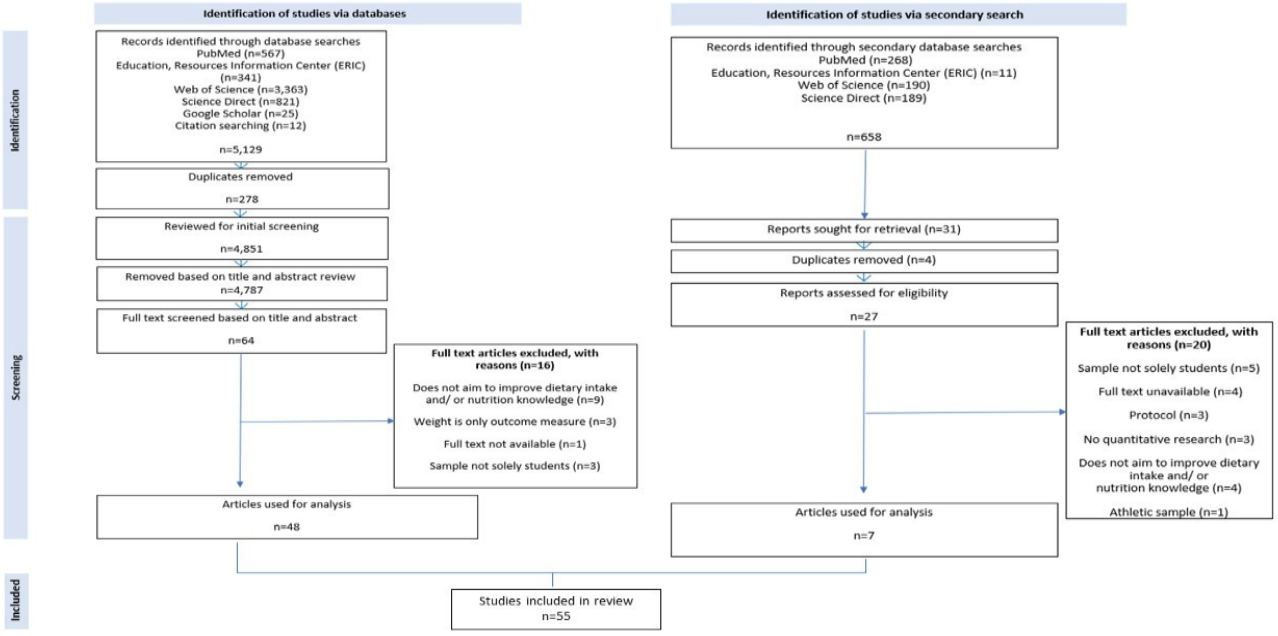

Figure 1. Flow diagram to demonstrate the selection process.

Table 2. Characteristics of single intervention studies.

Author and year	Country	Study Objective	Participants (a) student group (b) age (c) sample size	Study design	Intervention (a) description; (b) duration; (c) data collection methods (d) theoretical foundation	Outcomes	Quality
Rose et al 2018	USA	To determine impact of milk vending machines on milk and calcium intakes.	(a) College students-campus dorms (b) Not stated (c) 124	Pre and post test study	(a) Milk vending machines installed in two campus dorms. (b) 2 months. (c) Sales data from vending machines. Students surveyed about milk and calcium intakes, as well as attitudes regarding milk vending (before and 2 months after installation) (d) a "policies, systems, and environmental" (PSE) change approach - aligns theoretically with socioecological concepts.	Students reported similar milk and calcium intakes before and after the intervention. Mean calcium intakes before vending machine installation were 1,056 mg/day for 18-year-olds and 961 mg/day for those 19 years and older. When comparing these baseline intakes to the respective RDA, 72.9% of those 18 years old and 61.5% of those 19 years and older failed to meet the recommendation.	Weak
Brown et al 2014	USA	To determine the effects of a nutrition information intervention on vending machine purchases on a college campus.	(a) College students (b) Not stated (c) Not stated	Nonexperimental pre and post test	(a) Five high use vending machines were selected. Color-coded stickers placed near each item to identify less healthy (red), moderately healthy (yellow), and healthier (green) snack items. (b) 2 weeks. (c) Sales data from vending machines (baseline and 2 weeks). (d) No	There was a decrease in the sale of red-stickered items of 113 (4.84%), as well as a decrease of 47(15.21%) yellow-stickered items from baseline to after the intervention. There was an increase in the sale of green-stickered items of 235 (50.76%) from baseline to after the intervention.	Weak
Peterson et al 2010	USA	To determine the effects of a 3-week, multi-faceted, point-of-selection intervention on college students' perceptions and selection of 10 targeted healthful foods in a	(a) University students (b) 18-23 years (c) 458	Pre and post test	(a) Healthy choice indicators, large signs, table tents, flyers and colorful photographs with "benefit-based messages" promoting 10 targeted healthy foods were used. "The Right Stuff" was the featured slogan of targeted foods. (b) 3 weeks. (c) A survey (pre and post intervention) evaluated student's	Participants reported that healthful choices were clearly identified in the dining hall after the intervention. Increased self-reported intake for cottage cheese and low-fat salad dressing and a trend towards increased consumption of fresh fruit. Increased awareness was the top	Moderate

		university dining hall and changes in their self-reported overall eating behaviors.			perceptions of availability of healthful foods in the targeted dining hall while also inquiring about their weekly dining frequency. A short food frequency questionnaire assessed student's self-reported intake of the 10 targeted healthful foods that were available in the dining hall at lunch and dinner every day. (d) No.	reason for self-reported change in overall eating behaviors.	
McClain et al 2013	USA	To evaluate the effectiveness of a dining hall-based intervention developed using Iterative Design Process (IDP) on college students' eating behavior and values.	(a) College students (b) Not stated (c) Not stated	Randomized study	(a) The IDP process involved (i) idea generation, (ii) developing prototypes, (iii) receiving user feedback on the prototypes, and (iv) repeating the process until each component is believed to be functioning as designed based on user feedback. (b) 4 weeks. (c) Dietary intake was assessed with items adapted from the Harvard Food Frequency Questionnaire. (d) No.	Students in the intervention dining halls consumed significantly less junk food and high-fat meat and increased their perceived importance of eating a healthful diet relative to the control group.	Moderate
Freedman et al 2010	USA	To deter-mine whether the "Eat Smart" program affected food-purchasing habits of college students shopping at an on-campus convenience store.	(a) University students (b) Not stated	Quasi experimental	(a) Items in the cereal, soup, cracker, and bread categories were labelled as healthful using a "Fuel Your Life" shelf tag. In each of the four food categories, nontagged foods were available at the identical price as tagged items. (b) 5 weeks. (c) Sales data of foods in the cereal, soup, cracker, and bread categories were collected for 6 weeks and compared to baseline. (d) No.	Increased sales of tagged items in the cereal, soup, and cracker categories, while sales of bread decreased.	Moderate
Christoph et al 2016	USA	To investigate the influence of label placement on label awareness and use,	(a) University students	Cross-sectional	(a) Nutrition labels were placed on sneeze guards in two dining halls and directly in front of food in two comparator dining halls.	Nutrition label awareness and use did not vary by label placement or over time.	Strong

		including influences over time. To identify predictors of awareness and use, preferred label information, and reasons for label non-use.	(b) aged over 18 years (c) 2729		(b) Not clear. (c) Label awareness use and reasons for non-use were assessed by questionnaire. (d) No.		
Buscher et al 2001	Canada	To examine the effects of a point-of-purchase (POP) intervention emphasizing various properties of healthful food items on college students' snack purchases.	(a) University students (b) Not stated (c) 72	Prospective	(a) POP messages were placed on an 11 x 17-in poster located at the cafeteria entrance, and two 4 x 2.5-in signs placed next to the targeted food items (vegetables, fruit, pretzels, yogurt). Messages emphasized the Budget-friendly, Energizing, Sensory/taste, Time efficient/convenient (BEST) stimulus properties of food. (b) 4-week intervention. (c) Food sales data. (d) No.	Daily sales of targeted food items increased (fruit, vegetables, pretzels and yogurt).	Moderate
Gerend 2009	USA	To evaluate the effects of calorie information on college students' fast-food choices.	(a) Introductory psychology students (b) 17-25 years (c) 288	Randomized controlled trial	(a) Participants made food choices for three different scenarios. Scenario order was counterbalanced across participants. Some participants were randomly assigned to receive menus that listed number of calories per item, whereas others received menus containing no calorie information. Menus included typical fast-food items: sandwiches, French fries, chicken strips and nuggets, dipping sauces, salads, salad dressings, desserts, shakes, and beverages. (b) A single occasion (c) Participants made food choices in a scenario setting. (d) No.	Women chose lower calorie meals, lower calorie items, and lower priced meals when calorie information was provided than when it was not. Men's selections were unaffected. Providing calorie information at point of purchase could have positive implications for public health.	Moderate

Reed et al 2011	USA	To determine the impact of ‘‘point of decision’’ messages on fruit selection in a single dining hall setting.	(a) Undergraduate students (b) Not stated (c) 278	Pre and post test	(a) Point of decision messages were compiled into a 35-slide PowerPoint presentation. Messages were displayed on a computer screen at a ‘‘point of decision’’ between the cookie and fruit stations during lunch. (b) 9 days. (c) Total fruit and cookie counts were recorded daily after lunch by the dining hall staff. A random weighted sample of students was selected to participate in an online survey 1 week following the intervention to identify perceptions of the ‘‘point of decision’’ messages. (d) No.	A significant mean increase in daily fruit consumption was found following the slide presentation.	Moderate
van den Bogerd et al 2020	The Netherlands	To investigate the effects of providing free fruit and snack vegetables at a university on students’ fruit intake, snack vegetable intake and total vegetable intake.	(a) University students attending agrifood and environmental subject courses (b) 17-28 years (c) 453	Pre and post test	(a) Free fruit and raw snack vegetables were provided in a stand in the form of a miniature wooden house located in the central hall of the university’s main building. Three interventions tested with a pre-test/post-test design were performed. In these three interventions, small changes to the appearance of the stand were made. (b) 3 weeks. (c) Demographic characteristics and fruit and vegetable intakes were assessed with questionnaires. (d) No.	Post-test snack vegetable intake was consistently higher compared with pre-test. No differences in fruit intake or total vegetable intake were found. Subgroup analyses showed that, in all three interventions, students with the lowest pre-test fruit intake and total vegetable intake reported the largest increase in fruit intake and snack vegetable intake after the interventions.	Strong
Guichard et al 2021	France	To test the robustness of the positive impact of a social-norm intervention on vegetable purchase	(a) Students purchasing a meal from one of two on campus canteens (b) N/A	A cluster randomized controlled intervention	(a) Two canteens were randomly selected to display either a vegetable-related or a neutral-behavior norm message. After a first period of data collection, the displays were reversed for a second period: The number of vegetable	Vegetable- related norm message led to a sustained probability of choosing vegetables, contrary to a decrease observed in the control condition. Moreover, students who ordered vegetables ordered a higher quantity when exposed to a	Moderate

		in a field study in university canteens. To investigate whether a norm-based message can induce both a greater selection of vegetables and a larger number of vegetables purchased.	(c) Simulated 500 data sets		portions on the main plate were recorded before, during and after the message display. The second contribution was to test the impact of a message describing vegetables as the normative choice beyond the mere selection of vegetables, on the quantity of vegetables purchased in lunches containing some b) Data was collected during three days for 3 consecutive weeks corresponding to three stages. c)Estimated portions of vegetables (d) No.	vegetable-related message than before whereas quantity declined in the control condition.	

Table 3. Characteristics of educational intervention studies.

Author and year	Country	Study Objective	Participants (a) student group (b)age (c) sample size	Study design	Intervention (a) description; (b) duration; (c) data collection methods (d) theoretical foundation	Outcomes	Quality
Scourboutakos et al 2017	Canada	To test the effect of a nutrition intervention that included education and 2 labelling components on students' food choices.	(a) University students (b) 18-23 years (c) Approximately 368-510	Repeat cross-sectional	(a) A nutrition education interventio n and two labelling components to influence dietary behavior by increasing fruit and vegetable intake, water intake and reduce sugar sweetened beverage. (b) 7 months. (c) Food service inventory data + direct observational data collection. (d) No.	There was a significant decrease in the proportion of students selecting a sugar-sweetened beverage before vs after the intervention. There was an increase in students choosing water. There was a significant increase in students who took fruit after the intervention. The number of students visiting the vegetable bar significantly increased.	Weak
Greene et al 2012	USA	To identify the impact of an online nutrition and physical activity program for college students.	a) University students b) 18 to 24 (c) 1,347 completed, 1,126 completed 15-month follow-up	RCT	a) A 10-lesson curriculum was conducted, focusing on healthful eating and physical activity, stressing nondieting principles such as size acceptance and eating competence. Measurements included anthropometrics, cardiorespiratory fitness, fruit/vegetable (FV) intake, eating competence, physical activity, and psychosocial stress pre and post intervention. b) 10-weeks.	A 10-week online nutrition and physical activity intervention to encourage competence in making healthful food and eating decisions had a positive, lasting effect on fruit and vegetable intake. Weight and stress increased. Fitness levels decreased.	Very strong

					c) Two Item Screener and The National Cancer Institute (NCI) Fruit and Vegetable Screener. (d) No.		
Poddar et al 2012	USA	To improve social support, self-efficacy, outcome expectations, self-regulation, and behavior related to dairy intake in college students.	(a) Students from two health-related classes (Personal Health and Drug Education) (b) Not stated (c) 179	Randomized nutrition education intervention	(a) Participants in the intervention group and comparison group received an 8-week dairy intake or stress management intervention, respectively, via electronic mail. (b) 8 weeks. (c) 7-day food records and questionnaires with information that addressed SCT constructs. (d) Social Cognitive Theory.	Participants in the intervention group reported higher intake of total dairy foods and improved use of self-regulation strategies for consuming three servings per day of total dairy and low-fat dairy foods.	Moderate
Vijayapushpam et al 2009	India	To assess the impact of a classroom-based nutrition and health education intervention among student community volunteers in improving their knowledge on individual topics.	(a) Undergraduate volunteers belonging to various streams of study in Arts (Humanities & Social Sciences), Commerce and Science (b) Not stated (c) 687	Prospective follow-up study	(a) The educational intervention consisted of six 45 min to 1-hour lectures spread over a week. Topics include energy, fats, proteins and micronutrients, nutrition during adolescence, nutrition during pregnancy and obesity. (b) 1 week. (c) A knowledge assessment questionnaire to assess socio-economic characteristics, nutrition, and health related knowledge levels. (d) No.	A significant improvement in nutrition & health knowledge scores of student volunteers after the education intervention.	Weak
Brown et al 2014	USA	To evaluate the acceptance and effectiveness of repetitive nutrition-related text messages on	(a) Undergraduate non–health major students with a texting mobile phone	Pre and post test	(a) The intervention group received biweekly text messages of the My-Plate icon and the United States Department of Agriculture's	Greater MyPlate food group recognition, improved knowledge of dietary guidelines, increased fruit	Weak

		college students' nutrition knowledge and fruit and vegetable consumption.	(b) 18–24 years (c) 116		Dietary Guidelines. The control group received the same information in a mailed brochure. (b) 7 weeks. (c) An online survey to assess knowledge and behavior. (d) No.	consumption and a trend towards increased vegetable consumption.	
Arts et al 2016	USA	To improve wholegrain intake and coronary heart disease risk factors through an intervention in campus dining halls and to evaluate the impact of text messaging on diet and coronary heart disease risk factors.	(a) University students (b) 18-24 years (c) 63	Prospective	(a) The 6-week intervention consisted of wholegrain and low-fat dairy messages (written and verbal) in campus dining halls and text messages to a subsample. (b) 6-weeks. (c) The National Health and Nutrition Examination Survey 2009 to 2010 National Cancer Institute Dietary Screener Questionnaire was used to assess intake of fruits and vegetables, dairy/calcium, wholegrains/fibre, added sugars, red meat, and processed meat. Purchasing records from dining services. 24-hr Dietary recalls. Finger sticks to assess blood lipid and glucose concentrations. Waist circumference. blood pressure using an automatic monitor. (d) No.	Wholegrain consumption increased in general sample. There was no increase in the subsample group for whole grain intake and dairy intake.	Moderate
McMullen et al 2017	USA	To evaluate the impact of a campus-based culinary nutrition education program on attitudes, behaviors, and knowledge around health y eating/cooking.	(a) students from three Living Learning Programs (LLPs). LLPs are defined as programs where undergraduate	Quasi-experimental	(a) Campus-based culinary nutrition education program, encompassing nutrition education and cooking. Four 2-hour sessions were held weekly over the course of one month for each intervention group. Sessions	The intervention group improved self-efficacy for cooking skills and techniques, increased self-efficacy for intake of fruit and vegetable but no significant differences between the	Weak

			college students with similar interests and/or academic majors live together within a residence hall, participating in academic and/or social programming. (b) Not stated (c) 32		led by the researcher and aided by a university-employed dietician/health educator, as well as an undergraduate dietetic student. Each session began with a thirty-minute nutrition education session, followed by a demonstration of skills required to make the recipes. The skills portion of each session lasted approximately 75 minutes. This was followed by "Breaking Bread," during which all participants and instructors ate together. (b) 4 weeks. (c) Demographic questionnaire and a survey to gauge participants' cooking and eating knowledge, attitudes, and behaviors. (d) Social Cognitive Theory.	intervention and control group. Significant increase in mean scores for self-efficacy for use of fruit and vegetable and seasoning in cooking between groups favoring the intervention group.	
Quintiliani and Whitley 2016	USA	To examine the feasibility of a nutrition and physical activity behavioral intervention among non-traditional undergraduate college students at a large urban public university.	(a) University students (b) Not stated (c) 60	Randomized controlled trial	(a) participants received either (i) a brief tailored feedback report and 3 motivational interviewing-based calls from trained peer counsellors or (ii) the report only (presenting their baseline levels of diet and physical activity behaviors, recommended levels of these behaviors, and brief bulleted tips and links to health-related websites). (b) 8 weeks. (c) Questionnaire to assess socio-demographics and financial considerations.	The intervention group reported a decrease in SSBs and fast-food visits, an increase in fruit and veg. The control group had a non-statistical increase in PA compared with the intervention group. There was a non-significant but minor difference in psychosocial variables between groups, favoring the intervention group.	Moderate

					Fruit and vegetable intake via the 7-item Block Food Screener. Sugary drink intake via the 7-item Beverage Questionnaire. Fast food intake via a 1-item question: "In the past 7 days how many times did you eat fast food? The Behavioral Risk Factor Surveillance Survey assessing frequency and duration of moderate and vigorous physical activities. Perceptions of the counselling calls were assessed by survey. (d) Social Contextual Model.		
Whatnall et al 2019	Australia	To assess the feasibility and preliminary efficacy of the EATS (Eating Advice to Students) brief web-based nutrition intervention.	(a) University students (b) 17–35 years (c) 124	Randomized controlled trial	(a) The components of the EATS intervention included (1) a brief screening quiz providing personalized feedback on eating behaviors and barriers to healthy eating; (2) provision of information, tips, and strategies for each target behavior and two guided exercises to facilitate behavior change; (3) goalsetting; and (4) creating strategies. The website included links to other reputable sources. (b) 3 months. (c) Program acceptability was assessed by a process evaluation survey and website usage was objectively tracked. A Food Frequency Questionnaire was used to assess changes in diet quality, fruit,	The intervention group significantly decreased the % energy per day from discretionary foods compared with control group.	Strong

					vegetables, discretionary foods and breakfast intake. (d) The PRECEDE-PROCEED participatory research mode. Draws on social cognitive theory and the theory of planned behavior.		
Brown et al 2014	Canada	To examine the effects of a Healthy Active Living (HAL) community intervention on moderate-to-vigorous physical activity (MVPA), fruit and vegetable consumption, and psychosocial mediators of physical activity.	(a) Undergraduate university students (b) Not stated (c) 60	Prospective	(a) Students were assigned to reside in either the HAL community or no treatment control residence. The HAL community intervention was developed specifically to provide students with systematic exposure to information and develop knowledge related to healthy active lifestyle behaviors upon entry into university. This included structured activities provided periodically throughout the academic year, some of which incorporated specific behavior change techniques. Students in the nontreatment control group participated in standard residence community activities. (b) structured activities provided periodically throughout the academic year (week 1, 4, 6, 8, 20). (c) Demographic questionnaire, Global Physical Activity Questionnaire. Two questions were asked about recent habitual fruit and	Students living in HAL community reported significantly more MVPA and FVC compared with the control group. Participants in HAL also scored significantly higher in action planning, partially mediating the effect of intervention on MVPA.	Moderate

					vegetable consumption. A 7-item inventory was used to measure outcome expectancies. (d) Social Cognitive Theory.		
Pope et al 2019	USA	To evaluate the feasibility of a combined smartwatch and theoretically based, social media delivered health education intervention versus a comparison on improving college students' health behaviors/outcomes.	(a) University students (b) Not stated (c) 38	Two arm, randomized pilot trial	(a) Participants were randomized into: (i) experimental: Polar M400 smartwatch use and twice-weekly social cognitive theory and self-determination theory-based Facebook-delivered health education intervention; or (ii) comparison: enrolment only in separate, but content identical, Facebook intervention. (b) 12 weeks. (c) Survey to assess intervention use/acceptability. Cardiorespiratory Fitness evaluated with the YMCA 3-Minute Step Test. Height, weight and body composition were assessed using a Seca stadiometer and Tanita BC-558 IRONMAN® scale. Psychometrically validated questionnaires assessed SCT-related psychosocial constructs. A six-item questionnaire examined participants' self-efficacy in overcoming certain barriers. Social support was evaluated via a five-item questionnaire. A modified five-item questionnaire assessed participants' enjoyment of health-related behaviors. A	Intervention adherence was high. Participants implemented health education tips 1 - 3 times per week. Both groups increased moderate to vigorous PA at six weeks and partially maintained at 12 weeks. Both groups decreased body weight, increased self-efficacy, social support, and intrinsic motivation at pre - and post - intervention. Small decreases in daily caloric consumption over time were observed. Smartwatch provision may not result in an additional benefit.	Moderate

					14-item questionnaire examined participants' perceived health behavior barriers by asking participants to rate agreement between perceived barriers and hypothetical barriers. Participants' outcome expectancy was assessed via a modified 12-item dichotomous questionnaire. (d) Social Cognitive Theory and Self-Determination Theory-Related health determinants.		
Mackey et al 2015	USA	To evaluate the feasibility and acceptability of an e-mail delivered program to promote nutrition and physical activity in African American college students.	(a) University students (b) 18-20 years (c) 47	RCT	(a) Students received either general health information or the intervention focused on diet and physical activity. (b) 24 weeks. (c) Demographic questionnaire. Weight (Scale-Tronix® digital weight scale) height (Harpenden® wooden stadiometer) and waist circumference taken at the right suprailiac crest were measured. Percent body fat calculated using a BodPod. Dietary intake was assessed with a food frequency questionnaire. Participants wore an Actical accelerometer for an objective measure of volitional physical activity. (d) Social Cognitive Theory.	100% of participants in the intervention group reported changing behaviors vs 86.7% in 86.2% of intervention group reported increased knowledge and 60% of the control group. 72.7% of the control group and 83.3% of the intervention group reported emails to be beneficial in receiving this information.	Moderate

Chughtai et al 2019	Pakistan	To determine changes in nutrition knowledge, attitude, and practices of students after a nutrition education intervention.	(a) University students (b) 20-22 years (c) 153	Pre and post test	(a) Nutrition education lectures on milk consumption were delivered. (b) Eight 30-minute nutrition education lectures were delivered with the interval of one week. (c) KAP (knowledge, attitude and practices) questionnaire and FFQ (food frequency questionnaire). (d) No.	Significant difference in mean score of students' KAP pre to post intervention. No significant differences in the two months following the intervention. Increased consumption of certain milk products pre to post intervention.	Strong
Ohtsuki et al 2018	Japan	To evaluate the effect of an educational intervention to increase vegetable consumption.	(a) University students (b) 18-24 years (c) 104	Randomized controlled trial	(a) Participants were divided into an intervention group and a control group. Intervention group received educational approaches, including a lecture on the nutritional significance of vegetable intake, a tour of an agricultural farm, and learning of cooking skills, focusing on increasing the consumption of vegetables by university students. (b) 25 weeks. (c) Questionnaire to assess lifestyle and health related knowledge. Vegetable intake was assessed using a diet history questionnaire. (d) Social Cognitive Theory.	Vegetable intake in the intervention group was well maintained at the end of the study, whereas the control group was significantly decreased by seasonal change.	Moderate
Yan et al 2014	USA	To examine a peer education program aimed at promoting cultural competence and health behaviors.	(a) University students (b) Not stated (c) 72	Pre and post test	(a) Peer pairs met twice a week (1 hour each time) for tutoring, discussion, counselling, and activities (content included nutrition, physical activity, smoking cessation, stress management, and cultural competence). The domestic	Significant intervention effects were observed for all variables except nutrition knowledge, PA practice and stress management practice. The intervention effects were different between the Americans and the	Moderate

					peers provided one-on-one advice and support, targeting the knowledge, attitudes, and skills necessary to increase and support the health behavior practices noted. (b) 6 weeks. (c) A total of 42 items were included in a survey aimed at measuring the knowledge, attitudes, and practice of those health behaviors previously noted. A separate 27-item questionnaire measured cultural competence. Nutrition knowledge was measured using a 3-item questionnaire. Attitudes toward nutrition were measured using a 3-item scale. To measure dietary practices, participants were asked to report their fruit and vegetable consumption over the past 7 days and how they practiced eating a healthy diet. Knowledge of nutrition labels and nutrition label usage were also measured. Physical activity was assessed using 3 items aimed at examining the participants' knowledge of physical activity, attitudes toward physical activity, and their actual physical activity behavior. Self-reported physical activity was measured using the weekly Leisure Time Exercise	international students on nutrition practice, smoking cessation practice, knowledge of stress management, and cultural concepts and cultural patterns.	

					Questionnaire. The subjects' knowledge of smoking was measured using 3 items about health risks related to smoking and secondhand smoke. Stress management knowledge was measured using 2 items, and stress management practice was measured using a single item. The Cultural Self-Efficacy Scale (CSES)21 was adapted for use in the present study. The modified CSES included 27 items, and those items were grouped into 3 subcategories: knowledge of cultural concepts, cultural patterns for a specific ethnic group, and skills in performing health promotion skills. (d) No.		
Ha et al 2011	USA	To estimate current consumption of wholegrains in college students and determine any increase in wholegrain consumption after the students completed an interactive introductory nutrition course focusing on disease prevention.	(a) University students (b) 18-24 years (c) 80	Pre and post test	(a) The introductory sophomore-level nutrition course consisted of 50-minute sessions 3 times a week. Lectures emphasized the following: increasing consumption of fruit, vegetables, and whole-grain products; encouraging the consumption of low-fat dairy products; discouraging over-reliance on dietary supplements; and promoting active lifestyles. (b) Not clear. (c) Grain and wholegrain consumption, wholegrain food sources, and energy	Wholegrain consumption significantly increased from 0.37oz to 1.16 oz, whereas total grain intake remained the same (3.07 oz). The number of wholegrain food sources increased from 7 to 11 food items after the intervention.	Strong

					intake were measured using a 3-day food diary. (d) Social Cognitive Theory.		
Soederberg Miller et al 2019	USA	To investigate the impact of label-reading training on effort, as well as accuracy and motivation.	(a) University students (b) Not stated (c)80	Prospective	(a) The training consisted of a background tutorial on nutrition followed by three blocks of practice reading labels to decide which of two foods was the relatively better choice. (b) Not clear. (c) Label-reading effort was assessed using an eye tracker and motivation was assessed using a 6-item scale of healthy food-choice empowerment. (d) No.	Students showed increases in label-reading accuracy, decreases in label reading effort, and increases in empowerment.	Moderate
Quartiroli 2012	USA	To develop and pilot a theory-based, computer-tailored feedback system for healthy behaviors at a large, public university, aiming to enhance student wellness.	(a) University students (b) Not stated (c) 62	Quasi experimental design	(a) Participants were randomly assigned into two groups (received either personalized feedback or normative feedback) and completed three surveys. After completion of each of the three surveys, the personalized feedback group received information on a description of their current behaviors and suggestions to develop, improve and/or maintain a healthy lifestyle. (b) 8 weeks. (c) The survey's pool of questions had a total of 80 items across four main sections: Introduction (three questions), Physical Activity Behaviors (twelve	This theory-based, computer-tailored feedback system for healthy behaviors increased the number of people who were in the action and maintenance stages of behavior change but there were no positive changes in alcohol, fruit and vegetable consumption.	Moderate

					questions), Eating Behaviors (fourteen questions), and Drinking Behaviors (twelve questions). The three behavior-specific sections were similar in their structure, while the other sections were alternatively presented during the three administrations of the survey. Five main sections characterized each portion of the survey. Each one of the behavioral sections included: a) descriptive questions (between four and nine items); b) a stage of readiness item (one item), c) a question focusing on intentions to behave (one item), d) barriers (seven -six items), e) perceptions of peer behavior (one –four items), and eventually, if necessary, f) follow up theory of planned behavior related questions (three items). (d) Transtheoretical Model of Change (TTM) and the Theory of Planned Behavior (TPB).		
Khan 2018	Pakistan	To determine the effectiveness of a nutrition education intervention in improving nutritional knowledge and diet quality.	(a) University students (b) 18-24 years (c) 56	Quasi experimental with control group	a) The nutrition education intervention in the experimental group consisted of 44 lessons. Two lessons each lasting 90 minutes were delivered every week. (b) 6 months of nutrition education in the experimental group. (c) Semi quantitative food frequency questionnaire to	Mean knowledge scores in only the intervention group increased significantly between the 3 stages. In the CG, calcium, and vitamin D intake decreased and, in the IG, there was a significant increase in fiber and calcium intake. DQI score of	Moderate

					determine average daily intake of nutrients and total energy of students and were completed before and after the intervention. (d) No.	only the IG increased and post hoc test showed 6 months of NE were required to significantly increase diet quality.	
Mumena et al 2020	Saudi Arabia	To evaluate the effectiveness of a nutrition education intervention to limit added sugar intake among undergraduate female students.	(a) Undergraduate female students (b) Not stated (c) 46	Quasi experimental pretest posttest control group	a) Two face-to-face educational sessions and weekly messages providing information about the definition, health consequences of excessive intake, food sources, label reading, and healthy alternatives to foods containing high amounts of added sugar. (b) 8 weeks. (c) Height was measured by a wall mounted measuring tape. Weight was measured using an electronic scale. Dietary intake was determined via two 24-h dietary recalls (d) No.	In the IG, reduction of 58.3% of added sugar intake occurred, and added sugar contributed to 4.95% of the total energy. In the CG, it contributed to 10.7% of total energy.	Moderate
Bernardo et al 2018	Brazil	To determine the effects of the 'Nutrition and Culinary in the Kitchen' (NCK) program in improving students cooking skills and healthy eating.	(a) University students (b) Not stated (c) 76	Quasi experimental pre and post test	a) Five hands-on cooking classes and one food market visit per week (totaling 3 hours). Control group continued their usual activities. (b) 6 weeks. (c) Questionnaire including demographics, Accessibility and Availability of Fruits and Vegetables Index, Cooking Attitude, Cooking Behavior at home, Cooking	There were significant improvements in participants accessibility and availability of fruits and vegetables, cooking attitudes, produce consumption self-efficacy, self-efficacy for using cooking techniques, self-efficacy for using fruits, vegetables, and	Strong

					Behavior away from home, Self-Efficacy for Using Basic Cooking Techniques, Self-Efficacy for Using Fruits, Vegetables, and Seasonings (while cooking), Produce Consumption Self-Efficacy, Knowledge of Cooking Terms and Techniques. (d) No.	seasonings (while cooking) and knowledge of cooking terms and techniques (CTT) but not in their cooking behaviors at home and cooking behaviors out of the home.	
Miskovsky 2012	USA	To evaluate the effect of a web-based nutrition Jeopardy Game on nutrition knowledge and nutrition self-efficacy in college freshmen.	(a) College freshmen (b) 17-19 years c) 23	Randomized controlled trial	(a) A web-based nutrition Jeopardy game: topics included food pyramid, fruits and vegetables, healthy snacks, advertising, exercise and nutrition. Participants were asked to view the game three times over a 2-week period. (b) 2 weeks. (c) The General Nutrition Questionnaire and The General Nutrition Self-Efficacy Questionnaire. (d) The Health Promotion Model (HPM) was the framework used to guide this study.	There were no significant differences between the pre-test and post-test regarding nutrition knowledge or nutrition self - efficacy.	Moderate
Ha et Caine-Bish 2009	USA	To evaluate the effectiveness of implementing nutrition intervention using a general nutrition class to promote consumption of fruits and vegetables in college students	a) University students b) 18-24 years c) 80	Pre and post test	a) Class lectures took place 3 times a week for 50 minutes over a 15-week period in which they discussed topics that addressed overall dietary quality. Various class activities and videotapes were also introduced. Students completed 50-minute interviews at before and after to assess anthropometric	Students significantly increased consumption of total fruit and vegetables as well as fresh fruits and vegetables. Intake of French fries decreased significantly.	Strong

					data and to complete food records . b) 15 weeks. c) 3-day dietary records, food models, household utensils to determine portion size, food labels. (d) Social Cognitive Theory.		
Clifford et al 2009	USA	To determine if a series of 4 x 15-minute, theory-driven cooking programs aimed at college students living off campus improved cooking self-efficacy, knowledge, attitudes, and behaviors regarding fruit and vegetable intake.	a) University students from upper-level non health courses b) Not stated c) 101	Randomized controlled trial	a) The intervention group watched 4 weekly episodes of the cooking show, GoodGrubbin'. The control group watched 4 weekly episodes on sleep disorders. b) 4 weeks. c) Surveys, FFQs and personal factors survey at 3 time points (Pre-test, post-intervention and at 4 months follow-up). (d) Social Cognitive Theory.	There were no significant improvements in knowledge of fruit and vegetable recommendations in the IG compared to CG post intervention and at 4 month follow up. There were no significant changes in fruit and vegetable motivators, barriers, self - efficacy or intake.	Strong
O'Brien and Palfai 2016	USA	To test the efficacy of two e-health intervention approaches for increasing healthy eating behaviors among university students.	a) Student volunteers from an introductory psychology class b) 18-26 years c) 154	Randomized controlled trial	a) Students were randomized to either an assessment only (AO), web-based nutrition intervention only (WBO), or web-intervention with daily text-messaging condition (WBO + M). Personalized feedback, tips and self - regulated approaches for healthy eating were provided after an online assessment. b) 30 days. c) 7-day recalls, questionnaires. Participants completed measures of	Only the web-intervention with daily text messaging intervention significantly increased the likelihood of attaining vegetable consumption standards and increased the frequency of designated healthy food choice options guidelines at follow-up compared to the assessment only condition.	Strong

					vegetable and fruit consumption and frequency of meals with designated healthy food selections at baseline and one-month follow-up. (d) Both web intervention and text messaging content were based on self-regulation and goal systems theory.		
Poddar et al 2010	USA	To improve outcome expectations, self-efficacy, self-regulation, and behavior related to dairy intake in college students using social cognitive theory	a) University students enrolled in a personal health class b) Not Stated c) 271	Randomized controlled trial	a) The intervention was delivered through an independent online course, one topic per week for 5 weeks, and addressed self-efficacy, outcome expectations, and self-regulation related to consumption of dairy foods. For each topic, a variety of information was provided in short, educational "flyers" sent through email. b) 5 weeks. c) 7-day food records, social cognitive theory questionnaire. (d) Social Cognitive Theory.	Participants in the intervention group made greater increases in use of self-regulatory strategies and self-efficacy for consuming three servings/day of dairy products. The intervention group increased self-efficacy for dairy products. No change in total or low-fat dairy intake for IG or comparison group.	Strong
Werch et al 2007	USA	To examine the effects of brief image-based intervention in impacting multiple health behaviors of students in a university health clinic.	a) University students b) Not Stated c) 155	Pre and post test	a) Participants were randomly assigned to one of three treatments as they presented at the clinic: 1) multiple behavior health contract, 2) one-on-one tailored consultation, or 3) combined consultation plus contract intervention. Baseline and one-month post-intervention data were collected using computer-assisted questionnaires. b) Not stated.	Omnibus repeated measures MANOVAs were performed and were significant for drinking behaviors, exercise behaviors, nutrition habits, sleep habits and quality of life with improvements on each of these behaviors across time. No differences were seen over time on alcohol, cigarette and	Strong

					c) The Fitness and Health survey, three self-image scales, body image satisfaction and health behavior coupling beliefs. (d) No.	marijuana consumption measures	
Tas et al 2020	UK	To examine the impact of presenting healthy snack foods on the knowledge of the key recommendations for healthy eating patterns among university students.	a) First year university students b) Not Stated c) 99	Cross-sectional	a) The 4-week intervention included the presentation of healthy snacks and information leaflets to participants. Each week featured a key recommendation of healthy eating that was given in dietary guidelines. b) 1 month. c) Nutrition knowledge questionnaire. (d) No.	Intervention improved knowledge of the theme 'less saturated fat and trans-fat'	Strong
Shahril et al 2013	Malaysia	To evaluate the effectiveness of implementing multimodal nutrition education intervention (NEI) to improve dietary intake among university students.	a) University students b) 18 -24 years c) 380	Cluster randomzied controlled trial	a) Students were randomly selected and assigned into two arms, that is, intervention group (IG) or control group (CG) according to their cluster. The IG received a 10-weekmultimodal intervention using three modes (conventional lecture, brochures, and text messages) while CG did not receive any intervention. Dietary intake was assessed before and after intervention. b) 10 weeks. c) Diet history interview. (d) No.	Participants in IG significantly improved their dietary intake by increasing their energy intake, carbohydrate, calcium, vitamin C and thiamine, fruits and 100% fruit juice, fish, egg, milk, and dairy products while at the same time significantly decreased their processed food intake.	Very Strong
Lachausse 2012	USA	To determine the impact of My	a) University students	Randomized controlled trial	a) Participants were randomly assigned	Compared with the on-campus course and a	Strong

		Student Body (MSB)– Nutrition, an Internet-based obesity prevention program for college students.	b) 18-25 years c) 312		to one of three conditions: MSB-Nutrition program, an on-campus weight management course, and a comparison group. The MSB-Nutrition comprised of four Rate Myself assessments (to provide individual feedback to the user), three information links (Ask the Expert, Student Voices, College News), and four main learning modules (Nutrition 101, Eating on the Run, Weighing In, Fitness). Participants assigned to the online course were instructed to visit the MSB-Nutrition (via a link on a secured Web server) for at least 2 hours per week over a 12-week period. Course participants were asked to complete, print out, and turn in each of the 4 Rate Myself Assessments by the end of the course. Students completed baseline and follow-up surveys regarding their nutrition and physical activity behaviors, self-efficacy, stress, attitudes, and body weight. b) 12 weeks. c) Self – Efficacy to Regulate Exercise Scale, Fruit and Vegetable Self – Efficacy Scale, Exercise Attitudes Scale, Perceived Stress Scale, items from the Centre for Disease Control and Prevention's Youth Risk Behavior Survey	comparison group, the MSB-Nutrition program increased fruit and vegetable consumption, reduced stress, and increased fruit and vegetable self-efficacy but had no significant effect on students' exercise self-efficacy, exercise behavior, or weight loss.	

					(d) No.		
Wang et al 2021	China	To evaluate a social media-based intervention applying the RE-AIM framework to promote healthy eating behaviors.	a) University students b) Not Stated c) 87	Quasi experimental	a) All eligible participants received 21 days of a free, social media-based health promotion program. At the baseline and post intervention, participants completed questionnaires on demographic details, dietary intake estimates, and physical activity (PA) information. Both intervention group and control group downloaded the WeChat app onto their mobile phones and received the weekly offline course of Application of Nutrition and Health Care for eight weeks. Only intervention group subjects were receiving dietary advice, exercise encouragement, healthy habits reminders. b) 8 weeks. c) Questionnaires and surveys. (d) No.	The IG showed significant progress in terms of healthy food intake (all $P< 0.05$), and an improvement in PA level ($P=0.004$) over 21 days. About 60.9% subjects were satisfied with the whole program and 64.4% would like to join the program again.	Strong
Ha et al 2009	USA	To assess soft drink and milk consumption and to evaluate the effectiveness of 15-week class-based nutrition intervention in changing beverage choices among college students.	a) University students b) 18- 24 years c) 80	Pre and post test	a) Class lectures focused on healthful dietary choices related to prevention of chronic diseases and were combined with interactive hands-on activities and dietary feedback. The class met three times per week for 50 minutes per session. Class lectures specifically emphasized 1) the	Intervention was successful in decreasing soft drink consumption. Total milk consumption, specifically fat free milk, increased in females and male students changed milk choice favoring skim milk over low fat milk.	Strong

					importance of nutrition related to prevention of chronic diseases, 2) increasing consumption of fruits, vegetable, and whole grain products, 3) encouraging low fat dairy product consumption, 4) discouraging over reliance on dietary supplements and 5) promoting active lifestyle. b) 15 weeks. c) 3-day food records (d) No.		
Hager et al 2012	USA	To assess a single-semester university general education (GE) health and wellness influence on physical activity (PA) and dietary habits among university students and compare the course delivered through lecture or online for these outcomes.	(a) University students b) Not Stated c) 2971	Pre and post test	a) Participants were required to take a general education health and wellness course either by classroom lecture or online. The lecture and online curriculum content were similar. In addition, students were required to complete a course assessment to enhance student awareness and teach self-assessment techniques. Participation in the study was entirely voluntary and was not connected to course grade. b) 15 weeks. c) Physical activity and dietary outcomes were determined from questions used in the Behavioral Risk Factor Surveillance System survey and were assessed pre- and post-intervention. (d) No.	Students improved overall level of PA by 12%, daily minutes of moderate-intensity PA by 8%, and fitness level by 2%. Students improved fruit/vegetable consumption by 4%, bran/whole grain cereal consumption by 8%, and brown rice/whole bread consumption by 11%. All improvements were statistically significant ($p < .001$) with percent values indicating the size of the effect. The classroom lecture course yielded stronger improvements in several PA and dietary outcomes than the online course.	Strong

Hekler et al 2010	USA	To examine whether an innovative educational course focused on societal-level issues related to food and food production (Food and Society) would promote healthful eating and improve dietary quality among college students.	a) Undergraduate university students b) Not Stated c) 100	Quasi-experimental	a) This study was conducted as a "stealth intervention". Students in the Food and Society course covered topics highlighting environmental, ethical, social justice, political and agricultural issues related to food and food production. b) 2 months. c) Food Frequency Questionnaire (d) No.	The students who took the Food and Society course reported significantly improving their healthful eating, with greatest improvements in increased vegetable and decreased high-fat dairy intakes relative to the comparison group.	Strong
King et al 2013	Germany	To determine whether residency (living on campus versus off campus) was related to the effects of Fit into College on students' health behaviors.	(a) University students b) Trainees: 18-25 years Interns: 21-33 years c) 24	Pre and post test	a) Trainees teamed up with an intern to improve and/or maintain healthy nutrition and physical activity behaviors. Trainees' nutrition and physical activity behaviors and perceptions were quantitatively assessed through surveys at preintervention and postintervention. b) 14 weeks. c) Interns participated in an open – ended focus group interview session. International Physical Activity Questionnaire, Exercise Decisional Balance Scale, twenty-four-hour intake record, Fruit and Vegetable Decisional Balance Scale. (d) No.	Trainees' perceptions of the health benefits of eating fruits and vegetables improved during the intervention. For the trainees' living on campus, the intervention was not effective in increasing the number of fruits and vegetables consumed or the planning for food preparation. The interns perceived that they did not have adequate access to healthy foods, the knowledge or skills to prepare healthy food, or the competency to teach food prep strategies to their trainees. For trainees living on campus, the intervention was more effective in decreasing perceived exercise	Moderate

						barriers than trainees living off campus.	
Brown et Oler 2000	USA	To determine if visually estimating food portions in a display case could improve college students' estimates of portion sizes.	a) University students b) Not Stated c) 380	Quasi experimental	a) Sections were randomly assigned to 3D model, 2D model or the control treatment. Baseline data were collected when all students viewed real foods in a display case in a classroom building on campus. The display included 3 dinners (starchy food, cooked vegetable, salad, milk, and meat). 11 dinners plates were used and varied in sizes of beverage glasses for display. Students estimated the amount of food on a closed – end format assignment page - they received feedback by correcting their own papers in class where the actual amount of food was revealed. b) 6 weeks. c) Student's assignment containing the estimate of the amount of each food in a closed–end format. (d) No.	Modest improvements in portion estimation. The intervention increased awareness of portion sizes in 94% of the sample and 62% reported becoming more aware of their own portion sizes.	Moderate
Franko et al 2008	USA	To assess the effect of MyStudentBody.com-Nutrition on college students.	a) University students b) 18 - 24 years c) 476	Randomized controlled trial	a) Students were randomized into 1) experimental 1 participant were asked to use MSB-N for two web sessions 2) Experimental II participants (Booster) were asked to use MSB-N for two web sessions and a subsequent booster session:	Experimental group participants increased their fruit and vegetable intake relative to the control group at post-test. Both experimental groups improved their motivation to change eating behaviors and	Strong

					and 3) Control participants. The website MSB-N was an internet - based program providing nutrition and PA education to college students and comprised of 1) three information links (ask the expert, student voices, college news) 2) Rate myself assessment and 3) four main topic pages (nutrition 101, Eating on the run, weighing in, fitness) and 4) resources. Students logged onto the site and completed the rate me questionnaires which assessed current dietary intake and patterns as well as PA. b) Not stated. c) Food Frequency Questionnaire, Stages of Dietary and Physical Activity Change, Nutrition Knowledge Test, International Physical Activity Questionnaire, Social Support, Encouragement and Self-efficacy for Dietary Changes and Exercise Benefits and Barriers. (d) No.	were also more likely to increase their social support and self-efficacy for dietary change. Experimental groups also improved their attitude toward exercise but no behavioral changes in physical activity were noted.	
Finckenor et al 2000	USA	To develop and evaluate the long-term effectiveness of an intervention program, based on pre-action-stage-oriented change processes of the	(a)Undergraduate students b) 17-55 years c) 110	Pre and post test	a) Students from an undergraduate introductory nutrition science course were assigned to an experimental, pre-test/post-test control, or post-test-only control group. Daily fat intake and stage of change of	For pre-test and post-test dietary fat intake scores, stage and time were significant, and there was a significant time-by-stage interaction. Time was significant for pre-test	Moderate

		Transtheoretical Model of Behavior Change.			the experimental and pre-test/post-test control groups were determined at the pre-test and post-test and 1-year later at a follow-up test. The experimental group participated in a group-based, dietary fat intake intervention that included a series of 11 lessons taught over a 14-week period. Each lesson was based on 1 or 2 of the pre-action-stage-oriented change processes of the Transtheoretical Model. Data were evaluated to determine the effects of the intervention program on long-term dietary fat reduction and stage of change progression. b) 11 weeks. c) Eating Choices Food Questionnaire, Stage of Changes algorithm for dietary fat reduction. (d) Transtheoretical Model of Behavior Change.	and post-test stage scores. Subjects in the pre-action-stage experimental group significantly increased their mean stage of change and reduced their fat intake between the pre-test and post-test; these changes persisted for 1 year. Pre-test/post-test control group participants who began in a pre-action stage also significantly increased their mean stage and reduced fat intake by the post-test, but these changes did not endure until the follow-up test.	
Brown et al 2011	USA	To assess the effectiveness of the integration of vegetable demonstration videos and tasting experiences into a college nutrition course to influence students' readiness to change vegetable intake, self-efficacy for vegetable preparation, and usual vegetable intake.	(a) University students enrolled in a large general education nutrition course b) Not Stated c) 186	Quasi-experimental	a) Participants viewed online vegetable preparation videos and participated in vegetable tasting experiences that featured four target vegetables. Preintervention and postintervention online surveys determined usual vegetable intake, readiness to change vegetable consumption, and self-efficacy of vegetable preparation. Additional post viewing assessments and post tasting assessments also	Online vegetable demonstration videos may be an effective and cost-efficient intervention for increasing self-efficacy of vegetable preparation and readiness to increase vegetable consumption among college student but did not increase total vegetable consumption.	Strong

					took place including questions about past preference and intake of target vegetable and questions about current purchasing, cooking and eating habits as well as intentions to try the target vegetable in a new recipe in the next month. b) 4 months. c) Online surveys and Food Frequency Questionnaires, stage of readiness to change vegetable consumption. (d) No.		
Schroeter et al 2019	USA	To determine if dietary education, incentivized by financial rewards is effective at improving dietary intake	a) Undergraduate non-nutrition major students (b) 18-24 years c) 57	Pre and post test	(a) The intervention group participated in weekly nutrition education meetings which focused on MyPlate. The respondents' diet quality was determined by their compliance with MyPlate and their Healthy Eating Index's recommendations. (b) 4 weeks (c) Both the control and the intervention groups completed two online surveys that assessed the students' knowledge and dietary behavior pre and post intervention. (d) No.	Students who received education showed the most improvement regarding their knowledge and dietary behavior. These respondents tripled their average per capita consumption of whole grains and increased their fruit and vegetable intakes.	Strong
Bhurosy et al 2020	USA	To determine if counting and goal setting can increase red/orange vegetable intake.	(a) Undergraduate students (b) Aged ≥18 years (c) 165	Pre-post-test experimental	a) Intervention group was asked to count the number of times they ate red/orange vegetables and set a goal to eat 1 more time. b) 3 days.	A mobile method that helped people count their daily red/orange vegetable intake and set a goal appeared to increase consumption.	Moderate

					c) frequency of red/orange vegetable intake based on estimates by independent raters using photographs and descriptions uploaded by participants. (d) Goal Setting Theory.		
Hardan-Khalil et al 2021	USA	To examine the effect of receiving daily motivational text messages on the change in college students' nutritional choices and levels of physical activity.	(a) University students (b) Aged ≥18 years c) 201	Quasi experimental	(a) All participants received a brochure that contained nutritional and physical-activity information. The survey consisted of three parts: demographic information, health and diet, and physical activity. All participants completed a self-administered survey at the beginning and the end of the eight-week study. The experimental group participants received a daily motivational-text message. (b) 8 weeks. (c) Demographic information, health and diet and physical activity were assessed using a survey. (d) No.	There were significant interactions between group and time on most of the health and diet items, but there were no significant interactions on the physical activity items.	Strong

Table 4. Characteristics of multicomponent intervention studies.

Author and year	Country	Study Objective	Participant characteristics (a) student group (b) age (c) sample size	Study design	Intervention (a) description; (b) duration; (c) data collection methods; (d) theoretical Foundation	Outcomes	Quality
Roy et al 2016	Australia	This study assessed the impact of kilojoule (kJ) labelling alone or accompanied by a social marketing campaign on food sales and selection of less energy-dense meals by young adults from a university food outlet.	(a) University students (b) 19-24 years (c) 713	Repeat cross sectional	(a) There were two kJ labelling intervention phases (1) kJ labelling alone (2) kJ labels with marketing materials ("8700 kJ campaign"). (b) 5-week interventions. (c) Food sales of labelled items were tracked during each intervention and five weeks after and compared to sales of foods in the same 10-week period in the previous year. A sub sample of young adults were surveyed during both the interventions to assess awareness, influence, sentiment and anticipated future impact of kJ labels and the social marketing campaign respectively. (d) No.	There were no differences in sales between the KJ labelling with social marketing and the 5 weeks of labelling before and after. The sale of certain foods were lower in the year with menu labelling and social marketing campaign. Only 30% of students were initially aware of the KJ labels on the menu but 75% of students were accepting of KJ labelling after they were made aware. Those viewing the marketing campaign elements and then using KJ values selected lower mean energy content.	Weak
Shive et Morris 2006	USA	To evaluate the effectiveness of the Energize Your Life! social-marketing campaign pilot study to improve knowledge, attitudes, and fruit intake among community college students.	(a) University students (b) Not stated (c)1367	Cross sectional, quasi-experimental	(a) Students were exposed to fruit fairs on campus which distributed fresh fruit, 100% fruit juice, and fruit smoothie samples and information about fruit to students. The authors also addressed policy change to increase the accessibility of fruit on campus. (b) 10 weeks. (c) A survey to measure knowledge, attitudes, and behavior related to fruit intake. (d) No.	There was a significant increase in fruit intake between pre and post-tests at the intervention campus. Although students had positive attitudes towards fruit intake, most did not achieve minimum recommended daily intake of 2 servings of fruit. Approx. 25% of students had insufficient funds which affected intake.	Moderate

Risk of Bias (Quality Assessment)

The quality rating system was modified from the Cochrane guidelines on quality assessment[26] as previously outlined by Mikkelsen et al 2014.[25] The rating scheme assessed the quality of the studies as weak, moderate, strong or very strong. The studies were rated based on the quantity of information, study population, study duration, study design and risk of bias. All studies were rated independently by two authors (RK & GW) and any discrepancies were resolved through discussion with the third author (LK).

3. RESULTS

The initial database search found a total of 5129 results after applying the predefined search strategy. A secondary search in March 2022 found a total of 658 results. After removal of duplicates and review of title and abstract of all papers to determine eligibility, 91 articles remained for full text review. After review, 55 articles remained. The reasons for exclusion of the final 36 papers are outlined in Supplementary Material 2. Figure 1 provides an overview of the screening process.

Interventions

The 55 studies from the literature search were divided into 11 single intervention studies,[27,37] 42educational interventions[38,79] and 2 multicomponent studies.[80,81] The single intervention studies involved the modification of a single factor in the environment in order to promote milk and calcium intake,[27] healthy meal and vending machine purchases[29,31,33,35,37] or increase fruit and vegetable intake,[36] food label[32] and calorie awareness.[34] Educational interventions were carried out online or on campus, either by researchers, student trainees, or lecturers that completed a training program These interventions aimed to increase healthy eating knowledge and portion size awareness,[41,44,48-50,52,55,56,58,59,6165,68,71,74,77,79] food label awareness,[54] healthy cooking skills[44,58] and promote healthy behaviors specifically by aiming to increase intakes of dairy,[40,43,60,63,66] fruit,[28,38,39,61,62,66,67,69,71] vegetables,[28,38,39,45,47,51,61,62,66,67,69,71,76,78] whole grains,[43,53,70] breakfast[46] and reduce intakes of added sugar, fat, salt, alcohol and sugar sweet end beverages.[38,45,46,57,60,64,66,75] Multicomponent interventions included more than one strategy to improve nutrition knowledge or dietary behaviors.[80,81] Tables 2-4 show the characteristics of the studies.

Study characteristics

Thirty-eight studies took place in the United States of America,[7-32,34,35,39,40,42-45,48,49,52-55,59-64,67,69-71,73-79,81] three in Canada[33,38,47] and two in Australia.[46,50,56,80] Brazil,[58] United Kingdom,[65] India,[41] Germany,[72] Malaysia,[66] Japan,[51] Saudi Arabia,[57] France,[37] the Netherlands[36] and China[68] were each the location of one study. Forty-four of the interventions were conducted onsite in the higher education setting of which six were in the campus canteen,[29,30,32,35,37,43] one in a convenience shop[31] and one was a marketing campaign[80].Ten interventions were conducted online.[39,46,49,59,62,63,70,74,76,81] Out of these interventions, one was a marketing campaign.[81] Two interventions were delivered via text messaging.[28,79] One intervention was a mobile health intervention.[78] Six hundred and thirty-six participants from a total of 17,017 participants(3.7%) in our review were enrolled in health-related classes or a general education nutrition course.[40,63,76]

Study design of studies

Seventeen of the studies were randomized control trials.[30,34,37,40,43,45,46,48,49,51,58,61-63,66,67,74] Seventeen studies employed a pretest posttest study design.[27-29,35,36,50,52,53,60,64,69,70,72,75,77,78] Twelve were quasi experimental studies,[31,44,55-57,59,68,71,73,76,79,81] five were prospective[33,41,43,47,54] and four were cross sectional studies.[32,38,65,80]

Quality of studies

Most studies were classified as moderate quality (n=28, 45.9%) or strong quality (n=24, 39.3%) following the quality rating scheme designed by Mikkelsen et al 2014.[25] 12.7% (n=7) and 3.6%(n=2) were classified as weak quality and very strong quality respectively.

Sampling methods

Convenience sampling was used in 29 studies.[29,32,36,41,44,47,50,52-54,56,57,59-62,65,68-72,75-79,81] Eighteen studies used random sampling.[28,30,34,35,39,45,46,48,49,51,55,58,63,64,66,66,72,73] Two studies used food sales data only,[31,33] two studies combined observational data with food sales data,[38,80] while one study combined convenience sampling and food sales data.[43] One study combined random and convenience sampling[40] and one study used observational.[37]

Sample size

Sample sizes varied greatly between interventions, ranging from 23 to 2,971 participants. The mean sample size of the single component interventions (n=9) was 526. The mean sample size among the educational (n=40) and multicomponent (n=2) interventions were 214 and 1,040 respectfully. The mean sample size of 50 studies where sample size was available was 300.

Duration

Overall, the duration of studies ranged from a single occasion[34] to 7 months.[38] The single interventions ranged from a single occasion[34] to 2 months.[27] The educational interventions ranged from single occasion[34] to 7 months.[38] The multicomponent interventions ranged from 5 weeks[80] to 10 weeks.[81]

Main target behaviors

Point-of-purchase nutrition information and color coded indicators displayed in canteens and milk vending machines were commonly seen among the single interventions to promote healthy food and beverage choices.[27-35,37] Improved calorie awareness and dietary intake with specific focus on increasing milk, calcium, fruits, vegetables and decreasing high fat dairy and high fat meats were seen among single interventions.[27-37] In the educational interventions, attitudes and knowledge were the main target behaviors. Dietary intake was mainly assessed using food frequency questionnaires.[30,46,50,56,61,71,74,76] Three-day food records were used in two studies.[53,69] Weight and height were the main anthropometric measurements used in four of the educational studies[39,48,49,67] and one of these studies also reported waist circumference.[49] One of the multicomponent interventions aimed to influence fruit intake by reducing the cost offer it and increasing the accessibility of fruit on campus by distributing fruit, 100% fruit juice, and smoothie samples.[81] An energy labelling campaign with social marketing to select less energy dense meals in canteens was the main target behaviors in the other multicomponent intervention.[80]

Theoretical foundations of interventions

Twenty of the interventions based their interventions on health behavioral theories. Eleven used social cognitive theory.[40,44,46-49,51,53,58,61,63,69] Two interventions used the transtheoretical model[55,75] and the others were self-regulation and goal systems theory,[62] goal setting theory,[78] the health promotion model,[59] social contextual model[45] or social ecological model.[27]

Bias

Most employed a pre/post-test study design which does not allow for causality to be determined (n=17, 30.9%), lacked a control group (n=34, 56.5%) and follow-up measures (n=44, 80%) to determine long term behavior change. One in five studies had a female only or female dominated sample (n=12, 21.8%). In general, the interventions used convenience sampling (n=29, 52.7%) and relied on self-reported data (n=37, 67.3%). Some of the educational interventions had a low adherence rate and a small sample size (n=6, 10.9%).[44,48,49,57,59,72]

Effects of interventions

Single interventions

Among the single exposure interventions, point-of-purchase nutrition information and color-coded indicators in canteens positively influenced dietary intake and awareness of eating a healthful diet with the exception of one study.[32] Calorie labelling on meals influenced meal choices among females but not in males.[34] Vending machines failed to increase milk and calcium intake.[27] Total fruit and vegetable intake did not increase after the provision of free fruit and vegetables.[36]

Educational interventions

Of the three studies that reported anthropometric measurements, one study reported minor or no changes.[39] Wang et al 2021 reported reductions in

anthropometric measurements but they were not significant[68] and Mackey et al recorded bodyfat, waist circumference and BMI (Body Mass Index) but did not report changes in these variables.[49] Most of the studies which aimed to improve nutrition knowledge or dietary intake did so (n=39,92.9%) except for three studies.[52,59,61] One study successfully improved food label knowledge and empowerment.[54] One study increased awareness of portion sizes in 94% of the sample and 62% reported becoming more aware of their own portion sizes.[73] An online nutrition education program was more successful at increasing fruit and vegetable intake and self-efficacy in comparison to the same program delivered on campus.[67] Most of the twenty four studies which aimed to increase fruit and vegetable intake reported positive outcomes (n=21, 87.5%), however some were unsuccessful.[55,72,76] In general, studies were more effective at increasing fruit intake than vegetable intake. One study which aimed to reduce sugar sweetened beverages at point of purchase in a university campus residence was successful[38] and one study which aimed to reduce added sugar intake by delivering two face-to-face educational sessions and sending weekly messages for 8 weeks was successful at reducing added sugar in comparison to the control group.[57] Of the five studies which aimed to either increase the intake of low fat dairy or reduce whole dairy products, three were successful[40,66,71] while two were unsuccessful.[43,63] These unsuccessful interventions aimed to alter intake by displaying messages in campus dining halls (39) and via email messaging.[43,63] However, Poddar et al 2010 reported improvements in self-regulatory strategies and self-efficacy for consuming three servings/day of dairy products.[63] Although there was nonpositive impact on dairy intake for Arts et al, there was a positive impact on wholegrain consumption as food sales data indicated that whole grain consumption doubled (12.7%-23.9%) in the dining hall during the six week intervention.[43]

Multicomponent interventions

Shive and Morris reported significantly increased fruit consumption and/or fruit sales after the provision of free fruit and informational resources.[81] Although the authors in that study also addressed policy change to increase the accessibility of fruit on campus, most participants did not meet their daily recommended intake of fruit.[81] Cost was identified as a barrier to fruit consumption which was evident in 25% of students in one study.[81] Individuals who participated in the energy labelling campaign had increased energy label awareness at the point of purchase.[80] Participants who also took part in a social marketing campaign along with the energy labelling campaign selected lower energy meals, however most of these participants stated that the effect of the interventions did not impact their food choices.[8]

4. DISCUSSION

The current review identified 55 studies that aimed to improve dietary intake and/or nutrition knowledge in students attending higher education institutions. Most studies reported at least one significant improvement in nutrition knowledge or dietary intake with several studies (n=50, 90.9%) having multiple significant outcomes including improved nutrition knowledge, healthy food purchases, portion size awareness, food label understanding and improved intakes of dairy, fruits, vegetables, and wholegrains in addition to reduced intakes of added sugar, fat, salt, alcohol, and sugar sweetened beverages. Most of the studies in this review had a moderate (n=25, 45.5%) or strong (n=21, 38.2%) quality rating following the research design rating scheme.[25] Eighty percent of online interventions reported positive outcomes (n=8, 80%).

Seventeen of the studies aimed to improve additional health behaviors such as exercise, stress management, smoking, alcohol and sleeping. Previous literature has indicated that interventions which solely targeted nutrition resulted in more significant outcomes[10]. However, our study found that most of the studies which included multiple health behaviors reported positive outcomes in

nutrition knowledge and/or dietary intake. [39,45,47-49,64,67,68,70,74] Most studies in this review were educational interventions (n=42, 76.4%) which may alter students understanding or awareness of the target concept and the estimation of their level of functioning with respect to the concept.[82] We identified four studies that improved nutrition knowledge and positively influenced dietary behaviors.[28,50,56,77] Chughtai et al 2019 reported an increase in milk consumption awareness after the delivery of eight nutrition education lectures which resulted in an increased consumption of fresh milk, low fat milk and butter milk. However, this also included an increased consumption of milkshakes.[50] We cannot assume that the educational intervention was solely responsible for behavior change as there are many intrinsic and extrinsic factors that influence behavior change.[83] Multicomponent interventions may be more effective at changing behavior as they use more than one strategy to improve behavior. A recent systematic review concluded that interventions which specifically aim to positively influence food choice at point of purchase, education, motivation and target food quantity or quality have the most potential to elicit health promoting behaviors in the workplace.[84] Our research correlates with these findings as both multicomponent studies resulted in positive outcomes, however, there was only two multicomponent studies included in our review.[80,81] Previous research indicates that multicomponent interventions can be difficult to replicate in educational settings without considerable funds, time, and manpower,[85] which maybe the reason why limited multicomponent interventions were reported in this review. Some studies had a female only sample[57] or a predominantly female sample.[43,44,69,78-80] This may be due to the higher proportion of females attending some higher education institutions. However, sex differences in health habits and in motivation for a healthy lifestyle among higher education students have been identified, with males generally less interested in nutrition advice and health promoting activities than females and less likely to participate in these studies than females.[86,87] It was noted in our review that there were dietary differences as a result of intervention between males and females.[34,60] Gerend reported that females chose lower calorie meals, lower calorie items, and lower priced meals when calorie information was displayed on fast food items at the point of purchase, whereas males' selection was unaffected.[34] Ha et al reported that total milk consumption significantly increased in females but not in males.[60] This indicates that interventions designed to improve dietary intake and/or nutrition knowledge may need to be sex specific to tackle the needs of both sexes or designed for populations with similar characteristics and interests. Individualized dietary interventions according to a person's specific dietary preferences have been reported to be more successful than those that are not.[88] Therefore, it is recommended to conduct a needs assessment prior to designing and implementing dietary and/or nutrition education interventions in higher education institutions. The literature suggests that interventions underpinned by a theoretical foundation are more effective at improving health behaviors than studies which lack a theoretical foundation.[89] Theory based interventions enable a greater understanding of the effectiveness of interventions as they can identify constructs that influence behavior and inform the development of behavior change interventions. In our review just over a third of studies (n=19, 34.5%) based their interventions on health behavioral theories, which is in accordance with the literature as theory is not often used in the development of health interventions.[89] Most of the studies that based their interventions on health behavioral theories reported positive outcomes which highlights their effectiveness (n=15, 78.9%). Social cognitive theory was the most common theory used in our review and had the most successful impact in the studies it was used in (n=8, 72.7%). However, most of the studies that did not base their interventions on health behavioral theories also reported positive outcomes (n=34, 94.4%). In our review most studies reported positive outcomes regardless of if they used a health behavior theory. However, interventions

that lack a theoretical foundation are more difficult to replicate as the successful components are not identifiable.

Limitations

Most studies in this review used convenience sampling and relied on self-report data which limits the generalizability of outcomes as self-selection can result in a sample who are conscious about a healthier lifestyle.[55] Randomized controlled trials are the 'gold standard' of measuring the efficacy of interventions due to the ability to minimize bias and avoid false conclusions.[91] However, it can be difficult to blind participants in these types of interventions (nutrition knowledge and dietary interventions). In our review, seventeen of the studies (30.9%) were randomized control studies. A lack of follow-up in these studies makes it difficult to conclude whether the reported effects were sustainable over time. Although nine educational interventions reported follow-up analysis,[39,41,50,58,61,62,67,75] only one of these studies conducted long term follow-up analysis after 12 months.[75] Therefore, the long-term effectiveness of these educational interventions on behavior is unknown and warrants follow-up analysis. Most of the studies were conducted in the United States of America (n=38, 69.1%) thus the global generalizability of these results should be interpreted with caution as food provision schemes widely vary between countries. It should be noted that the validity of systematic reviews can be undermined by publication bias as there is a tendency to publish studies that report positive impacts and so we are unaware of ineffective studies if not published which can provide useful information for future research.

Recommendations for future practice

The World Health Organization (WHO) identifies higher education institutions as important settings for health promotion.[92] The Okanagan Charter for Health Promoting Universities and Colleges is a call to action to promote health in these settings. Numerous national networks have been formed globally to adopt this charter and its principals using diverse approaches to suit specific populations worldwide.[93,94] The Department of Health in Ireland have recently developed a higher education healthy campus charter and frame-work 2020–2025 which is aligned with the principles of the Okanagan Charter.[15] Within the strategy action plan, the government of Ireland aims to implement healthy campus programs in thirty higher education institutions within the next three years.[15] Based on the findings from this review, we suggest that interventions have a greater potential for success when, (i) underpinned by a theoretical foundation, (ii) interactive and delivered online, (iii) they provide information aimed at improving nutrition knowledge and dietary intake at point-of-purchase settings in higher education environments. We also advise to recruit a gender balanced sample to avoid bias and conduct long-term follow-up analysis to determine long-term effectiveness.

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Conceptualization, L.K.; Methodology, L.K.; Formal Analysis, L.K., R.K., G.W..; Investigation, L.K., R.K., G.W Data Curation, L.K., R.K., G.W.; Writing – Original Draft Preparation, L.K., R.K., G.W.; Writing – Review & Editing, L.K., R.K., G.W.; Visualization, L.K., R.K., G.W.; Supervision, L.K.

STATEMENT OF POTENTIAL CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors have no conflict of interest to declare.

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No funding was received for this work.

Supplementary Material 1. PRIMSA checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Pages 2 & 3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Pages 3 & 4
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 4
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Page 4 + supplementary material 3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Pages 3 & 4
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome do main in each study were sought (e.g., for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Pages 3 & 4
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 5
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g., tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Pages 3 & 4
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Page 5
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 5

	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 5
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g., subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Page 5
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Page 5
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Pages 4 & 5
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Page 4
Study characteristics	17	Cite each included study and present its characteristics.	Page 5
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Page 8
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	N/A
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Pages 7 & 8 & Pages 10 & 11
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g., confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Page 5
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Pages 10 & 11
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Page 8
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Pages 12, 13 & 14
	23b	Discuss any limitations of the evidence included in the review.	Page 14 & 15
	23c	Discuss any limitations of the review processes used.	Page 15
	23d	Discuss implications of the results for practice, policy, and future research.	Page 15
OTHER INFORMATION			

Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	No funding was received for this work
Competing interests	26	Declare any competing interests of review authors.	The authors have no conflicts of interest to declare
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Tables 2, 3 & 4 & supplementary material.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

Supplementary Material 2. Papers excluded from the systematic review ordered by year.

Author and country	Design and participants	Outcome assessed	Reason for exclusion
(Barr *et al.*, 2018) [1] USA	A one-group, pre- and post-test model was used. Three cooking-classes were developed with parameters of limited cooking skills, limited access to kitchen equipment, and shelf-stable ingredients that are readily available on campuses. Participants(n=38) were recruited using tabling, posters, email, and social media.	Pre- and post- surveys assessed nutrition knowledge, frequency of healthy eating, cooking confidence, cooking ability, cooking frequency, and food safety knowledge. Participants were also queried on their perception of the cooking classes and their dietary behaviours post-intervention.	No full text available
(Harvey-Berino *et al.*, 2012) [2] USA	A 12-week online behavioural weight management program for college students focused on behavioural strategies to modify eating and exercise behaviours of students interested in losing weight and/or developing a healthy lifestyle. Specific tools included weekly chat meetings with a facilitator, calorie and fat gram recommendations, daily food logs, and exercise guidance.	Body mass index was assessed pre and post the intervention.	Weight is only outcome measure
(Wei-wei and Ling., 2021) [3] China	60 female college students with invisible obesity were randomly divided into three groups: control group, exercise intervention group	Body mass index, body fat percentage, visceral fat index, waist and hip	Weight is only outcome measure

	and exercise + nutrition health education group. The control group had normal study and life; the exercise intervention group used aerobic exercise and resistance exercise to carry out collective exercise prescription exercise and individual contract exercise; the exercise intervention + nutrition health education group carried out nutrition health education on exercise intervention.	circumference and physical fitness tests including 800m, standing long jump, sit-up for 1 minute, sit and reach were measured using The Hengkangjiaye tester.	
(West *et al.*, 2016) [4] USA	Undergraduates (n =58) in two sections of a public university course were allocated to either a behavioural weight gain prevention intervention or a human papillomavirus vaccination awareness intervention. All students were enrolled, regardless of initial body weight or expressed interest in weight management. The interventions delivered 8 lessons via electronic newsletters and Facebook postings over 9 weeks, which were designed to foster social support and introduce relevant educational content. The weight gain prevention intervention targeted behavioural strategies to prevent weight gain and provided participants with a Wi-Fi-enabled scale and an electronic physical activity tracker to facilitate weight regulation.	Body weight, height, body mass index, Behavioural weight control practices were evaluated with a 28-item checklist that assessed both appropriate behavioural weight management strategies	Weight is only outcome measure

(Bertrand *et al.*, 2018) [5] Canada	A convenience sample of first and second-year students (n=47) registered in the "Understanding Foods".	Completed an online survey at the beginning and at the end of the semester about food habits, food skills, confidence in food preparation, food safety knowledge, and grocery shopping habits.	Does not aim to improve dietary intake and/or nutrition knowledge
(White *et al.*, 2009) [6] USA	A web-based survey was administered randomly to 2000 undergraduate students to determine the impact of peer health education on the health behaviors of undergraduate students pertaining to alcohol and drug use, eating and nutrition, and sexual health.	Knowledge, attitudes, and behaviours of alcohol, drug use, eating and nutrition, and sexual health.	Does not aim to improve dietary intake and/or nutrition knowledge
(Stice *et al.*, 2014) [7] USA	408 women were recruited from seven universities across the USA and were randomized to the dissonance eating disorder prevention programme or an educational brochure control condition.	The 6-item Ideal-Body Stereotype Scale-Revised assessed thin-ideal internalization. Items from the Satisfaction and Dissatisfaction with Body Parts Scale assessed satisfaction with 9 body parts. The 10-item Dutch Restrained Eating Scale assessed the frequency of dieting behaviours. The 21-	Does not aim to improve dietary intake and/or nutrition knowledge

		item Beck Depression Inventory assessed negative affect. The semi-structured Eating Disorder Diagnostic Interview assessed eating disorder symptoms. Psychosocial functioning in the family, peer, school, and work spheres was assessed with items adapted from the Social Adjustment Scale. Health service utilisation was assessed with an adapted version of the Patterns of Help Seeking Behaviour Scale	
(Abolfazl *et al.*) [8] Iran	A convenience sample of 500 college students aged 18-24 years completed measures of aspects of decisional balance (pros and cons) of milk consumption.	Decisional balance was assessed using a 30 question 5-point scale that was developed by Specter. The algorithm developed by the national cancer institute was used to assess respondents stag of change for milk consumption.	Does not aim to improve dietary intake and/or nutrition knowledge

(Cárdenas *et al.*, 2015) [9] Peru	Quasi-experimental pilot study of a three-phase stepped intervention. In Phase 1, fruit was displayed >3 m from the point of purchase with no additional information. Phase 2 consisted in displaying the fruit near the point of purchase with added health and price information. Phase 3 added a 33 % price reduction.	Fruit and meal sales.	Not solely a student sample
(Hoefkens *et al.*, 2012) [10] Belgium	The point-of-purchase nutrition-information intervention used a one-group pre test-post-test design. A sample of 224 customers of two university canteens completed the baseline and 6-months follow-up surveys.	A multi-group structural equation modelling analysis was used to test mediation effects of individual difference variables (liking, understanding and use of the information, subjective knowledge and attitude) on the energy intake from canteen meals, moderated by the objective nutrition knowledge and motivation to change diet.	Not solely a student sample
(Marks and Ogden, 2017) [11] United Kingdom	The study involves a 2×2 factorial design with two conditions: group (weight loss vs food intolerance) and condition (intervention vs control). The intervention aimed to generate a “teachable moment” by providing knowledge regarding the	Participants receiving the intervention completed measures of dietary behaviour and either weight or food intolerance symptoms before	Not solely a student sample

	relationship between food and the problem (overweight or food intolerance), focussing on the negative aspects of the problem, creating a behavioural model, and encouraging hope and reinvention.	receiving the intervention and again one month later.	
(Di Sebastiano *et al.*, 2021) [12] Canada	This study developed the Healthy Beverage Initiative (HBI) to ultimately reduce the consumption of sugar sweetened beverages (SSB) on campus. The design included a Naturalistic observation of environmental changes to induce behaviour change conducted in a large urban research university campus. Participants included university community members and campus visitors.	Reduce the consumption of sugar sweetened beverages (SSB) on campus	Not solely university students

(Wright *et al.*, 2021) [13] USA	First, a nutrition improvement program called CENTS (Cost of Eating Nutritiously during Time as a Student) that disseminated specific information and utilized experiential activities for mindset change was developed and pilot tested using a pre/post study design. Second, using a similar pre/post method, the CENTS program was evaluated in a quasi-experimental design.	The perceived barriers to healthy eating (e.g., too costly, too much time), fruit and vegetable consumption, and other variables related to healthy eating (e.g. cost estimates, diet attitudes, self-efficacy, sugary foods consumption).	No full text available
(Mahmoud *et al.*, 2021) [14] UK	Students attending Western University were invited to participate in 3 cooking classes over a 3-month period. All participants were asked to complete the FSQ pre- and post-intervention. The FSQ evaluated food skills in 3 domains-Food Selection and Planning, Food Preparation, and Food Safety and Storage-with a maximum score of 100 per domain. Domain scores were then computed as a weighted average for the Total Food Skills Score out of 100. Open-ended questions assessed	Food planning, selection, food preparation, food safety and storage was assessed in this study.	No full text available

	participants' perceptions of the classes.		
(Teesson *et al.*, 2020) [15] Australia	A multisite cluster randomised controlled trial will be conducted among year 7 students (11–13 years old) from 72 Australian schools. Stratified block randomisation will be used to assign schools to either the Health4Life intervention or an active control (health education as usual). Health4Life consists of (1) six web-based cartoon modules and accompanying activities delivered during health education (once per week for 6 weeks), and a smartphone application (universal prevention), and (2) additional app content, for students engaging in two or more risk behaviours when they are in years 8 and 9 (selective prevention).	Primary outcomes assessed in this study are consumption of sugar-sweetened beverages, moderate-to-vigorous physical activity, sleep duration, sedentary recreational screen time and uptake of alcohol and tobacco use.	Does not aim to improve dietary intake and/or nutrition knowledge

(Bramston *et al.*, 2020) [16] Australia	Thirty-four young adults participated in four focus groups.	To develop and evaluate cooking videos to educate young adults about calcium-containing foods and provide demonstrations for culinary skills training.	No quantitative results
(Lieffers *et al.*, 2021) [17] Canada	One-on-one semi structured interviews were conducted in a randomised control trial with 32 first-year university students.	To understand experiences and perception of MVP by first-year university students using this tool as part of a 12-week randomized controlled trial.	No quantitative results
(Seah *et al.*, 2022) [18] Singapore	A cluster-randomized trial with university students and staff (n = 247) who frequently dined at these centres. Six food centres at a large university campus were randomly	To evaluate effects of a 'Healthier Diner Programme' on out-of-home dietary intakes.	Sample not solely university students

	assigned to the intervention or control arm.		
(Vermote *et al.*, 2020) [19] Belgium	A mixed-method real-life experimental design was used to examine the effect of combining food labelling and point-of-purchase messaging in a university restaurant. The sample consisted of all students and staff members who ate lunch at the restaurant.	To examine the effect of nudges, inspired by the recently renewed Flemish Food Triangle on fruit sales.	Sample not solely university students
(Coccia *et al.*, 2020) [20] USA	Participants included 50 male and female National Collegiate Athletic Association Division I student-athletes between the ages of 18 and 24 years. The study design employed a 6-week social media intervention using Twitter, to increase nutrition knowledge, self-efficacy, social support, and dietary adherence to the recommendations from the Dietary Guidelines for Americans.	To determine the feasibility and efficacy of a social media-based nutrition intervention using Twitter on nutrition knowledge, dietary practices, body mass index (BMI), self-efficacy, and social support among student-athletes	Athletic sample
(Guichard *et al.*, 2021) [21] France	A cluster randomized crossover design: Two canteens were randomly selected to display either a vegetable-related or a neutral-behaviour norm message.	To assess the impact of a vegetable-related descriptive norm message on vegetables purchase in university canteens.	Sample not solely university students
(Szczepanski *et al.*, 2022) [22] USA	A nutrition education program, *Culinary Boot Camp* (*CBC*), was developed and delivered to college students at a land-grant university.	Online surveys assessed food/nutrition aptitudes and dietary intake pre-/post-	Full text unavailable

		/follow-up intervention.	
(Rhea *et al.*, 2020) [23] USA	The *Eating with Ease* program developed and tested a nutrition education/culinary skill-building program to build first-and second-year veterinary medicine students' food literacy and healthy behaviours toward food. Students engaged in four 30-minute sessions and communicated through a mobile group messaging application.	To improve veterinary medical students' behaviours to choose, prepare and consume healthy foods	Full text unavailable
(Lee *et al.*, 2020) [24] USA	Pre-experimental single group repeated-measures field study design with qualitative programme evaluation feedback at post-test. Participants attended FitU which is a peer-led non-diet nutrition and physical activity mentoring intervention developed to promote lifelong health habits for college students.	To examine the nutrition and PA outcomes of FitU participants.	Does not aim to improve dietary intake and/or nutrition knowledge
(Trottier *et al.*, 2021) [25] Canada	12-week randomized controlled trial with 97 first-year undergraduate students who were randomized to either the intervention (n=48) or control (n=49) group.	To assess the impact of a web-based wellness platform on perceived stress among first-year university students. The secondary aim is to assess the effects of the platform on diet quality.	Does not aim to improve dietary intake and/or nutrition knowledge
(Downes *et al.*, 2021) [26]	A total of 96 university employees participated in a one-group pre- and	To determine the effect of a novel	Not a university sample

USA	postintervention from 2017 to 2019. The intervention included eight weekly face-face education sessions. We assessed dietary habits, physical activity, motivators and barriers of a healthy lifestyle, emotional eating, confidence levels, body mass index, and lipid levels. Descriptive statistics, chi-square test, one-way analysis of variance, and Wilcoxon rank test were performed.	nutrition education program implemented in the workplace on health behaviors (dietary habits and physical activity), motivators and barriers, emotional eating, confidence, and biometrics (body mass index and lipid levels).	
(Hussien *et al.*, 2021) [27] Ethiopia	The study was be conducted among public colleges in Dessie town, Northeast Ethiopia. Study population: students who are studying in all public colleges. Intervention: a text message related to cancer risk factors once a day for two months. Control groups will receive general health messages daily for two months. Data: Socioeconomic characteristics, health belief variables, and behavioral risk factors of cancer will be collected before and after the intervention. Text messages will be provided based on the health belief model (HBM)	Cancer risk knowledge score and risk perception will be measured at baseline and 6 months post-randomization. a change in mean healthy diet score, physical activity level, alcohol intake, and tobacco use will be measured at baseline-, 3-, and 6-months post-randomization.	Does not aim to improve dietary intake and/or nutrition knowledge
(Vedovato and Leonardi, 2021) [28] Brazil	Online questionnaires were made available on the course's platform, and were filled out by the participants of each edition (2015-2019) at the time of the course. The variables to describe the	Online questionnaires assessed the profile of participants and changes in their perception or	Does not aim to improve dietary intake and/or nutrition knowledge

	participants' characteristics and some eating practices were: area of the university campus; type of residence; company for meals; meal location at home; cooking skill; use of the university restaurant; perception of the need to change eating habits.	relationship with food.	
(Pfammatter *et al.*, 2020) [29] USA	302 incoming freshmen at a Midwest university will be cluster randomized by dormitory into one of two mHealth intervention groups: 1) Cardiovascular Health (CVH), addressing behaviors related to CVD risk; or 2) Whole Health (WH), addressing behaviors unrelated to CVD. Both groups will receive smartphone applications, co-designed with students to help them manage time, interact with other participants via social media, and report health behaviors weekly.	To evaluate whether the NUYou cardiovascular mHealth intervention is more effective than an active comparator to promote cardiovascular health during the transition to young adulthood	Protocol
(Soriano-Ayala *et al.*, 2020) [30] Spain	University students (n = 51) in Spain were randomly assigned to a seven-week mindfulness treatment or a waiting list control group.	To evaluate the effects of mindfulness on a range of different life behaviors and	Does not aim to improve dietary intake and/or nutrition knowledge

		variables including eating patterns	
(Wilson *et al.*, 2020) [31] USA	Female university students aged 18–30 took part in an intervention which consisted of two 90–120 min interactive group sessions designed to engender the rejection of dieting, increase body acceptance, and develop healthy eating skills. Assessment measures were completed at baseline, post-treatment and one - month follow-up.	To increase body acceptance, develop healthy eating skills and disengage with dieting habits.	Does not aim to improve dietary intake and/or nutrition knowledge
(Buscemi *et al.*, 2011) [32] USA	Undergraduate university students completed an assessment about weight related health behaviours and then were randomized to either receive a single 60-min Brief Motivational Intervention (BMI) plus a booster phone call or to assessment only.	BMI, diet and physical activity	Does not aim to improve dietary intake and/or nutrition knowledge
(Matvienko *et al.*, 2001) [33]	The intervention was a one semester nutrition science college course. Body weight, nutrient intakes, and knowledge were measured at baseline, the end of the intervention (4 months from baseline), and 1 year later (16 months from baseline). The intervention was a college course for credit, composed of both lectures and laboratory exercises. Female undergraduate students were exposed to	Weight, nutrient intakes and knowledge	Does not aim to improve dietary intake and/or nutrition knowledge

	scientific literature through discussions of relevant published human studies on energy balance and its control by genetic, dietary, and physical activity factors. Classroom exercises included estimation of the basal metabolic rate, body composition, fat distribution, energy expenditure, and fat use for various physical activities. Laboratory exercises included body composition measurements, serving sizes, food sensory exercises with low- and high-fat foods, and food preparation methods.		
(Hernández-Jaña *et al.*, 2020) [34] Chile	Students not studying nutrition and dietetics, or physical education were involved in a single nutritional education talk about obesity health risks, the benefits of a healthy lifestyle, distribution of meals, and the detrimental effect of a critical period such as the national holidays. The intervention group received a series of healthy recommendations specially focused on the national holidays; the control group was asked to continue their normal activities.	Body composition, diet, physical activity	Does not aim to improve dietary intake and/or nutrition knowledge
(Napolitano *et al.*, 2020) [35] USA	Undergrad first year students reviewed a digital program providing self-assessment and brief tailored feedback on 8 behaviours	Weight, diet and physical activity	Does not aim to improve dietary intake and/or nutrition knowledge

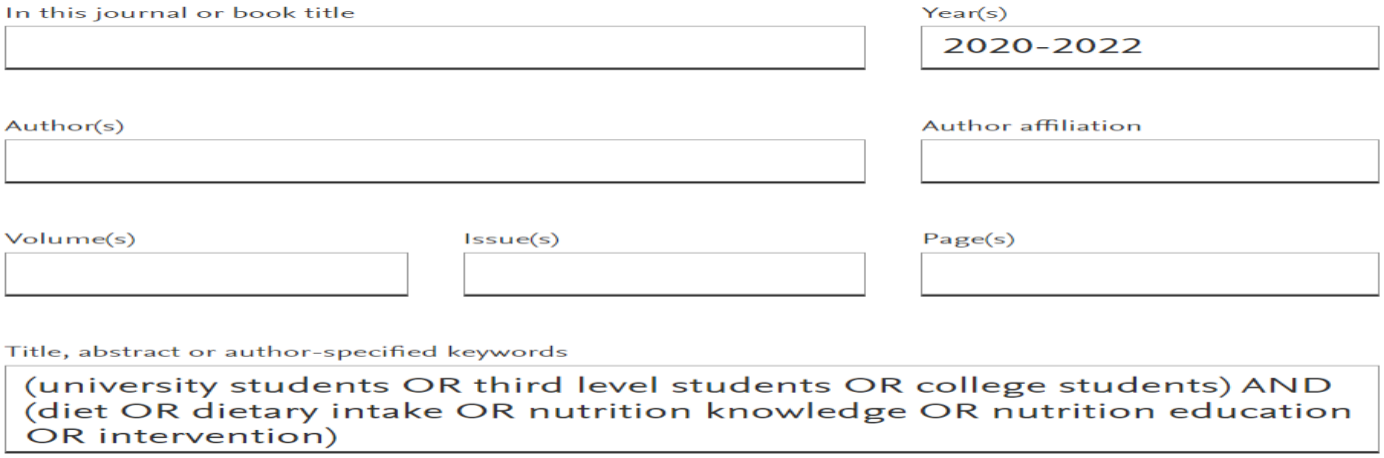
	that relate to a healthy weight: physical activity, sedentary behaviour, and consumption of sugary beverages, high fat snacks, breakfast, fried foods, fruits and vegetables, and pizza.		
(Krzyzanowski *et al.*, 2020) [36] USA	Rams Have Heart, a tool developed as part of a larger pilot study to test an evidence-based CVD intervention in a susceptible demographic-AA college student integrates self-reported health screening with health education, diary tracking, and user feedback modules to acquire data and assess progress.	Improved healthy behaviours tracking-increased fruit and vegetable consumption and physical activity	Does not aim to improve dietary intake and/or nutrition knowledge

Supplementary Material 3. Search strategy
PubMed Search Strategy (n=567)
(university) OR (college)) OR (campus)) OR (third level) OR (students) AND (dietary intake) OR (food intake) OR (diet) OR (eating) OR (nutrition knowledge) OR (nutrition education) OR (health promotion) OR (intervention)

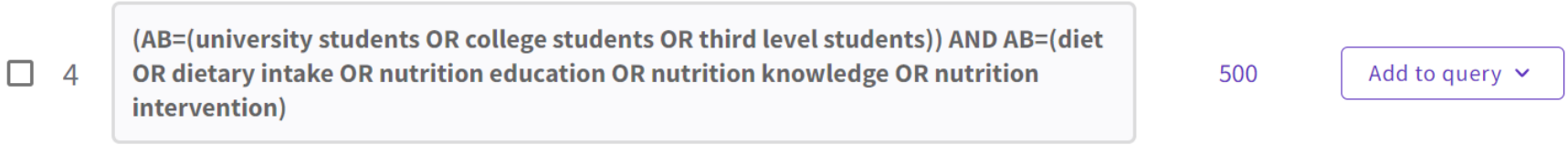
PubMed

#22	•••	›	Search: **(((university students[MeSH Terms]) OR (third level students[MeSH Terms])) OR (college students[MeSH Terms]) AND ((fha[Filter]) AND (humans[Filter]) AND (2020/7/1:2022/2/16[pdat]) AND (english[Filter]) AND (alladult[Filter]))) AND (((((dietary intake[MeSH Terms]) OR (diet[MeSH Terms])) OR (food[MeSH Terms])) OR (nutrition education[MeSH Terms])) OR (nutrition knowledge[MeSH Terms]) AND ((fha[Filter]) AND (humans[Filter]) AND (2020/7/1:2022/2/16[pdat]) AND (english[Filter]) AND (alladult[Filter]))))** Filters: **Abstract, Humans, English, Adult: 19+ years, from 2020/7/1 - 2022/2/16**	256

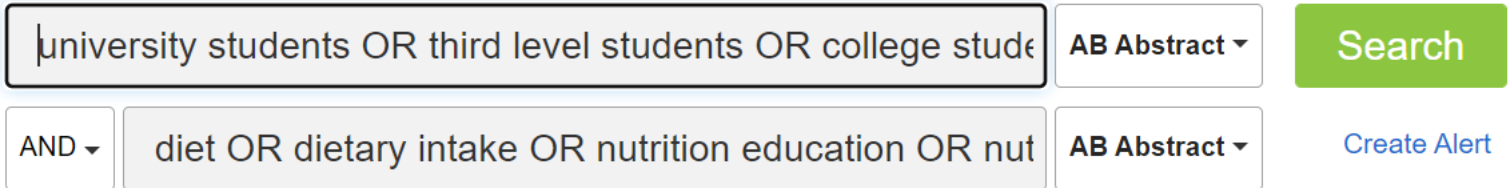
Science direct



Web of Science



ERIC



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