Sustainable Solutions:
Increasing Legume Consumption in Israel – A Behavioral Intervention Among Dietitians

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Abstract

The health and environmental benefits of consuming legumes (beans, lentils, peas and soy) are reflected in dietary recommendations worldwide. In Israel, the dietary guidelines recommend daily legume intake. However, a substantial gap exists between guidelines and actual legume intake, particularly in Western countries, including Israel. It is a task of global importance to develop effective interventions promoting legumes as a meaningful source of protein and micronutrients. A target population of particular significance is dietitians. They are the health professionals responsible for implementing nutritional recommendations in the population. Equally important is their role in modifying dietary patterns at both the individual and community level. The aims of this work were to document the actual legume intake in Israel; characterize the current counseling practices of Israeli dietitians regarding legume intake; and finally, develop and evaluate an intervention to improve counseling practices among dietitians that are integral agents of change.

In line with these goals, the first chapter of this dissertation aimed to estimate and characterize legume consumption in the Israeli population using secondary data analysis from the Israeli Health and Nutrition 2014-2016 MABAT Adult Survey, a nationally representative sample of the adult population (n=2808). Legume consumption was found to be significantly lower than recommended levels. Only 31.1% of the sample (n=874) consumed legumes, with a median intake of approximately 0.25 cup. Of the legume consumers, more than half (52.9%, n=462) reported consuming hummus, where an average serving was measured to be one tablespoon. Legume consumers were less likely to suffer from comorbidities [Adjusted OR (aOR) 0.54 (95% CI:0.37-0.78)], and more likely to be male [aOR 1.41 (95%CI:1.2-1.65)] and born in Israel [aOR 1.24 (95%CI:1.01-1.51)]. These results reflect a distinct need for promoting legume consumption in the entire adult population and provided data showing the need for an intervention.

The second chapter of the dissertation aimed to evaluate knowledge, attitudes and practices regarding legume counseling and consumption among Israeli dietitians (n=309) using an online cross-sectional survey. Results showed that less than half, or 47.4% (n=146) of the participants recommended to most or all of their patients to increase legume intake. Factors that were associated with recommending legumes were perception of fewer barriers for consumption [aOR 1.92 (95% CI 1.24-2.96)]

and positive attitudes towards legume counseling pertaining to its importance [aOR 1.95 (95% CI 1.12-3.4]. Negatively associated factors were a low level of personal legume consumption [aOR 0.38 (95% CI 0.15-0.94)] and working in hospitals [aOR 0.43 (95% CI 0.19-0.98)]. Results indicated that there was a distinct need to encourage dietitians to include legume promotion in their counseling practices. Based on these findings, an online intervention was developed that incorporated behavior change models, the Capability, Opportunity, Motivation – Behavior (COM-B) model and the Theoretical Domains Framework (TDF). Both are validated and integrative models of behavior change. The intervention included: a) a prerecorded webinar regarding the health, food security and environmental benefits of legume intake; b) small-group online workshops to enhance skills in regard to overcoming barriers to legume consumption; and c) counselling brochures for patients and a professional guide on legume counselling for dietitians. The third chapter's aim was to evaluate the developed evidence and theory-based intervention with the objective to improve dietitians' legume counselling practices, knowledge, attitudes and personal consumption. This study used a randomized control trial (RCT) design. Dietitians (n=213) were recruited and randomized to the intervention group (n=109) and a wait-listed control group (n=104). Data were collected at baseline and three months post-intervention using an electronic survey. The primary outcome was the proportion of dietitians that recommended to patients to consume legumes on a daily basis. This was measured using a 1-5 Likert scale ((1) none; (2) ≤25%; (3) 26–50%; (4) 51-75%; and (5) 76-100%). In the intervention group, dietitians recommending to 76-100% of their patients to consume legumes daily increased from 32% (n=35) at baseline to 51% (n=56) post-intervention; compared to 25% (n=26) and 27% (n=28), respectively, in the control group. Recommending daily legume consumption improved significantly in both the intervention group (3.73±1.1 to 4.28±0.86, p=0.001) and the controls (3.67±0.98 to 3.88±0.92, p=0.03), with a higher increase among the intervention group (p=0.014). Knowledge and attitudes improved significantly in the intervention group (p<0.001) but not for controls, except in the attitude score regarding sustainability (p=0.026). Personal legume intake significantly increased only in the intervention group, with lower odds of continuing to consume a small amount of legumes, of once a week or less [aOR 0.46 (95%CI:0.25-0.82)].
In conclusion, there is a distinct need to increase legume consumption in Israel. An online training intervention significantly increased dietitians' legume counseling

practices and improved attitudes, knowledge and personal legume consumption. Utilizing dietitians as agents of change to promote sustainable diets might be a low-cost, effective approach to meet Israeli dietary guidelines.

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1. Introduction

Legumes belong to the Fabaceae (Leguminosae) botanical family, and are categorized into oilseed legumes (soybeans and peanuts) and non-oilseed legumes. The non-oilseed legumes include pulses (dry beans, dry peas, lentils, chickpeas and cowpeas) which are the dried, mature seeds of the pods, and undried legumes (fresh beans and peas) which are harvested before drying (1). The common nutritional definition of legumes includes dry pulses and soybeans (2–4), excluding the fresh legumes which are included in the vegetable food group and peanuts which are nutritionally classified as nuts (2).

1.1 Legume nutritional value

There are unique nutritional advantages to consumption of legumes. They are a protein source low in saturated fat, while high in fiber and phytochemicals, unlike animal protein sources. Additionally, they provide complex carbohydrates, B vitamins and minerals such as iron, zinc and potassium (5). American adults with higher pulse intake were found to have higher intakes of fiber and potassium (6), both nutrients are under consumed in the United States (US) (7,8). Higher intakes were also found for iron, zinc, magnesium, folate and choline. Conversely, lower intake of fat was reported in pulse consumers (6). Legume protein quality is considered adequate due to the high content of the essential amino acid lysine, which is the main limiting amino acid in grains. According to The Academy of Nutrition and Dietetics the terms "complete" and "incomplete" are misleading in relation to plant protein (9). Plant-based diets are more susceptible to suboptimal intake of lysine, while the essential amino acid methionine can be easily obtained from grains, seeds, nuts and also from legumes (9,10). Legume iron bioavailability is generally higher than those of other plant non-heme iron sources. The iron is stored in the form of ferritin, a stable complex unaffected by iron chelators present in the diet, such as phytates (11,12). Legumes are an excellent source of dietary fiber, containing soluble fibers, insoluble fibers and resistant starch (13). The approximate one to one ratio of dietary fiber to protein in pulses is unique in comparison to other plant foods. It is even more important when comparing legumes to animal food sources, which do not contain dietary fiber at all (13). Both dietary fiber and protein are known to improve satiety and help with weight management (14). Legumes also contain various bioactive

compounds (e.g., phytates, protease inhibitors, lectins, oxalates and saponins). However, some are considered antinutrients, due to their negative effects on nutrient absorption (15). This can be overcome during food preparation using techniques including boiling, soaking, sprouting, fermenting and milling. Cooking and processing can remove or reduce the negative effects (9,15). Despite potential impact on nutrient availability, these compounds have also been associated with health benefits due to their antioxidant, anti-inflammatory and anti-carcinogenic activities (15).

1.2. The health effects of legume consumption

1.2.1. Cardiovascular diseases (CVD)

In a meta-analysis of cohort studies comparing highest vs. lowest categories of intake (16), legume consumption was inversely associated with CVD [RR 0.94 (95% CI 0.89,0.99)] and coronary heart disease (CHD) [RR 0.90 (95%CI 0.85,0.96)], but not with stroke [RR 1.00 (95%CI 0.93,1.08)]. In addition, an inverse dose response association was found with CHD, increasing in magnitude up to an intake of 400 g/week (~2 cups) [RR 0.79 (95%CI 0.67,0.95)]. The potential mechanisms for the observed associations may be mediated by the lipid lowering effects of legumes (17), which are predominately attributed to their high soluble fiber content (18). Additionally, the variety of phytochemicals possess anti-inflammatory and antioxidant properties, thus mitigating inflammation and oxidative stress, which are established risk factors for CVD (19).

1.2.2. Type 2 diabetes

Legume consumption was not associated with a lower risk of type 2 diabetes incidence in meta-analyses of cohort studies (20,21). Conversely, positive effects on prominent biomarkers including fasting glucose, glycated hemoglobin A1c (HbA1c) and homeostatic model assessment of insulin resistance (HOMA-IR) have been found in meta-analyses of randomized controlled trials (RCTs) (20,22). This inconsistency may be explained by the generally low legume intake found in cohort studies. The amounts of legumes consumed in RCTs were higher (>120–150 g/day) than the mean of the highest intake category in cohort studies (20). The observed beneficial effect of legume intake on glycemic response and insulin sensitivity regulation can be explained by their high content of dietary fiber, including resistant starch (10) and

various flavonoids (23). Additionally, legumes contain peptides that have been reported to inhibit the activities of key enzymes involved in the progress of diabetes (α-amylase,α-glucosidase, DPP-4)(24).

1.2.3. Colorectal cancer

Legume consumption has been associated with a lower risk of colorectal cancer [RR 0.90 (95% CI 0.83,0.98)], when comparing highest vs. lowest categories of intake. Additionally, a dose response association was found with a 100 g/day (~0.5 cup/day) increment of legume intake [RR 0.79 (95% CI 0.64,0.97)] (25). Legumes' high dietary fiber content is considered as the primary contributor for the observed association (26). Dietary fiber can bind and excrete carcinogens, while also reducing intestinal transit time and increasing fecal bulk, which would lower the potential for carcinogens to interact with the colon mucosa (26). Soluble fiber is also fermented by intestinal microbiota forming short chain fatty acids, which possess anti-carcinogenic effects (27). Lastly, the high content of phytochemicals (e.g., phenolic acids, proanthocyanidins, phytic acid and saponins) provide various anti-carcinogenic properties (28). The World Cancer Research Fund recommends legumes, along with wholegrains, vegetables and fruits as a major part of the daily diet (29).

1.3. Environmental benefits of legumes

Food that we produce, distribute, consume and waste is a major contributor to greenhouse gas (GHG) emissions, water use, land use, deforestation and biodiversity loss (30,31). Food systems are responsible for a third of GHG emissions with the livestock industry being the biggest contributor (32). Substituting pulses for beef would achieve 46–74% of the US's target reduction of GHG emissions, and would free up 42% of cropland in the US (33). Reduced land use for agriculture can aid in protecting biodiversity by restoring previous cropland to open space (34). In addition, legumes possess some unique attributes offering additional benefits. They fix atmospheric nitrogen using specialized root nodules that contain symbiotic rhizobacteria, eliminating the need for nitrogen fertilizer. When incorporated into crop rotations, legumes increase the yields of subsequent crops (35). Legumes are also well adapted for growth in adverse environmental conditions and possess high disease resistance (36). The use of pesticides and nitrogen-based fertilizers leads to loss of plant and insect biodiversity which jeopardizes the pollination of many food crops,

threatening future yields (37). Thus, legumes could aid in protecting biodiversity and promote more sustainable agricultural practices (36).

1.4. Legumes in dietary guidelines

The health and environmental merits of legumes have been reflected in dietary guidelines worldwide. The Food and Agriculture Organization (FAO) declared 2016 as the 'International Year of Pulses' stating that "Pulses have a crucial role in sustainable food production and healthy diets; therefore, it is not only our duty but also our primary responsibility to raise awareness of the benefits of pulses for humankind"(38). In 2019, The EAT–Lancet Commission published 'The planetary health diet', global recommendations for healthy and sustainable diets, emphasizing legumes as the primary protein source with a recommendation of a daily consumption of ~2/3 cup of cooked pulses and 25 g of soy foods (31). The dietary guidelines of Canada (39), the United Kingdom (40) and New Zealand (41) have reorganized the recommended order of protein food sources, listing legumes first and animal protein last, thus highlighting legumes as the preferred protein source. The recent Scientific Report of the 2025 Dietary Guidelines Advisory Committee (42) has similarly proposed to reorder the Protein Foods Subgroups in the upcoming 2025-2030 Dietary US Guidelines to list "Beans, Peas, and Lentils first, followed by Nuts, Seeds, and Soy Products, then Seafood, and finally Meats, Poultry, and Eggs". The 2020 Israeli dietary guidelines "Israel's Nutritional Rainbow" include legumes in a category of foods recommended for consumption of at least once a day (along with olive oil, tahini, nuts, and milk and its substitutes) (Figure 1) (4).

- **The Green Rainbow** – vegetables, fruits and whole grains: diversify on a daily basis.
- **The Yellow Rainbow** – olive / canola oil, tahini, nuts, legumes, milk, dairy products and their substitutes: at least once a day.
- **The Orange Rainbow** – chicken, turkey, fish and eggs: diversify on a weekly basis.
- **The Pink Rainbow** – beef: up to 300 grams a week.

Figure 1. The Israeli National Nutrition Recommendations -the Nutritional Rainbow
Adapted from: Israeli Ministry of Health. Israel's New National Nutrition Recommendations – the New Nutritional Rainbow. https://www.gov.il/en/pages/dietary-guidelines. Published December 2020. Accessed October 4, 2025.

1.5. Legume consumption

The existing literature indicates a substantial gap between dietary recommendations and actual consumption levels. Unfortunately, much of the available data are outdated. The proportion of legume consumers among Americans was 20.5%, with a mean intake among consumers of ~ 0.3 cup/day. according to the National Health and Nutrition Examination Survey (NHANES) 2017–2018 (43). A national survey executed in 2011-2012 among Australians identified 12.3% legume consumers with a median intake of ~ 0.2 cup/day (44). In contrast, dramatically higher rates were found in a nationally representative survey of urban populations from Latin American countries. The average percentage of pulse consumers in 2014-15 was reported to be 60% with a mean intake of ~0.5 cup/day (45). A relatively high percentage of legume consumers was also found in a Swedish national survey (2011); 44% of the population with a median intake of 0.2 cup/day (46). However, this rate may be attributed to a longer dietary intake period of 4 days in comparison to 1-2 days recorded in other studies. In addition, it is important to note that legume classification differed among studies. Legumes were defined as pulses (beans, lentils, peas) in the American (43) and Canadian (47) surveys; as pulses and soy in the Australian survey (44); and as beans, lentils, chickpeas and green peas in the Latin American survey (45). Lastly, the definition in the Swedish study was exceptionally broad and included pulses, fresh

beans, snap peas, sprouts, peanuts and peanut butter. Beyond methodological differences, variation in legume intake across countries also reflects differences in culinary traditions and the habitual role of legumes within national dietary patterns (48). In Latin America, legumes are traditionally consumed as staple foods and regularly incorporated into main meals (49). In contrast, in Australia, the US and Canada, legumes play a limited role in dominant dietary patterns (43,47,50).

1.6. Barriers to legume consumption

Possible reasons for the observed low legume consumption include the perception of legume preparation and cooking as time consuming and effortful (51–55); insufficient knowledge on preparation or cooking methods (52,55–60); low familiarity with legumes (51,59–61); concerns about flatulence or abdominal discomfort (51,55,60,62), a dislike of the taste or texture (52,56,58,60); perception of legumes as a ‘poor man’s food' (54,59,60) and inadequate knowledge of their health benefits (60–62).

Numerous approaches to overcome these barriers have been suggested. Introducing practices that reduce cooking and/or preparation time including soaking (63,64), batch cooking and freezing (59,63), using fast cooking legumes (e.g., lentils) (63,64), incorporating minimally processed legume products (e.g., tofu, legume pasta) (65) and preprepared pulses (52,59). Additionally, providing recipes or simple cooking suggestions, such as adding pulses to existing dishes like soups and salads, may aid in familiarity, acceptability and enjoyment (63,64). Other suggestions to overcome some of these barriers include conveying to consumers that flatulence or abdominal discomfort are transitional effects, decreasing significantly with habitual legume consumption over time (66,67), and providing practical tips to reduce flatulence such as increasing consumption gradually (67) and soaking (68). The gas producing oligosaccharides (i.e., raffinose, stachyose and verbascose) are released into the soaking water, thus it is recommended to change the water several times over prolonged soaking and to discard the water before cooking (68). Lastly, providing information and education through varied settings regarding the health and nutritional benefits of legumes may also reduce barriers to consumption (53,59).

1.7. Interventions promoting the use of legumes

To the best of our knowledge, interventions aimed at improving knowledge, attitudes and practices regarding legumes have been executed only among the general public and predominately in Ethiopia (69–73). RCTs were carried out among adolescent girls (69), school age children (70) and women of reproductive age (71). Quasi-experimental studies were carried out among adolescent girls (72) and mother-child pairs (73). All of the interventions improved knowledge, attitudes and practices, except for one intervention among adolescent girls that improved pulse consumption but not knowledge and attitudes (69). Three interventions have been performed in high-income countries (64,74,75). In all three, the sample size was small and a RCT design was not used. Two studies were conducted by an American research team among Colorado adults (64,74), with participants predominately women. The first study (n=56) evaluated a citizen science project (i.e., a 2-week meal plan with 56 pulse-centric recipes corresponding to breakfast, lunch, snack and dinner ideas), aiming to address the barrier of unfamiliarity with pulses and encourage their regular inclusion in daily diets (74). An improvement in knowledge was found, along with a trend towards increasing frequency of consumption, but significance was not reached (74). The second study (n=86) evaluated the effectivity of a 'Bean Toolkit' that included a one-hour online class, informational social media posts and pulse cooking guidance (64). Significant gains in knowledge and attitudes were observed (64). Most participants reported an intention to eat more pulses, and among those who completed the one-month follow-up survey (n = 40), pulse intake frequency significantly increased (64). Lastly, a pilot study (n=32) among Canadian high school students (75) was carried out through a teacher-led nutrition education intervention. An emphasis was put on pulses during a 7-week period among students taking food studies and home economics–commercial cooking classes. Significant improvement in knowledge was found, but not in attitudes or consumption(75).

1.8. Dietitians and legume counseling

The data pertaining to legume knowledge, attitudes and practices among dietitians are limited and out-of-date. Two studies were conducted in Arizona in 2012 and focused solely on beans (76,77); a third study executed in 2000 in Canada evaluated attitudes and practices regarding legumes, but not knowledge (78). Finally, these studies did

not evaluate the factors that may influence adequate legume counseling. One study found that Arizona dietitians were largely aware of the numerous health benefits of beans; however, some gaps in knowledge were identified, for example, legumes' effect on lowering cancer risk (76). The second study focused specifically on bean promotion among diabetic patients and reported that Arizona dietitians were aware of the health benefits of beans, and approximately 80% of participants often or almost always recommended that diabetic patients "eat more beans for good nutrition" (77). Canadian dietitians (78) reported having sufficient knowledge and time for legume counselling, while not having adequate didactic resources. In addition, 64%, 68% and 84% reported they often or always recommend legumes for those with obesity, diabetes and CVD, respectively. Approximately 70% of Arizona dietitians reported consuming beans at least once a week (76), and 64% of Canadian dietitians reported consuming half a cup of cooked legumes at least once a week (78). The majority of dietitians surveyed had positive attitudes towards legume consumption (e.g., liking the taste and finding them easy to prepare) (76,78).

1.9. Dietitians and sustainable diets

Sustainable healthy diets are defined by the FAO as "Dietary patterns that promote all dimensions of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable" (79). The EAT-Lancet Commission global recommendations for sustainable healthy diets issued in 2019, emphasized legumes as the central source of protein in their reference diet. Indeed, legumes meet the above criteria; in addition to their health and environmental merits, they are affordable, shelf stable and traditionally have been a staple food worldwide (80,81).
National dietetic associations (i.e., Canada (14), The UK (82), Australia (83), The US (84), Germany (85) and Italy (86)) and international associations (i.e., Society for Nutrition Education and Behavior (87), The International Confederation of Dietetic Associations (88) and The European Federation of the Associations of Dietitians (89)) have recognized dietitians as key agents for change in the transition from the current Westernized dietary patterns, characterized by an excess of animal-source proteins and of ultra-processed food towards sustainable food systems. This can be achieved through the numerous roles dietitians play throughout the food systems: counseling of

individuals or groups, developing and running health programs in communities, menu planning and procurement for institutions, advising the food industry, working in research and academic settings and affecting food and health policy at the government level. Dietetic Associations have also acknowledged the necessity of providing adequate sustainability training and resources for dietitians and dietetic students (82,83,86–88,90–92).

1.10. Theory-based interventions to change health provider behavior

Theory-based interventions to change health providers' behavior have been found to be more effective than those that are based on researchers' perceptions (93,94). The Behavior Change Wheel (BCW) is a model synthesizing knowledge from 19 behavior change frameworks (Figure 2) (95). The COM-B model forms the center of the BCW, and enables to analyze the capabilities (C), opportunities (O) and motivations (M) people possess, and how they influence (and are influenced by) behavior (B). Each of the three components comprises of two dimensions: 'Capability' is divided into physical and psychological; 'Opportunity' into physical and social; and 'Motivation' into reflective and automatic (95). The Theoretical Domains Framework (TDF) is a validated and integrative theoretical framework developed for behavior change research and cross-disciplinary implementation (93,94). The TDF covers a range of domains known to be applicable to professional behavior change and has been applied across a wide scope of clinical situations (93,96). The TDF is linked to the BCW and can be integrated into it to practically identify and overcome barriers to achieving evidence-based care. The intervention described in this dissertation was designed using these models.

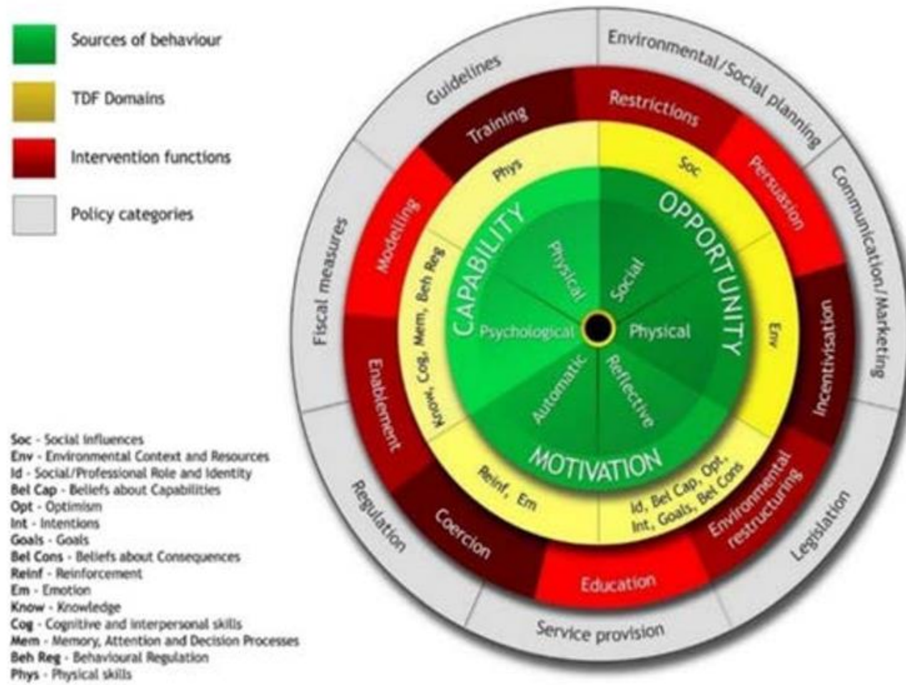

Figure 2. The Behavior Change Wheel

Published with permission Prof Susan Michie. Michie S, Atkins L, West R. The Behaviour Change Wheel. A Guide to Designing Interventions. United Kingdom: Silverback Publishing 2014.

1.11. Research Objectives

The primary aim of this research study was:
Promotion of legume consumption in Israel using dietitians as agents of change.

Specific objectives included:

1- Estimation of legume consumption among the Israeli adult population and characterization of the Israeli legume consumer using the data of the national Israeli Health and Nutrition MABAT Survey (Chapter 1).

2 -Assessment of Israeli dietitians' legume counselling practices, attitudes towards legume counselling and consumption, personal intake, knowledge regarding the health and nutritional attributes of legumes, and identifying which factors are associated with adequate legume counselling (Chapter 2).

3- Development, implementation and evaluation of an evidence and theory-based behavioral intervention aimed to improve Israeli dietitians' knowledge, attitudes, legume counselling practices and personal consumption patterns (Chapter 3).

2. Thesis chapters

2.1. First paper: Legume Consumption among Israeli Adults- Results from a National Health and Nutrition Survey

In accordance with Specific Objective 1, a secondary data analysis from the Israeli Health and Nutrition 2014-2016 MABAT Adult Survey was conducted. Results were reported in the manuscript:

Ofir O, Dor C, Stark AH, Dichtiar R, Shimony T, Bar-Zeev Y, Sinai T. Legume consumption among Israeli adults- results from a national health and nutrition survey. (under review in European Journal of Nutrition)

Legume Consumption among Israeli Adults- Results from a National Health and Nutrition Survey

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Abstract

Purpose: Substantial health and environmental benefits of legume consumption are reflected in dietary recommendations worldwide. However, data regarding legume intake are limited, particularly in Mediterranean countries. This study aimed to estimate and characterize legume consumption in the Israeli population.

Methods: This cross-sectional study used data from the Israeli Health and Nutrition Survey (2014-2016), a nationally representative sample of the population aged 18-64 years. A personal, face-to-face interview was conducted in the interviewee's home using a structured comprehensive questionnaire. Single 24-hour dietary recalls (n=2808) were evaluated to identify legume consumers, including quantity and type of legumes consumed. Consumers were defined as respondents who reported intake of any amount of legume (beans, lentils, peas and soy) or legume-containing products. Demographics, health conditions, and lifestyle habits were compared between legume consumers and non-consumers. Multivariable logistic regression identified factors associated with being a legume consumer.

Results: Legumes were consumed by 31.1% of respondents. Median (interquartile range) daily legume intake among consumers was 40.8g (20.4-74.0), equivalent to ~0.25 cup per day. Chickpeas were most commonly consumed (67.0%), followed by lentils (14.5%) and dry beans (12.2%). Legume consumers were less likely to have chronic comorbidities [OR 0.54 (95% CI:0.37-0.78)], and more likely to be male [OR 1.41 (95% CI:1.2-1.65)] and born in Israel [OR 1.24 (95% CI:1.01-1.51)].

Conclusions: Legume consumption among Israeli adults was substantially below current guidelines. Further studies evaluating legume consumption worldwide and specifically in Mediterranean countries are needed, alongside public health strategies promoting legume consumption as part of healthy, sustainable dietary patterns.

Introduction

Substantial scientific evidence supports the health benefits and environmental advantages of legume consumption [1–4]. Legumes include beans, lentils, peas, chickpeas and soy [5]. Pulses are a subgroup of legumes defined as the non-oil seed varieties, thus excluding soy [5]. Legumes provide protein, B vitamins, and minerals such as iron and zinc [6]. Additionally, they are low in saturated fat and high in dietary fiber and phytochemicals - unlike animal protein sources [6]. This unique nutritional profile may account for the health benefits attributed to legume consumption in the prevention of cardiovascular diseases [7–10], type 2 diabetes[11], colorectal cancer [10] and a decrease in all-cause and stroke mortality [12]. Legume consumption is also recognized as an important factor in the current global efforts to diminish the environmental crisis by decreasing greenhouse gas emissions and reducing use of water, land, and fuel in comparison to animal protein production[1, 13, 14].

The health and environmental merits of legumes have been reflected in dietary guidelines worldwide. The EAT–Lancet Commission global recommendations for healthy and sustainable diets, emphasize legumes as the primary protein source, with daily consumption of ~ 2/3 cup of cooked pulses and 25 g of soy foods[1]. The Dietary Guidelines of the United Kingdom[15], Canada [16], New Zealand [17], and The 2025 Advisory Committee for the Dietary Guidelines for Americans 2025-2030[18] have also declared legumes as a preferred source of protein. The 2020 Israeli Dietary Guidelines include a recommendation for daily legume intake [19]. Data regarding legume consumption globally are limited and outdated. However, the data that does exist show that there is a considerable gap between dietary recommendations and actual consumption levels [20–24]. According to the National

Health and Nutrition Examination Survey (NHANES) 2017–2018., the proportion of legume consumers among Americans was 20.5% with a mean intake among consumers of ~0.3 cup/day [20]. Specifically, the proportion of peas and lentils consumers was 6% [25]. A national survey executed in 2011-2012 among Australians identified 12.3% legume consumers with a median intake of ~0.2 cup/day among consumers [21]. In contrast, dramatically higher rates were found in a nationally representative survey of urban populations from Latin American countries. The average percentage of pulse consumers in 2014-15 was reported to be 60% with a mean intake of ~0.5 cup/day among consumers [26]. According to a review [23] based on the 2018 Global Dietary Database [27], only 11 out of 93 countries had a median legume intake higher than 50 g (~1/4 cup/day) among the general population. Data regarding the median intake only among legume consumers and the percentage of legume consumers among the general population were not provided.

In order to understand the extent of the gap between current guidelines and actual intake, there is a need to obtain comprehensive data regarding legume consumption. The Mediterranean countries may serve as a particularly relevant research area, since traditionally legumes have been an integral component of the Mediterranean diet [28]. Notably, Israel legume consumption may be perceived as sufficient, being a Mediterranean country known for its legume based national dishes [29]. Whether legumes are being consumed in adequate amounts in Mediterranean countries is a question of interest. Therefore, the current study aimed to examine legume consumption among the Israeli adult population and characterize the legume consumer using the data of the most recent nationally representative Health and Nutrition Survey.

Methods

Study design and population

This cross-sectional study is based on secondary data analysis obtained from the Second National Health and Nutrition Survey. The survey was conducted by the Ministry of Health (the Israel Center for Disease Control and the Nutrition Division), and the Central Bureau of Statistics, between March 2014 and May 2016 [30]. This is a nationally representative sample of the population aged 18-64 years and includes 2,957 participants (52.9% women). The survey was approved by the Ethics Committee of the Ministry of Health and written informed consent was obtained upon enrolment. A personal, face-to-face interview was conducted in the interviewee's home using a structured comprehensive questionnaire including socio-demographic characteristics, health conditions and lifestyle habits. The survey questionnaire underwent pretesting and construct validity assessment. Furthermore, standardized procedures and continuous monitoring during data collection and entry ensured accuracy and maintained data quality. Detailed descriptions of the survey design, procedures and questionnaires, can be found online [30]. Briefly, a random stratum sampling was executed, according to population group and locality. In addition, the data were weighted for the total population by weighting factors provided by the Central Bureau of Statistics, based upon age, sex, education, place of birth, population group, and dietary recall day. The questionnaire included a single 24-hour dietary recall, wherein the interviewers asked the participants to describe their food intake on the day prior to the interview. In order to assist the participants in identifying foods, a visual guide containing numerous images of Israeli dishes was used. The interviewers also used measuring cups, tablespoons and teaspoons in order to help respondents estimate the quantities of food consumed. A total of 149 participants were excluded

from this study due to missing data on dietary intake (n= 53) and outlying diet records defined as having an estimated energy intake greater than 5000 kcal (n=14) or lower than 500 kcal (n=82). Therefore, the final sample for this study was n=2,808.

Data collection

Participants' characteristics

Data were self-reported and collected from survey responses, education level was dichotomized to a high school level education or less (≤12 years) or higher education (>12 years). Place of birth was defined as Israel vs. Other. Total household income was dichotomized to below and above the poverty line (~3100 New Israeli Shekels per person) [31]. Participants who performed at least 150 min of moderate-intensity physical activity or 75 min of vigorous-intensity physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity, were identified as meeting the WHO recommendations for adults [32]. Smoking status was dichotomized to never or ever smoked (current and former smoker combined). Alcohol consumption was recorded (type, frequency, and amount) and calculated as grams alcohol/wk. This was categorized to participants who consumed at least one alcoholic beverage a week, of at least 14 g of alcohol (according to the Centers for Disease Control and Prevention (CDC) definition[33]); participants who consumed less than one alcoholic beverage a week, and those who did not consume alcohol on a weekly basis. Comorbidity was defined as reporting a doctor's diagnosis of two or more of the following conditions: hypertension, diabetes, ischemic heart disease, stroke, non-alcoholic fatty liver disease (NAFLD) and cancer. Body mass index (BMI) was calculated from measured weight and height as "weight [kg]/ height [m^2]". Self-reported data were used for individuals with missing information on weight

and/or height (25.4%, n=684). BMI was assessed as a continuous variable and was also categorized according to the World Health Organization (WHO) BMI categories: underweight (BMI <18.5 kg/m^2), normal weight (BMI 18.5 to <25 kg/m^2), overweight (BMI 25 to <30 kg/m^2) and obesity (BMI ≥30 kg/m^2) [34].

Legume intake

In order to calculate the total legume intake from the single 24-hour dietary recall for each participant, legume-containing foods, products, and recipes were retrieved from the Israeli nutritional data base, and categorized according to legume type. The legume percentages in the recipes were calculated using accepted yield factors for cooked legumes [35]. Chickpeas and soy were further categorized according to specific products. Legume consumers were defined as respondents who reported consuming any amount of legumes (beans, lentils, peas, chickpeas and soy; excluding green peas and fresh beans) or legume-containing products. The proportion that just consumed pulses (beans, lentils, peas, chickpeas; soy excluded) was also calculated.

Data analysis

The mean and standard deviation (SD) or median and interquartile range (IQR) of legume intake were determined and the percentage of legume consumers was calculated. Variables potentially influencing intake were compared between legume consumers and non-consumers using Chi-square tests for categorical variables and Mann–Whitney U tests for continuous variables. Multivariable logistic regression was used to determine which factors increased the likelihood of being a legume consumer; odds ratios (ORs) and 95% confidence intervals (95% CIs) are presented. Variables significantly associated with the dependent variable ($p<0.05$) in the bivariate analysis were included in the multivariable logistic regression model; age (in increments of ten years) and sex were included as universal confounders. Two-tailed tests were run, and

statistical significance was set at $p<0.05$. Statistical analysis was performed utilizing SAS statistical software, version 9.4 (SAS Institute, Cary, NC).

Results

Among the 2808 participants included in the study (mean age 39.8±12.4 years, 50.1% women), approximately half (52.4%, n=1549) had a higher education (>12 years) and 16.0% (n=468) lived below the poverty line. Almost half (48.7%, n=1297) were overweight or obese and 7.6% (n=206) reported having two or more comorbidities. A third (33.4%, n=911) of the participants reported meeting the recommendations for physical activity and 62.8% (n=1709) reported they have never smoked (**Table 1**). Legumes were consumed by 31.1% (n=874) of the participants, and pulses were consumed by 28.4% (n=791) of participants. Median (IQR) legume intake among legume consumers was 40.8 g (20.4, 74.6). Median (IQR) legume intake among the general population (legume and non-legume consumers) was 0g (0, 19.5). The most frequently consumed legume was chickpea (68.1% of legume consumers), followed by lentils (13.5%) and dry beans (12.7%). The least frequently consumed legumes were mung beans and lupine (0.2%; 0.1%, respectively). The legumes consumed in the highest amounts were lentils with a median (IQR) daily intake of 54.7 g (19.5, 111.4), lupine: 60 g (60.0, 75.0), beans: 50 g (33.3, 97.1), and fava beans: 50 g (29.17, 89.77) (**Table 2**). Hummus was consumed by more than half (55.2%) of legume consumers and by 81.1% of chickpea consumers, however in relatively small amounts [27.2 g (20.4- 49.8)] (**Table 3**). Soy was eaten by 8.8% of legume consumers and soy drinks were the most frequently used product, drunk by 58.0% of those reporting soy intake (**Table 3**).

In the bivariate analysis, compared to non-legume consumers, legume consumers were more likely to be men (47.5% vs. 55.2%, $p<0.001$) and to be born in Israel

(74.6% vs. 80.8%, p=0.005). Both groups were similar in age, level of education and income. Legume consumers were less likely to report a physician's diagnosis of hypertension (14.1% vs. 16.7%, p = 0.017), NAFLD (3.9% vs. 11.5%, p = 0.046), stroke (0.7% vs. 1.9%, p = 0.018), cancer (1.7% vs. 3.4%, p = 0.028), and overall comorbidity (4.7% vs. 8.9%, p <0.001). BMI, smoking status, alcohol consumption, and adherence to physical activity recommendations did not differ between the groups (**Table 1**).

Figure 1 presents the multivariable logistic regression results for factors associated with being a legume consumer. Legume consumption was associated with 46% lower odds to suffer from comorbidities [OR 0.54 (95% CI:0.37-0.78), p= 0.001], 41% higher odds to be male [(OR 1.41 (95% CI 1.2-1.65), p= <0.001)], and 24% higher odds to be born in Israel [(OR 1.24 (95% CI 1.01-1.51) p= 0.038)].

Discussion

This nationally representative sample of Israeli adults indicates that legume consumption in Israel is substantially below the current EAT–Lancet Commission global recommendations of ~2/3 of a cup per day [1]. Less than a third of the participants reported eating legumes with a median intake of approximately 0.25 cup/day. In addition, more than half of legume consumers reported consuming legumes in the form of hummus (Chickpea spread), with an average intake of one tablespoon per day. Legume consumers were less likely to report comorbidities and more likely to be male and born in Israel.

Despite the low proportion of legume consumers in this study, it was higher than the rates previously reported in Australia [21], USA [20] and Canada [36], but lower than Latin America [26]. It is important to note that legume classification differed between studies, thus limiting comparison. Legumes were defined in this study as pulses

(beans, lentils, peas) and soy, similarly to the Australian survey in which the rate of legume consumers was considerably lower (12.3%) [21]. The US [20] and Canadian [36] surveys analyzed solely pulse consumption, reporting 20.5% and 13% consumers, respectively. These rates were lower than the 28.4% pulses consumption rate found in this study. Conversely, an almost twofold higher rate of 60% legume consumers was found among Latin Americans [26], with legumes defined as beans, lentils, chickpeas and green peas. A rate of 44% legume consumers was reported in Sweden; however, the legume definition in this study was exceptionally broad and included foods typically classified as vegetables (i.e., fresh beans, snap peas and sprouts) or as nuts (i.e., peanuts and peanut butter). Additionally, the Swedish study recorded a longer dietary intake period of 4 days, which further limits direct comparison with our findings.

Among legume consumers, the low legume intake of ~0.25 cup/day observed in this study is comparable to that reported in Australia [37], USA[20] and Sweden [22]. A higher daily intake of ~0.5 cup and 2/3 cup was reported in Latin America [26] and Canada [36], respectively. The most frequently consumed legumes in this study were chickpeas, followed by lentils and beans, which were consumed in significantly smaller amounts. Most studies did not report the type of legume consumed, but available data show markedly different preference patterns. Beans (pinto, black and kidney) predominated in the American data, followed by lima bean, chickpeas, great northern beans and lentils, as reported by grocery store purchases by cost [20]. Mung beans were the most frequently consumed pulse in Canada, followed by kidney beans, lentils and chickpeas [36].

In this study legume consumers were similar to non-consumers in age, level of education and income. While legume consumption was not associated with income in

previous studies [20, 21, 26, 36]; some studies found a positive association with education[20, 22] and age [22, 36]. In accordance with our study, BMI was not found to be associated with legume consumption in Sweden [22] and Australia[21]. Smoking, alcohol consumption and physical activity were also not associated with legume consumption in this study. To the best of our knowledge, previous studies did not report these health behaviors [20, 21, 26, 36], an exception was observed in a Swedish study, which reported an inverse association between legume and alcohol consumption [22]. The lack of association with education and health related behaviors observed in Israel might be related to the overall unsatisfactory consumption patterns among legume consumers. It may also reflect a lower public awareness regarding the health benefits of legumes compared to other food groups, such as vegetables, whose intake is typically associated with higher education and health-related behaviors [38, 39].

Legume consumers in this study were less likely to report having two or more morbidities. Non-communicable diseases were not reported in other studies [20–22, 26, 36]; however, substantial evidence from cohort and clinical research has demonstrated the role of legume consumption in the prevention and management of chronic diseases [7, 8, 10, 11]. None-the-less, as this is a cross-sectional study, these data cannot determine causality.

Legume consumers in this study were more likely to be men and to be born in Israel. Similarly, more men were found among Latin American legume consumers [26]; however, no association to sex was found in other studies [20–22, 36]. The Israeli cuisine traditionally incorporates legume-based dishes [29], while most of the participants who were not born in Israel reported being born in Europe, where legumes are less common in the cuisine [40]. Ethnicity was found to be associated

with legume consumption also among Hispanic individuals in USA[20] and among individuals of Asian, Arabic and Latin descent in Canada [36].

Key known barriers to legume consumption include a long preparation time [37, 40], concerns about flatulence [40, 41] and insufficient knowledge on preparation methods [37, 42–44]. Considering the critical role legumes play in both human health and environmental sustainability, developing interventions to increase their consumption is both timely and essential.

Israeli dietitians' recommendations for legume consumption and their personal intake were found to be substantially below the guidelines of daily legume consumption [45]. It is important to note that this survey among Israeli dietitians [45] was carried out after the publication of the 2020 Israeli Dietary Guidelines, indicating that a fundamental step in bridging the vast gap between dietary guidelines and actual legume consumption might be informing, training and empowering dietitians to act as agents for change promoting legume intake among the general public [45].

The strengths of this study include the use of data from a large nationally representative sample. Internal validity was strengthened by the use of validated measurement tools, standardized protocols, and interviews conducted by trained personnel. To the best of our knowledge, this is the first study executed in a Mediterranean country to comprehensively estimate and characterize legume consumption, providing important data regarding the current implementation of this aspect of the Mediterranean diet. The study has some limitations; despite it being a well-known and validated dietary assessment method, a single 24-h dietary recall may not reflect the habitual diet. The large sample size and the data representing different days across the week aid in mitigating this limitation. Secondly, although this study is based upon the most recent national survey performed among Israeli adults, the data

were collected between 2014-2016. However, currently available data from other countries are similarly from these years [20, 26] or earlier [21, 22, 36].

Conclusions

This study is the first to comprehensively estimate and characterize legume consumption in a Mediterranean country. Legume consumption among Israeli adults was substantially below current guidelines. Legume consumers were less likely to report comorbidities and more likely to be male, and born in Israel. Evaluating current legume consumption is a fundamental step in striving towards the global task of promoting legume intake as a sustainable and healthy protein source. Further similar studies worldwide and specifically in Mediterranean countries are needed.

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Table 1. Sociodemographic and health-related characteristics of legume consumers and non-consumers (n=2808)

Variable	N total	All (n=2808)	Legume Consumers (n=874) n (%)	Non-Legume consumers (n=1934) n (%)	p value
Age, y (mean ± SD)	2808	39.8±12.4	39.3±12.2	40.1±12.5	0.11
Sex, % women	2808	1467 (50.1)	407 (44.8)	1060 (52.5)	<0.001
Education, % ≥12y	2755	1206 (47.6)	377 (46.8)	829 (47.9)	0.99
Income, % < poverty line	2158	468 (16.0)	150 (16.9)	318 (15.7)	0.86
Place of birth, % Israel	2808	2134 (76.6)	694 (80.9)	1440 (74.7)	0.005
BMI, kg/m^2 (mean ± SD)	2697	25.5±5	25.5±5.2	25.6±4.9	0.32
BMI categories[1]	2697				0.19
Underweight, %	115	115 (4.5)	45 (5.4)	70 (4.1)	
Normal weight, %	1285	1285 (46.8)	401 (47.2)	884 (46.7)	
Overweight, %	833	833 (31.2)	247 (29.1)	586 (32.1)	
Obese, %	464	464 (17.5)	152 (18.3)	312 (17.1)	
Morbidity[2] (% yes)	2767	206 (7.6)	40 (4.7)	166 (8.9)	<0.001
Hypertension (% yes)	2757	424 (15.9)	111 (14.1)	313 (16.7)	0.017
Diabetes (% yes)	2774	227 (8.3)	61 (6.9)	166 (9.0)	0.14
NAFLD (% yes)	2763	151 (5.3)	36 (3.9)	115 (11.5)	0.046
Ischemic heart disease (% yes)	2765	103 (3.9)	31 (3.9)	72 (3.9)	0.82
Cancer (% yes)	2768	84 (2.8)	17 (1.7)	67 (3.4)	0.028
Stroke (% yes)	2767	46 (1.6)	7 (0.7)	39 (1.9)	0.018
Physical activity as recommended[3], %	2732	911 (33.4)	176 (30.1)	735 (34.1)	0.97
Smoking status, % Never smoked	2746	1709 (62.8)	535 (63.5)	1174 (62.4)	0.99
Weekly alcohol serving	2718				0.18

Non consumers, %	1229	1229 (45.7)	399 (47.9)	830 (44.8)	
< 1 portion/week, %	711	711 (26.6)	227 (26.4)	484 (26.6)	
≥ 1 portion/week, %	778	778 (27.7)	223 (25.7)	555 (28.6)	

Calculated with the application of sample weights of the Second Israeli National Health and Nutrition Survey.

[1] Underweight- BMI <18.5 kg/m^2; normal weight- BMI 18.5 to <25 kg/m^2; overweight- BMI 25 to <30 kg/m^2; obesity BMI ≥30 kg/m^2.

[2] Diagnosed with two or more of the following conditions: hypertension, diabetes, ischemic heart disease, stroke, non-alcoholic fatty liver disease and cancer (self-reported physician diagnosis).

[3] At least 150 min of moderate-intensity physical activity or 75 min of vigorous-intensity physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity, was identified as meeting the WHO recommendations for adults.

Abbreviations: BMI, Body Mass Index; NAFLD, Non-alcoholic fatty liver disease

Table 2. Characteristics of consumption by legume variety among legume consumers (n=874)

Legume variety	Consumers n (%)	Median (g/day) (IQR)
Chickpeas	586 (67.0)	34.0 (20.4,62.0)
Lentils	127 (14.5)	54.7 (19.5,111.4)
Beans	107 (12.2)	50.0 (33.3,97.1)
Soy	83 (9.5)	50.0 (29.2,89.8)
Dry peas	33 (3.8)	36.7 (23.9,50.0)
Fava bean	12 (1.4)	50.0 (29.2,89.8)
Mung beans	2 (0.2)	39.0 (13.4,39.0)
Lupine	2 (0.2)	60.0 (60.0,75.0)

Abbreviations: IQR- interquartile range

Table 3. Characteristics of Consumption by Chickpea (n=586) and Soy (n=83) Variety

Legume variety	Consumers n (%)	Median (g/day) (IQR)
Chickpea variety (n=586)		
Hummus	462 (81.1)	27.2 (20.4,49.8)
Chickpea beans	100 (15.0)	21.0 (8.8,57.3)
Falafel	74 (13.5)	59.4 (38.8,77.6)
Chickpea flour	5 (0.7)	32.4 (19.0,36.0)
Roasted chickpea	1 (0.1)	124.0 (124.0,124.0)
Soy variety (n=83)		
Soy milk	49 (58.0)	15.6 (7.8,23.4)
Tofu	16 (19.5)	32.7 (30.0,66.3)
Edamame	6 (9.3)	120.0 (18.0,350.0)
Soy yogurt	6 (5.6)	16.6 (19.8,47.5)
Miso	4 (4.9)	250.0 (50.0,356.0)
Soy chunks	2 (2.4)	146.0 (53.5,146.0)
Soy flour	2 (3.0)	44.2 (5.2,44.2)
Soybeans	1 (1.6)	5.0 (5.0,5.0)

Abbreviations: IQR- interquartile range

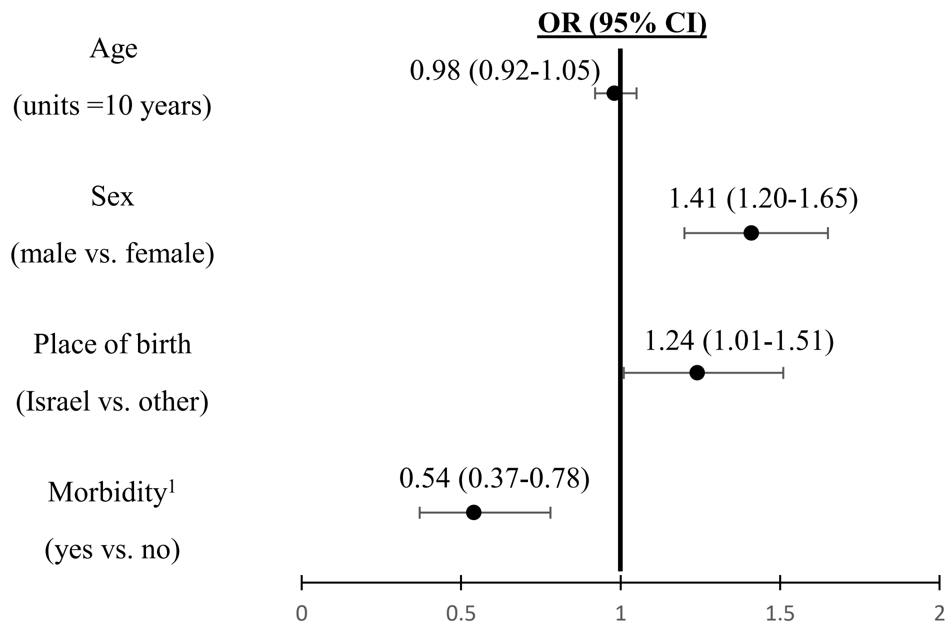

Fig. 1 Factors associated with legume consumption among Israeli adults

[1] Diagnosed with two or more of the following conditions:
hypertension, diabetes, ischemic heart disease, stroke, non-alcoholic fatty liver disease, and cancer (self-reported physician diagnosis).

2.2. Second paper- Promotion of Legume Intake- Israeli Dietitians' Knowledge Beliefs and Practices

In accordance with Specific Objective 2, an online, self-reported survey was carried out among Israeli dietitians. Results were published in the article:

Ofir O, Stark AH, Bar-Zeev Y. Promotion of legume intake- Israeli dietitians' knowledge, beliefs and practices. J Public Health (Oxf). 2024;46(3):e468-e476. doi:10.1093/pubmed/fdae055

Insufficient Promotion of Legume Consumption – Israeli Dietitians' Knowledge, Beliefs and Practices

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ABSTRACT

Background: Health and environmental benefits of legume consumption are reflected in dietary guidelines worldwide. However, legume intake fails to meet recommendations. Dietitians' legume counselling practices can impact consumption patterns. This cross-sectional study assessed Israeli dietitians' knowledge, attitudes, perceptions and practices regarding legume counselling and identified pertinent barriers and facilitators.

Methods: An electronic survey among Israeli dietitians (n=309) was performed. Multivariable logistic regression assessed associations between recommending legumes with participants' socio-demographic and professional characteristics, knowledge, perceptions, attitudes towards legume counselling and personal legume intake.

Results: Almost half (47.4%) of the participants recommended to 76% or more of their patients to increase legume intake. Factors that were associated with recommending legumes were perception of fewer barriers for consumption [Adjusted OR (aOR) 1.92 (95% CI 1.24-2.96)] and positive attitudes towards legume counselling pertaining to its importance [aOR 1.95 (95% CI 1.12-3.4]. Negatively associated factors were a low level of personal legume consumption [aOR 0.38 (95% CI 0.15-0.94)] and working in hospitals [aOR 0.43 (95% CI 0.19-0.98)].

Conclusions: Israeli dietitians' recommendations for legume consumption were well below current guidelines. These findings indicate the need for a tailored intervention for nutrition professionals to increase the frequency of legume counselling and overall consumption.

INTRODUCTION

Legumes (beans, lentils, peas and soy) are protein sources with unique nutritional advantages (low in saturated fat, high in dietary fiber, phytochemicals and minerals). [1] Legumes have been shown to provide health benefits for the prevention and management of type 2 diabetes [2,3] cardiovascular diseases (CVD) [4,5] and colorectal cancer. [6] Legume consumption is also acknowledged as a vital component in global endeavors to combat the ecological crisis, by decreasing greenhouse gas emissions and the reduced use of land, water and fuel in comparison to animal protein production. [7–9] The health and environmental benefits of legumes are reflected in dietary recommendations worldwide. The EAT–Lancet Commission recommends use of legumes as the primary protein source with daily consumption of ~2/3 cup of cooked pulses [8]. The most recent dietary guidelines for the UK [10], Canada [11] and New Zealand [12] emphasize legumes as a preferable source of protein. Lastly, the Israeli Dietary Guidelines (2020) recommend daily legume intake. [13]

A substantial gap exists between guidelines and actual legume intake worldwide**.** Legume intake per day was far below The EAT–Lancet Commission recommendations and national guidelines in all G20 countries (intergovernmental forum comprising 19 countries and the European Union), apart from Brazi.l[14] Israel's legume intake is also low, according to the 2014-2016 national nutrition survey legumes were consumed by 31% of Israelis with mean intake among consumers of ~ 0.3 cup/day (Israel Ministry of Health , 2022, secondary data analysis, unpublished results).

Previous studies have identified various barriers to legume consumption, including a long preparation time [15,16], flatulence [15,17], insufficient knowledge on preparation and cooking methods and a dislike of the taste or texture. [16,18–20]

Dietitians play a salient role in affecting consumption patterns. Therefore, gaps in their knowledge regarding legume health attributes, unfavorable perceptions or low personal use, could hinder their ability to promote legume consumption among their clients.

The data pertaining to legume knowledge, attitudes and practices among dietitians are limited and outdated. [21–23] Two studies were conducted in Arizona in 2012 and focused solely on beans; a third study executed in 2000 in Canada evaluated attitudes

and practices regarding legumes, but not knowledge. [23] Lastly, these studies did not evaluate the factors that may influence adequate legume counselling.

The aims of this study were to assess Israeli dietitians' legume counselling practices, attitudes towards legume counselling and consumption, personal intake, knowledge regarding the health attributes of legumes, and ultimately to identify which factors were associated with adequate legume counselling. Findings from this study will help develop a tailored behavioral intervention aimed at improving dietitians' knowledge, attitudes and practices regarding legume counselling.

METHODS

Design

An online cross-sectional survey was carried out from August to September 2020.

Population

Eligible participants were Israeli dietitians who currently counsel patients. Dietitians that work in the food industry or in the public health sphere were excluded.

Procedure

A link to an online survey was disseminated via: a) the electronic mailing list of ATID- the Israeli Dietetic Association (n= 2452), b) personal communications with head dietitians in the four Israeli Health Maintenance Organizations (HMO), c) posting on relevant Facebook groups. No incentives or compensation were provided for completion of the survey. The study was exempt from IRB approval by the Ethics Committee of our institution. Completing of the survey was deemed as consent for study participation.

Data collection tool

The survey (Supplementary File 1) was based on adaptation of questions from previous surveys regarding legume consumption among dietitians [21,23] and the general public. [18,24] Additionally, the questions regarding attitudes toward counselling were based on the Theoretical Domains Framework (TDF) and the COM-B behavior change model (Capability, Opportunity and Motivation Model of Behaviour change) (Supplementary File 2). [25–27] Both are validated and integrative models of behavior change and have been applied across a wide scope of clinical situations. [28]

The survey was reviewed by five experienced public health researchers who specialize in survey development. Subsequently it was pre-tested with eight dietitians

who work with different populations and have various clinical proficiencies. At each stage, the survey was clarified and modified. The final survey, in Hebrew, required 10-15 minutes to complete. The survey included five sections:

a) Socio demographic and professional characteristics including age, sex, education, primary workplace, years in practice, average number of patients per week, average number of meetings per patient, and area of expertise (e.g., obesity, diabetes and CVD); participants were asked to report up to four areas of expertise).

b) Personal legume intake was measured with the question: "How often do you consume legumes (not including soy milk in coffee)?" recategorized to 3 times a month or less, once a week, 2-3 times a week, 4 times a week or more.

Personal diet pattern was defined and categorized as omnivore, flexitarian (reduced meat intake), vegetarian + vegan.

c) Legume intake counselling to patients: The primary outcome was measured on a Likert scale as the proportion of patients that the dietitian recommends to increase legume consumption (76-100%; 51-75%; 26-50%; less than 25%; none dichotomized to 76-100% and 75% or less). Participants who recommended 76% or more of their patients to increase legume intake were labeled 'legume-oriented dietitians'; while those who made recommendations to 75% or less of their patients were labeled as 'non-legume oriented dietitians'. Two additional questions differentiated between the proportion of all patients that the dietitian recommended daily legume consumption, and a question specifically for vegans\ vegetarians or flexitarians patients, using the same Likert scale.

d) Legume perceptions were assessed by 11 statements regarding legume nutritional and health benefits and potential barriers for consumption. Each statement was measured using a 5-point Likert scale of "strongly agree" (5) to "strongly disagree" (1). In order to reduce the number of variables in the analysis, a principal factor analysis was performed. The 11 statements were reduced to three factors: 'legume advantages' included five statements pertaining to legume nutritional and health benefits; 'legume acceptability' included three statements regarding possible barriers and 'legume digestibility' included 2 statements focused on potential barriers due to digestion problems. For each factor, a mean composite perception score was created. Statements that were framed negatively were reversed such that all statements scores

would be in the same direction, i.e. a higher mean composite score corresponds to a higher positive attitude.

e) Attitudes toward legume counselling were measured with 11 statements based on the TDF and COM-B model; e.g., level of confidence, sufficient time and didactic resources and importance for the participants and their colleagues, measured with the same Likert scale as above. The same process mentioned above was implemented, with a principal factor analysis reducing the 11 attitude statements to three factors: 'resources and confidence' which included five statements; 'importance' which included four statements; and 'sustainability' which included 2 statements. For each factor, a mean composite attitude score was created.

f) Knowledge was measured using seven true/false/don't know statements pertaining to health, nutritional and ecological attributes of legumes. A composite knowledge score was constructed by summing the number of correct answers (scale 0-7).

*g) Data to develop future intervention*s included questions regarding preferred resources and topics to be included in a future intervention, and questions concerning perceptions of patients' legume knowledge, attitudes and consumption.

Data analysis

A descriptive analysis was performed; categorical variables were reported as frequencies and percentages and continuous variables as means and standard deviations. Bivariate analysis was conducted using the Chi-square test or the Fisher exact test as appropriate for categorial variables, and Student's T-Test or Wilcoxon rank sum test for continuous variables.

Variables found in the bivariate analysis to be significantly associated or near significantly associated with the dependent variable ($p<0.2$) were included in the multivariable analysis. Age was included as a universal confounder.

There was no indication for multi collinearity between attitudes toward legume counselling and legume perceptions, and between personal legume consumption and personal diet pattern.

Principal factor analysis was performed on attitudes toward legume counselling and legume perceptions. A Varimax rotation was applied to extract the number of factors. Sensitivity analysis was repeated after excluding the dietitians who specialize in gastroenterology, assuming that they may possess different counselling patterns and perspectives due to potential negative digestive effects of legumes on their patients.

The level of significance for all tests was set to 0.05. All statistical analyses were performed using the SAS® software (Enterprise Guide 7.1 SAS Institute, Cary NC, USA).

RESULTS

A total of 340 dietitians entered the survey with 312 eligible (those who currently counsel patients). Three participants had a high percentage of missing data and/or inconsistencies and were excluded from the analysis. Therefore, the final sample included 309 participants.

Socio demographic and professional characteristics

The sample was comprised of 96.5% (n=298) women, with a mean age of 41 (±10.6) years old. Mean years in practice was 13.12 (±10.7) with approximately half of respondents holding a Master's degree or higher (Table 1). Main workplaces were HMO (35.6%, n=108), hospitals (30.4%, n=92) and private clinics (16.8%, n=51). The most common areas of expertise were obesity (67.6%, n=208), diabetes (47.6%, n=147), CVD (25.9%, n=80), healthy eating promotion (22.7%, n=69), infants and children (21.7%, n=67) and geriatrics (19.7%, n=61). Only 5.5% (n=17) of the total sample consumed legumes daily, and over a fifth (20.7%, n=63) consumed legumes 3 times a month or less (Table 1).

Legume intake counselling to patients

Almost half (47.4%, n=146) of the participants were 'legume-oriented dietitians' (Table 1), i.e., recommending to 76% or more of their patients to increase legume intake. Only 30.6% (n= 94) recommended to 76% or more of their patients to consume legumes daily while 84.6% (n= 261) recommended to 76% or more of their vegan\vegetarian\ flexitarian patients to consume legumes daily. The percentage of 'legume-oriented dietitians' remained constant (47.2%) after exclusion of dietitians who specialized in gastroenterology (n=54).

Legume perceptions and attitudes towards legume counselling

Table 2 provides the mean score for each perception and attitude separately, and the composite mean score for each factor. Overall, for the composite perception scores there was a high level of agreement for statements on advantages of consuming legumes (4.31±0.55), a lower level of agreement regarding legume acceptability (3.59±0.64) and a low level of agreement regarding legume digestibility (2.82±0.78).

For the composite attitude scores, there was a high level of agreement with statements regarding confidence (3.98± 0.67) and importance (4.22± 0.52) of counselling patients regarding legume consumption as well as regrading sustainability (3.98± 0.89). However, there was a low level of agreement regarding the individual statement of having enough didactic resources (2.74 ±1.22).

Knowledge

The mean knowledge score was 5.17±1.21 (Table 1). Table 3 presents the proportion of correct answers for each knowledge statement. Approximately 53% of the dietitians erroneously considered legumes as an inferior protein source in comparison to animal protein, according to dietary guidelines worldwide; conversely, 96.7% of dietitians correctly identified legumes as an environmentally friendly source of protein in comparison to animal protein. Less than a quarter (23.5%, n=72) of participants did not know that the amount of protein in one egg is similar to that of half a cup of cooked chickpeas and 16.3% (n=50) did not know that it is not necessary to combine legumes and grains in a single meal in order to obtain a high-quality protein (Table 3).

Data to develop future interventions

Perceived patients' knowledge, attitudes and practice: Approximately 79% (n=243) of the dietitians agreed that most patients do not consume legumes on a regular basis, and 85% (n=263) agreed that patients do not necessarily know what legumes are, often confusing them with foods like rice, quinoa and sesame. Dietitians perceived digestion concerns (4.32 ±0.8) as the top patients' barrier regarding legume consumption (Supplementary File 3).

Resources and tools for promoting legume counselling: Dietitians expressed the highest interest in the topic of 'Ways to improve legume digestion' to be included in a future workshop regarding legume counselling (4.46 ±0.85). Brochures regarding how to incorporate legumes in different meals over the course of the day (4.62 ±0.67) and about legume preparation and cooking (4.61 ±0.76) were scored as the didactic resources that would aid the most in promoting legume consumption among patients in the clinical setting (Supplementary File 3).

Factors associated with legume intake counselling to patients

Table 1 provides the socio-demographic, work-related, knowledge and the different perception and attitude composite scores across 'Legume- oriented' and 'non-legume

oriented' dietitians. Both groups were similar in age, level of education, years in practice, number of patients per week and number of meetings per patient. 'Legume-oriented dietitians' were less likely to work in a hospital setting (21% vs. 38.8%, p=0.01), more likely to consume legumes 4 times a week or more (27.8%, vs. 14.3% ,p=0.001), and less likely to consume 3 times a month or less (12.5% vs. 28%, p=0.001) compared to 'non-legume oriented dietitians'. Only 5.5% of our sample consumed legumes daily, with no significant difference between 'Legume-oriented dietitians’ (n=9) and ‘non-legume oriented dietitians' (n=8) (p=0.625). ‘Legume-oriented dietitians' had higher knowledge scores (5.39±1.16 vs. 4.98±1.21, p=0.003); higher mean composite score of perceptions regarding legume advantages (4.44 ± 0.51 vs. 4.19 ± 0.55, p=0.001), and legume acceptability (3.74 ± 0.62 vs. 3.45 ± 0.64, p=0.001); and higher mean composite score for all three of the attitudes factors (Table 1). No significant differences were found between 'Legume-oriented dietitians’ and ‘non-legume oriented dietitians' in ‘perceived patients’ knowledge, attitudes and practice’ or in ‘resources and tools for promoting legume counselling’ (Supplementary File 3).

Table 4 presents the multivariable logistic regression results for factors associated with legume intake counselling to patients. Compared to dietitians working in private clinics, those working in a hospital setting had lower odds of being ‘legume-oriented' [aOR 0.43 (95% CI 0.19-0.98)]. Participants with a low level of personal legume consumption (3 times a month or less) had lower odds of being ‘legume- oriented, compared to participants that ate legumes 4 or more times a week [aOR 0.38 (95% CI 0.15-0.94)]. Only perceptions of 'acceptability' [aOR 1.92 (95% CI 1.24-2.96)] and attitudes regarding ‘importance’ [aOR 1.95 (95% CI 1.12-3.4] were significant in the multivariable analysis.

DISCUSSION

Main finding of this study

This study found that although Israeli dietitians view legume consumption as beneficial, recommendations to increase consumption are well below the current Israeli guidelines. Factors that were associated with recommending legumes to clients were higher personal legume intake, not working in hospitals, higher acceptability of

legume consumption and more favorable attitudes toward legume counselling pertaining to importance.

What is already known on this topic

A pilot study performed among Arizona dietitians found that approximately 80% of participants often or almost always recommended that diabetic patients "eat more beans for good nutrition".[22] Among Canadian dietitians, 64%, 68% and 84% reported they often or always recommend legumes for those with obesity, diabetes and CVD, respectively. [23] These studies provide partial data regarding legume intake recommendations and thus are unsuitable for direct comparison with the current study. Nevertheless, considering that these health conditions were the most common areas of practice among our participants, a lower rate of recommendations for increasing legume intake was found in this study.

What this study adds

Identifying dietitians' practices regarding recommendation of legumes to their patients is a vital step in the current global endeavor to increase legume consumption. This is the first study to comprehensively assess this issue and the factors that may influence adequate legume counselling, The 2020 Israeli Dietary Guidelines include legumes in a category of foods recommended for consumption at least once a day. In this study, approximately a third of the dietitians made this recommendation to most or all their patients. In contrast, 85% of participants recommended this to most or all of their vegan, vegetarian and flexitarian patients. While this rate is markedly higher, it is still inadequate considering legumes are a prominent source for protein, zinc and iron in well-planned plant-based diets.[29] Presumably, the recommendation to "increase legume intake" rather than the recommendation to "consume legumes every day" is easier to implement. However, even this more acceptable recommendation was provided to most or all patients by less than half of the participants, suggesting that dietitians are not providing counselling that is consistent with national guidelines. Legume intake among dietitians in this study was comparable to previous studies from Canada [23] and Arizona [21] , and is far below the current guidelines. 'Legume-oriented dietitians' were less likely to consume legumes three times a month or less. This relationship between personal behavior and professional practice has been reported in other studies among dietitians [30] and should be taken into consideration when planning interventions. Specifically, tailoring programs to focus on promoting

legume intake among dietitians that consume limited amounts, rather than among those who already eat legumes regularly. In addition, ‘legume-oriented dietitians’ were less likely to work in hospitals. Possible explanations for this might be that nutritional counselling in hospital settings is more time restricted, lacking follow-up and more focused on the acute needs of the patient. Specifically in our sample, dietitians working in hospitals had a lower agreement score with the statement concerning having sufficient time to counsel patients regarding legumes, compared to dietitians working in other clinical settings (data not shown). The overall sample, and even more so in ‘legume-oriented dietitians’, reported having sufficient knowledge and time for legume counselling, while not having adequate didactic resources. Similar results were found in Canadian dietitians. [23] There may be a greater necessity for supplemental didactic resources when counselling patients regarding legumes in order to overcome the barrier of insufficient familiarity with the foods included in this group. The majority of the dietitians in this study agreed that patients do not necessarily know what legumes are, and it is interesting to note that a lack of familiarity with the term 'pulses' was highly present in the Canadian survey. [23] Additionally, only 68.5% of the surveyed Arizona dietitians correctly defined the term legumes, with approximately a third responding that the term referred only to beans. [21]

Legume counselling was overall perceived as important and that should be included more in the dietitian's practice, with more favorable views among ‘legume-oriented dietitians'. The level of importance attributed to legume counselling may be related to dietitian’s familiarity with current guidelines concerning both health and environment. Although having an overall positive view of legumes as a protein source in aspects of quality, quantity and environmental friendliness, more than half of the dietitians in this study agreed with the statement that “Dietary guidelines worldwide define legumes as an inferior protein source in comparison to animal protein". This knowledge gap may reflect a lack of exposure to newer guidelines which recommend legumes as the preferable protein source, based on their environmental and health advantages. [8,10–12]

A fundamental step in achieving the goal of increasing legume intake is making sure that dietitians do in fact make this recommendation to their clients. It is essential to update dietitians regarding the prominent place legumes possess in the current dietary

guidelines. These findings indicate the need to design and implement an intervention to increase dietitian's legume counseling.

Limitations of this study

Generalizability is limited when a convenience sample is used; however, the sex and age distribution of our sample was very similar to that of the entire Israeli dietitian population, indicating that our sample was representative in those regards (Personal communication, Ministry of Health). Response bias is possible because those surveyed could represent dietitians with greater interest in legumes leading to over-representation of 'legume-oriented dietitians'. Thus, the true rate of legume counselling may be even lower than reported here.

Conclusions

Israeli dietitians' recommendations for legume consumption and their personal legume intake fail to meet the current guidelines, despite possessing overall positive views towards legume counselling and legume consumption. Considering the pivotal role legumes play in both health and environmental realms, it is critical to inform and empower dietitians to act as agents for change promoting legume consumption among the population. Providing sustainable nutritional guidelines is of global importance; every country has a responsibility to evaluate its practices and intervene in an appropriate fashion.

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Table 1. Socio-demographic, work-related, knowledge and attitudes of Israeli dietitians toward legumes, total sample and by practice of recommendation of legumes to patients (n=309)

Variable	Total sample, n=309 (n,%)	Legume intake recommendations to patients		p-value
		Legume oriented dietitians n=146	Non-legume-oriented dietitians n=163	
Age (mean ± SD)	41±10.62	42.08±10.77	40.23±10.43	0.183
Education - Master degree or higher	153 (50.2%)	76 (52%)	77 (48%)	0.418
Main workplace				
Hospital	92 (30.4%)	30 (21%)	62 (38.8%)	0.01
HMO	108 (35.6%)	56 (39.2%)	52 (32.5%)	
Private clinic	51 (16.8%)	28 (19.6%)	23 (14.4%)	
Other [1]	52 (17.2%)	29 (20.3%)	23 (14.4%)	
Years in practice (mean ± SD)	13.12± 10.67	13.41± 10.46	12.93± 10.93	0.281
Number of patients per week (mean ± SD)	28.29± 19.23	29.9± 22.33	26.9± 15.92	0.561
Number of meetings per patient (mean ± SD)	8.5 ±9.9	8.62±8.76	8.4±10.94	0.391
Personal legume consumption				
At least 4 times a week	63 (20.7%)	40 (27.8%)	23 (14.3%)	0.001
2-3 times a week	113 (37%)	59 (41%)	54 (33.5%)	
Once a week	66 (21.6%)	27 (18.8%)	39 (24.2%)	
3 times a month or less	63 (20.7%)	18 (12.5%)	45 (28%)	
Personal diet pattern				
Omnivore	163 (53.4%)	69 (47.9%)	94 (58.4%)	0.173
Flexitarian	95 (31.2%)	49 (34%)	46 (28.6%)	

Vegetarian+ vegan	47 (15.4%)	26 (18.1%)	21 (13%)	
Legume perceptions[2]				
Advantages	4.31 ± 0.55	4.44 ± 0.51	4.19 ± 0.55	0.001
Digestibility	2.82± 0.78	2.79 ± 0.79	2.85 ± 0.77	0.518
Acceptability	3.59± 0.64	3.74 ± 0.62	3.45 ± 0.64	0.001
Attitudes toward legume counseling[2]				
Resources and confidence	3.98 ± 0.67	4.16 ± 0.56	3.82 ± 0.72	0.001
Sustainability	3.98± 0.89	4.11 ± 0.89	3.86 ± 0.88	0.016
Importance	4.22±0.52	4.35 ± 0.47	4.11 ± 0.54	0.001
Knowledge (mean composite score)[3]	5.17± 1.21	5.39 ± 1.16	4.98 ± 1.21	0.003

Abbreviations: HMO, Health Maintenance Organizations

[1]Other: retirement home (n=19, 6.2%), university/research institute (n= 15 , 4.9%), public health (n=11 , 3.6%), gym (n= 3, 1%) medical clinic (n=2 , 0.7%) and food industry (n=2 , 0.7%).

[2] The score is a 5-point Likert scale of “strongly agree" (5) to "strongly disagree" (1); the statements of legume perceptions and attitudes toward legume counseling are featured in Table 2, respectively.

[3] Knowledge score was constructed by summing the number of correct answers (scale of 0-7); the statements are featured in Table 3.

Missing: age n=14, education- Master degree or higher n=3, main workplace n=6, years in practice n=5, number of patients per week n=18, number of meetings per patient n=53, personal legume consumption n=4, personal diet pattern n=4, knowledge composite score n=3, legume perceptions: mean composite score n=3, advantages, digestibility, acceptability n=1, attitudes toward legume counseling: mean composite score n=9, resources and confidence, sustainability, importance n=7

Table 2. Mean level of agreement with various legume perceptions and attitudes toward legume counseling statements, n=309

Legume perceptions and attitudes toward legume counseling	Mean composite score	SD
Perceptions		
Legume Advantages:	**4.31**	**0.55**
'Suitable for persons with diabetes'	4.59	0.66
'Satiating'	4.52	0.67
'A good source of protein'	4.41	0.73
'A replacement for a meat dish'	4.38	0.84
'A good source of iron'	4.11	0.95
'Promotors of weight loss'	3.83	1.01
Legume Acceptability:	**3.59**	**0.64**
'Easier to include lentils in the daily diet in comparison to other legumes'	3.55	1.21
*'Time consuming to prepare'**	2.68	1.03
*'Not suitable for children'**	1.37	0.75
Legume Digestibility:	**2.82**	**0.78**
*'A cause of intestinal gas'**	3.52	0.94
*'Hard to digest'**	3.16	0.90
Attitudes toward legume counseling		
Resources and confidence:	**3.98**	**0.67**
'I am confident in my ability to counsel patients regarding legume consumption'	4.34	0.8
'I have sufficient knowledge to counsel patients regarding legume consumption'	4.24	0.82
'I have enough time to counsel patients regarding legume consumption'	4.04	1.11
'I have adequate didactic resources to counsel patients regarding legume consumption'	2.74	1.22

*'I am not certain in what context it would be suitable to bring up the topic of legume consumption in a counselling session'**	1.91	1.23
Importance:	**4.22**	**0.52**
'Counselling patients regarding legume consumption is important for me'	4.58	0.67
'Counselling patients regarding legume consumption is important for my colleagues'	4.14	0.84
'I would like to include more legume consumption recommendations in my practice'	3.9	1.13
*'In my opinion, counselling patients regarding legume consumption is ineffective (does not result in higher consumption)'**	1.83	0.89
Sustainability:	**3.98**	**0.89**
'Dietary choices have a significant impact on the environment (i.e., greenhouse gas, water, and soil resources)'	4.34	0.91
'The environmental factor should become one of the dietitians's considerations when consulting patients'	3.64	1.14

The score is structured as a 5-point Likert scale of "strongly agree" (5) to "strongly disagree"(1).

* This table presents the original score for these negative statements; The composite score for the whole factor uses a converted score for the negative statements.

Table 3. Proportion of correct responses to the knowledge statements, n=309

Knowledge statements	**% correct responses**
'Legumes are an environmentally friendly source of protein in comparison to animal protein' (T)	96.7%
'Legumes may help reduce LDL cholesterol levels' (T)	93.2%
'It is necessary to sprout legumes in order to receive their nutritional benefits' (F)	87.6%
'It is not necessary to combine legumes and grains in a single meal in order to obtain high quality protein' (T)	83.7%
'The amount of protein in one egg is similar to that of half a cup of cooked chickpeas' (T)	76.5%
'Dietary guidelines worldwide define legumes as an inferior protein source in comparison to animal protein' (F)	47.4%
'The amount of iron in half a cup of cooked beans is higher than that of 200 gr of cooked turkey breast' (T)	35.5%

Abbreviations: LDL – Low Density Lipoprotein

T = true statement, F = false statement

Table 4. Multivariable analysis for factors associated with recommending to increase legume consumption ('legume-oriented dieticians’), n=298

Variable	Crude		Adjusted	
	OR (95%)	p-value	OR (95%)	p-value
Age	0.99 (0.98,1.00)	0.191	0.99 (0.99,1.00)	0.240
Main workplace				
Private clinic	Ref.		Ref.	
HMO	0.91 (0.47, 1.76)	0.490	0.85 (0.39,1.84)	0.684
Hospital	0.42 (0.21, 0.83)	0.001	0.43 (0.19,0.98)	0.045
Other	1.08 (0.50, 2.34)	0.197	1.03 (0.42,2.51)	0.957
Personal legume consumption				
More than 4 times a week	Ref.		Ref.	
2-3 times a week	0.62 (0.33,1.16)	0.182	0.63 (0.31,1.32)	0.221
Once a week	0.39 (0.19,0.79)	0.303	0.49 (0.21,1.17)	0.111
3 times a month or less	0.23 (0.11,0.48)	0.001	0.38 (0.15,0.94)	0.037
Personal diet pattern				
Vegetarian+ vegan	Ref.		Ref.	
Flexitarian	0.84 (0.42,1.70)	0.719	1.13 (0.50,2.56)	0.766
Omnivore	0.59 (0.30,1.13)	0.061	0.88 (0.39,1.98)	0.756
Legume perceptions				
Advantages	2.49 (1.58,3.91)	0.001	1.46 (0.82,2.59)	0.202
Digestibility	0.91 (0.68,1.21)	0.518	0.84 (0.59,1.19)	0.324
Acceptability	2.13 (1.46,3.09)	0.001	1.92 (1.24,2.96)	0.003
Attitudes toward legume counseling				
Resources and confidence	2.20 (1.52, 3.19)	0.001	1.44 (0.92,2.25)	0.107

Sustainability	1.38 (1.06, 1.79)	0.016	0.92 (0.66,1.27)	0.598
Importance	2.51 (1.58, 4.00)	0.001	1.95 (1.12, 3.40)	0.017
Knowledge (mean composite score)	1.35 (1.11, 1.65)	0.003	1.14 (0.88,1.47)	0.316

Abbreviations: OR, odds ratio; HMO, Health Maintenance Organizations

Supplementary file 1

Legumes: knowledge, attitudes and counselling habits - A survey among dietitians

We are conducting a survey regarding dietitians' attitudes, knowledge and counselling practices regarding legumes. The survey is anonymous and its findings will be used solely for research purposes. You are free to choose not to answer all the questions in the questionnaire and to stop at any time.
Completing and submitting the survey are deemed as consent for study participation

We thank you for your cooperation

Do you counsel patients as part of your dietetic practice?
-Yes (even if counselling patients is not your main professional activity)
-No

Completing the questionnaire takes approximately 10 minutes.
The questionnaire includes 6 sections: personal details, legume counselling practices and attitudes, patients' attitudes, knowledge, personal consumption patterns and resources for promoting legume counselling.

Personal details

gender

- female

- male

- other

- prefer not to answer

year of birth

Education

Bachelor's degree

Master's degree

Doctoral degree

Where is your primary workplace (the place you work the most hours in a typical week) ?

Hospital

Health Maintenance Organization (HMO)

Retirement Home

Private Clinic

Gym

Private Institute

Food Industry

Public Health

University / Research Institute

Other

Which conditions (or population groups) do you most often treat? (please mark up to 4 items)

obesity

diabetes

cardiovascular diseases

gastroenterology

nephrology

oncology

eating disorders

healthy eating promotion

vegetarian and vegan diets

infants and children

pregnancy and lactation

athletes

bariatrics

surgery

geriatrics

other

How many years have you worked as a dieititan?

How many patients do you see in an average week?

What is the average number of sessions for each patient?

Questions regarding legume counselling practice and attitides

I recommend consumption of legumes on a daily basis:

1.To almost all of my patients (76%-100% of my patients)

2. To most of my patients (51%-75% of my patients)

3. To some of my patients (26%-50% of my patients)

4. To a few of my patients (up to 25% of my patients)

5. To none of my patients (0% of patients)

I recommend consumption of legumes on a daily basis to patients who are vegan\vegetarian or rarely eat meat:

1.To almost all of my patients (76%-100% of my patients)

2. To most of my patients (51%-75% of my patients)

3. To some of my patients (26%-50% of my patients)

4. To a few of my patients (up to 25% of my patients)

5. To none of my patients (0% of patients)

I recommend that patients increase their legume consumption:

1.To almost all of my patients (76%-100% of my patients)

2. To most of my patients (51%-75% of my patients)

3. To some of my patients (26%-50% of my patients)

4. To a few of my patients (up to 25% of my patients)

5. To none of my patients (0% of patients)

Please indicate your level of agreement with the following statements:
Scale of 1-5: strongly agree (5 points) - strongly disagree" (1 point)

Counselling patients regarding legume consumption is important for me.

Counselling patients regarding legume consumption is important for my colleagues.

I would like to include more legume consumption recommendations in my practice.

I have sufficient knowledge to counsel patients regarding legume consumption.

I am not certain in what context it would be suitable to bring up the topic of legume consumption in a counselling session.

I am confident in my ability to counsel patients regarding legume consumption.

I have enough time to counsel patients regarding legume consumption.

I have adequate didactic resources to counsel patients regarding legume consumption.

In my opinion, counselling patients regarding legume consumption is ineffective (does not result in higher consumption).

Dietary choices have a significant impact on the environment (i.e., greenhouse gas, water and soil resources)

The environmental factor should become one of the dietitian 's considerations when consulting patients.

Please indicate your level of agreement with the following statements:
Scale of 1-5: strongly agree (5 points) - strongly disagree" (1 point)

I perceive legumes to be:

Satiating

Suitable for persons with diabetes

A good source of iron

A good source of protein

Hard to digest

Not Suitable for Children

Promotors of weight loss

A replacement for a meat dish

Easier to include lentils in the daily diet in comparison to other legumes

A cause of intestinal gas

Time consuming to prepare

Patients' knowledge, attitudes and practice

Please indicate your level of agreement with the following statements:
Scale of 1-5: strongly agree (5 points) - strongly disagree (1 point)

Patients do not necessarily know what legumes are (often confusing them with foods like rice, quinoa and sesame).

Patients view legumes as a substitute for meat.

Patients perceive legumes as a type of carbohydrate, such as rice and pasta.

Patients are concerned in regard to soy consumption.

Most patients do not consume legumes on a daily basis.

Acquiring the habit of legume consumption is difficult for the average patient.

In your opinion, what are patients' barriers regarding legume consumption?

Scale of 1-5: strongly agree (5 points) - strongly disagree" (1 point)

Lack of knowledge how to prepare and cook legumes

Concerns regarding digestion problems

Preparation time is too long

Lack of acceptance of legumes by the rest of the household members

Knowledge questions

The amount of protein in one egg is similar to that of half a cup of cooked chickpeas True\ False\ Don't know

The amount of iron in half a cup of cooked beans is higher than that of 200 gr of cooked turkey breast True\ False\ Don't know

Legumes are an environmentally friendly source of protein in comparison to animal protein True\ False\ Don't know

Legumes may help reduce LDL cholesterol levels True\ False\ Don't know

Dietary guidelines worldwide define legumes as an inferior protein source in comparison to animal protein True\ False\ Don't know

It is necessary to sprout legumes in order to receive their nutritional benefits

True\ False\ Don't know

It is not necessary to combine legumes and grains in a single meal in order to obtain high quality protein True\ False\ Don't know

Questions regarding personal consumption patterns

How often do you consume legumes (not including soy milk in coffee)*?*

- Once a month or less
- 2–3 times per month
- Once a week
- 2-3 times per week
- 4-6 times per week
- Every day

Do you define yourself as a vegetarian or a vegan?

- No
- No, but I try to reduce my meat intake
- Yes, vegetarian
- Yes, vegan

Resources and tools for promoting legume counselling

Which didactic resources would aid you in promoting legume consumption among patients in the clinic setting?

Scale of 1-5: Highly helpful (5 points) – not helpful" (1 point)

A recipe booklet

A link to a recipe website

A brochure about legume preparation and cooking

A link to a video regarding legume preparation and cooking

A brochure demonstrating how to incorporate legumes in different meals over the course of the day

Other____

If a workshop for dietitians regarding promoting legume counselling would take place in the future, which topics would you be interested for this workshop to include?
Scale of 1-5: Highly interested (5 points) – not interested " (1 point)

Incorporating legumes in diabetic patients' diets

Information on the quality of legumes as sources of protein and iron

The health effects of soy

Ways to improve legume digestion

Information on soaking and germination

A cooking workshop

Other____

We thank you for your participation in the survey. Would you be interested that we contact you in the future regarding the possibility of attending an online training program on legumes?

Supplementary file 2

Mapping of the Attitudes statements and their factor loading according to the COM-B behavior change model (Capability, Opportunity and Motivation Model of Behaviour change) and the Theoretical Domains Framework (TDF)

Statements in questionnaire	Factor	COM-B behavior change model	TDF
"I have sufficient knowledge to counsel patients regarding legume consumption."	Resources and confidence	Capabilities - psychological	Knowledge
"I am not certain in what context it would be suitable to bring up the topic of legume consumption in a counselling session."	Resources and confidence	Capabilities - psychological	Skills
- "Dietary choices have a significant impact on the environment (i.e., greenhouse gas, water and soil resources)." - "The environmental factor should become one of the dietitian's considerations when consulting patients."	Sustainability	Motivation - reflective	Social/professional role and identity

"I am confident in my ability to counsel patients regarding legume consumption. "	Resources and confidence	Motivation - reflective	Beliefs about Capabilities
"Counselling patients regarding legume consumption is important for me."	Importance	Motivation - reflective	Emotion
"In my opinion, counselling patients regarding legume consumption is ineffective (does not result in higher consumption)."	Importance	Motivation - reflective	Beliefs about Consequences Optimism
"I would like to include more legume consumption recommendations in my practice."	Importance	Motivation - reflective	Goals
"Counselling patients regarding legume consumption is important for my colleagues."	Importance	Opportunity - social	Social influences
- "I have enough time to counsel patients regarding legume consumption." - "I have adequate didactic resources to counsel patients regarding legume consumption."	Resources and confidence	Opportunity - physical	Environmental context and resources

Supplementary File 3: Data to develop future interventions

Perceived patients' knowledge, attitudes and practice

	Proportion that agreed & strongly agreed (%, n)	**Total sample, n=309**	**Legume oriented dietitians, n=146**	**Non legume oriented dietitians, n=163**	**P-value***
Patients do not necessarily know what legumes are (often confusing them with foods like rice, quinoa and sesame).	85.7 (263)	4.29 ±0.82	4.36 ±0.79	4.23 ±0.85	0.168
Most patients do not consume legumes on a daily basis.	78.6 (243)	4.16 ±0.83	4.19 ±0.81	4.13 ±0.85	0.492
Acquiring the habit of legume consumption is difficult for the average patient.	49.3 (151)	3.44± 1.01	3.31 ±1.03	3.55 ±0.98	0.037**
Patients perceive legumes as a type of carbohydrate, such as rice and pasta.	42.5 (130)	3.25 ±1.02	3.21 ±1.05	3.29±0.99	0.466
Patients view legumes as a substitute for meat.	25.1 (77)	2.85 ±1.06	2.83 ±1.1	2.88 ±1.03	0.686
Patients are concerned in regard to soy consumption.	57 (175)	3.59± 0.99	3.55 ±1.01	3.62 ±0.97	0.561

The score is structured as a 5-point Likert scale of "strongly agree" (5) to "strongly disagree"(1).

* The p-values presented in the table are the original values before adjustment for multiple comparisons. The corrected p-values are 0.964.

** The corrected p-value is 0.589.

In your opinion, what are patients' barriers regarding legume consumption?	**Total sample, n=309**	**Legume oriented dietitians, n=146**	**Non legume oriented dietitians, n=163**	**P value**	**p value ***
Concerns regarding digestion problems	4.32±0.8	4.31 ±0.55	4.23 ±0.86	0.05	0.705
Preparation time is too long	4.07±0.85	4.15 ±0.07	4 ± 0.88	0.12	0.955
Lack of knowledge how to prepare and cook legumes	4±0.96	4.12±0.9	3.89± 1	0.033	0.536
Lack of acceptance of legumes by the rest of the household members	3.79 ±1.02	3.87± 0.99	3.73 ±1.05	0.22	0.964

The score is structured as a 5-point Likert scale of “strongly agree" (5) to "strongly disagree"(1).

* P-values after adjustment for multiple comparisons.

Resources and tools for promoting legume counselling

If a workshop for dietitians regarding promoting legume counselling would take place in the future, which topics would you be interested for this workshop to include?	**Total sample, n=309**	**Legume oriented dietitians, n=146**	**Non legume oriented dietitians, n=163**	**p value***
Ways to improve legume digestion	4.46±0.85	4.42±0.95	4.5 ± 0.75	0.405
Information on the quality of legumes as sources of protein and iron	4.38±0.97	4.28±0.95	4.46±0.83	0.113**
Information on soaking and germination	4.31±0.97	4.28±1.04	4.33±0.91	0.651
A cooking workshop	4.27±1.13	4.29±1.09	4.25±1.17	0.737
The health effects of soy	4.19±1.08	4.19±1.14	4.19±1.03	0.964
Incorporating legumes in diabetic patients' diets	3.95±1.34	3.94±1.32	3.96±1.36	0.898

The score is structured as a 5-point Likert scale of "strongly agree" (5) to "strongly disagree"(1).

* The p-values presented in the table are the original values before adjustment for multiple comparisons. The corrected p-values are 0.964.

** The corrected p-value is 0.948.

Which didactic resources would aid you in promoting legume consumption among patients in the clinic setting?	**Total sample, n=309**	**Legume oriented dietitians, n=146**	**Non legume oriented dietitians, n=163**	**p value**	**p value ***
A brochure demonstrating how to incorporate legumes in different meals over the course of the day	4.62±0.67	4.71 ±0.59	4.55 ±0.73	0.038	0.505
A brochure about legume preparation and cooking	4.61±0.76	4.64 ±0.82	4.58 ±0.71	0.488	0.964
A recipe booklet	4.52±0.92	4.58 ±0.93	4.45 ±0.91	0.221	0.964
A link to a recipe website	4.31±1.04	4.4 ±0.97	4.23 ±1.1	0.173	0.964
A link to a video regarding legume preparation and cooking	4.2 ±1.09	4.35 ±1.03	4.07 ±1.12	0.03	0.589

The score is structured as a 5-point Likert scale of “strongly agree" (5) to "strongly disagree"(1).

* P-value after adjustment for multiple comparisons.

2.3. Third paper: Dietitians as Agents of Change to Increase Legume Consumption- A Randomized Controlled Trial of a Behavioral Intervention

In accordance with Specific Objective 3, an online, theory and evidence-based, behavioral intervention was developed and conducted among Israeli dietitians. Results were reported in the manuscript:

Ofir O, Stark AH, Abu Ahmad W, Bar-Zeev Y. Dietitians as agents of change to increase legume consumption- a randomized controlled trial of a behavioral intervention. (accepted for publication in Frontiers in Nutrition on 29 December 2025).

https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2025.1713719/abstract

Dietitians as Agents of Change to Increase Legume Consumption- A Randomized Controlled Trial of a Behavioral Intervention

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ABSRACT

Introduction: Health and environmental benefits of daily legume consumption are reflected in Israeli Dietary Guidelines. However, legume intake fails to meet recommendations. Dietitians may be effective agents of change for promoting legume consumption. This study evaluates an evidence and theory-based, multi-component, intervention aimed to improve Israeli dietitians' legume counseling practices, knowledge, attitudes and personal intake.

Methods: A randomized controlled trial (May-September 2023) was conducted among dietitians who actively counsel patients. The intervention included a prerecorded webinar followed by small-group workshops and provision of brochures for patients, alongside a professional guide on legume counseling for dietitians. Data regarding legume knowledge, attitudes, counseling practices and personal intake were collected at baseline and three months post-intervention. Controls were wait-listed to receive the intervention. The primary outcome was self-reported proportion of patients recommended to consume legumes daily (1-5 Likert scale: (1) none; (2) ≤25%; (3) 26–50%; (4) 51-75%; and (5) 76-100%). A repeated measures mixed-design model, chi-square tests and pairwise odds ratio tests were utilized for the analysis.

Results: Overall, 213 dietitians participated (Intervention: n=109, Control: n=104). The proportion of dietitians in the intervention group recommending to 76-100% of their patients to consume legumes daily increased from 32% (baseline) to 51% (follow-up); compared to 25% and 27%, respectively, in the controls. In the repeated measures model, recommending daily legume consumption improved significantly in both the intervention group (3.73±1.1 to 4.28±0.86, p=0.001) and the control (3.67±0.98 to 3.88±0.92, p=0.03), with a higher increase in the intervention group

(p=0.014). Knowledge and attitudes improved significantly in the intervention group (p<0.001) but not for controls, except in the attitude score regarding sustainability (p=0.026). Personal legume consumption improved significantly only in the intervention group, who had higher odds of increasing legume intake to at least twice a week [OR 2.81 (95%CI:1.10-8.11)**.**

Discussion: An online intervention significantly improved dietitians' knowledge, attitudes, counseling practices regarding legume consumption and personal intake. Utilizing dietitians' counseling might be a viable approach for promoting consumption of sustainable diets.

INTRODUCTION

There is universal consensus regarding legumes' key role in sustainable and nutritious diets (1–5). Daily consumption of legumes (beans, lentils, peas and soy; 75 g/day, equivalent to ~2/3 cup) is a central component in the EAT-Lancet Commission Planetary Health Diet (5). Legumes are a good source of protein and iron (6). In comparison to animal protein sources, they are low in saturated fat while high in dietary fiber and phytochemicals (6). Health benefits associated with legumes include prevention of cardiovascular diseases (7–10), diabetes (11,12), colorectal cancer (10), and a decrease in all-cause mortality (13). Legume intake is acknowledged as a vital factor in global endeavors to deal with the environmental crisis by decreasing greenhouse gas emissions and the reduced use of water, land and fuel compared to animal protein production (5,14,15). The 2025 Advisory Committee for the Dietary Guidelines for Americans 2025-2030 (16), and national guidelines from various countries such as Canada(17) and the United Kingdom (18) recommend legumes as a preferred protein source. However, actual consumption levels worldwide are low (19,20). Current Israeli dietary guidelines recommend daily legume consumption (21). Data from the 2014-2016 national nutrition survey, showed that legumes were consumed by 31% of Israelis with a mean intake of ~ 0.25 cup/day (Israel Ministry of Health), 2022, secondary data analysis, unpublished data). Thus, there is a distinct need to promote legume incorporation into the daily diet.

To the best of our knowledge, interventions aimed at increasing legume consumption have been conducted only among the general public, predominately in low-income countries (22–26). Three recent interventions were performed in high-income countries; however, the sample size was small and none were randomized control trials (27–29). In comparison to interventions among the general public, training

health professionals as “agents of change” could potentially reach a larger population, and may be more easily replicated across countries and cultures (30). Online training might also further increase reach (31). Thus, dietitians could be an ideal target population due to their prominent role in affecting consumption patterns (32–34). A previous survey among Israeli dietitians found their legume counseling and consumption practices were well below current guidelines (35). Less than a third of Israeli dietitians recommended to most or all of their patients to consume legumes daily, and only about 5% reported following the recommendation themselves. Factors that were associated with recommending legumes to patients were higher personal legume consumption, more favorable perceptions regarding barriers toward legume consumption, more favorable attitudes toward the importance of legume counseling and working in an outpatient setting (35). Based on these results (35), an online, multi-component, theory and evidence-based, behavioral intervention was developed. This study aimed to evaluate the impact of the intervention on Israeli dietitians' knowledge, attitudes and counseling practices regarding legumes, including improving their personal consumption patterns.

METHODS

Study design

A randomized controlled trial was carried out (May-September 2023), with participants randomly assigned, by the first author (OO) to either the control or intervention group using simple randomization based on the parity of their enrollment number (i.e., even vs. odd). All participants completed a baseline survey (May 2023), after which the intervention group received the intervention (May-June 2023), while the control group was wait-listed to participate at a later date. Both groups were followed for three months at which time they completed a follow-up survey

(September 2023) (Figure 1). After completing the follow-up survey, the control group had an opportunity to access the intervention. The study was approved by the Hebrew University of Jerusalem- Robert H. Smith, Faculty of Agriculture, Food and Environment Ethics Committee (AGHS/May-2.23).

Participants

Eligible participants were Israeli dietitians who actively counsel patients. Dietitians that work solely in the public health sphere or in the food industry were excluded. An invitation to participate in the study was dispersed via: 1) emailing dietitians who completed a preceding survey (35) and agreed to be contacted in the future (n=186); 2) electronic mailing list of the Israeli Dietetic Association (ATID); 3) WhatsApp groups of the nutrition division of the Israeli Ministry of Health; 4) personal communications with head dietitians in the four Israeli Health Maintenance Organizations (HMOs); and 5) relevant Facebook groups for dietitians. In order to aid recruitment and minimize dropout, a drawing for three ATID professional courses, three annual ATID conference registration fees and two electronic tablets, was carried out among participants who completed the follow-up survey.

(35)Informed consent was obtained upon enrollment. After randomization, all participants received an email containing a link to the baseline survey.

Intervention

The intervention design was guided by the Theoretical Domains Framework (TDF) and the COM-B Behavior Change Model.(36–38) Both the TDF and the COM-B are validated and integrative models of behavior change and have been applied across a wide scope of clinical situations (39).

The intervention was carried out by an experienced dietitian with proficiency in plant-based diets and specifically counseling regarding legume consumption (the first author), and included:

a) A prerecorded 45-minute webinar presenting nutritional, health, food security and environmental benefits of legumes.

b) Small-group Zoom workshops to enhance skills for overcoming common barriers to legume consumption. Nine workshops were carried out, with an average of 13 participants, lasting about 90 minutes; with attendance monitored. In order to ensure quality and consistency across all nine workshops, a single individual (first author) carried out all the sessions. The same presentation was used throughout, and slides were sent to the participants prior to each workshop. Additionally, following delivery of the workshops, the lecture given in the workshops was adjusted to incorporate additional topics that repeatedly arose. A recording of this comprehensive lecture was sent to the participants.

c) A professional guide on legume counseling for dietitians, and brochures to be distributed to patients (40). The brochure content is featured in Supplementary File 1a. Each participant received by mail one hard copy of the professional guide and 80 patient brochures, and via email PDF versions of the guide and the brochures.

d) An email reminder (August 2023) was sent to the intervention group recommending watching the webinar and workshop recording for a second time. The rationale was to allow participants to further assimilate the information presented and provide additional highlights on legume dishes that are more compatible in the summer (e.g., salads, omelets).

Measures and outcomes

The baseline survey (Supplementary File 1b) was based on a previous survey (35). Questions were adapted from previous surveys focusing on legumes among dietitians (41,42) and the general public (43,44). Questions regarding attitudes toward counseling were based on the TDF (37,38) and the COM-B model (36).

The survey included six sections:

a) Socio demographic and professional characteristics: including age, sex, education, primary workplace, years in practice, average number of patients per week, average number of meetings per patient, whether providing virtual counseling and area of expertise (e.g., obesity); Personal diet pattern was categorized as omnivore, flexitarian, vegetarian + vegan. Awareness of the current legume guidelines was assessed by inquiring whether the participant was aware of the recommendation of daily legume intake.

b) Legume counseling to patients: The primary outcome was measured on a 1-5 Likert scale as the proportion of patients that the dietitian recommends to consume legumes **daily**, dichotomized to 76-100% and 75% or less. Two additional questions used the same Likert scale, and asked about: 1) the proportion of patients that the dietitian recommended to **increase** legume consumption in general, and 2) legume counseling practices specifically for vegans\ vegetarians\ flexitarians.

c) Knowledge was measured using seven true/false/don't know statements pertaining to health, nutritional and ecological attributes of legumes (e.g., "Legumes may help reduce LDL cholesterol levels"). A composite knowledge score was constructed by summing the number of correct answers (scale 0-7). ‘Don’t know’ answers were considered as incorrect.

d) Attitudes toward legume counseling were measured with ten statements, using a 5-

point Likert scale of "strongly disagree" (1) to “strongly agree" (5). A principal factor analysis (varimax rotation) was performed to reduce the statements to three factors: 'Resources, confidence and knowledge', 'Importance, effectiveness and time' and 'Sustainability' (Supplementary File 1b). For each factor, a mean composite attitude score was created. Negatively framed statements were reversed such that all scores would be in the same direction, i.e., a higher mean composite score corresponds to a higher positive attitude. Cronbach's α was 0.673, 0.544, 0.614, respectively.

e) Legume perceptions were assessed by ten statements on legume nutritional and health benefits and barriers for consumption using the same Likert scale as above. A similar process was implemented, reducing the ten statements to three factors: 'Adequate protein and iron source', 'Management of consumption barriers' and 'Weight and glucose management' (Supplementary File 1b). For each factor, a mean composite attitude score was created. Cronbach's α for the three factors was 0.680, 0.668, 0.440, respectively.

f) Personal legume consumption was measured with the question: "How often do you consume legumes (not including soy milk in coffee)?" dichotomized to twice a week or more, and once a week or less.

The follow-up survey included the same questions, without the sociodemographic and professional characteristics section. The intervention group survey included an additional section evaluating the training program. The participants were asked to rate (5-point Likert scale, "to a small extent" (1) to "to a great extent" (5)) the entire program and each of its components (i.e., webinar, workshop, dietitian guide, printed brochure for patients, digital brochure and recipe links) across three parameters: contribution to improving legume counseling effectiveness (i.e., leading to an increase in legume intake among patients), compatibility to the population the dietitian treats,

and general satisfaction. Participants were also asked about their use of the program components (e.g., webinar completion, brochure and professional guide use).

Sample size

A sample size of 248 participants was determined to be sufficient to detect an increase of 20% in the proportion of dietitians in the intervention group that recommend 76-100% of their clients to consume legumes daily (assuming a baseline counseling rate of ~30%, based on our previous cross-sectional survey)(35) with 80% power and a 0.05 significance level, factoring in a 20% dropout rate.

Statistical Analysis

Participants were included in the analyses if they had completed both baseline and follow-up surveys. A descriptive analysis was performed; categorical variables were reported as frequencies and percentages, and continuous variables as means and standard deviations. Bivariate analysis was conducted using the Pearson's Chi-squared test or the Fisher's exact test as appropriate for categorical variables, and Welch Two Sample t-test for continuous variables. Legume counseling and personal consumption measures were dichotomized into two categories: 76-100% vs. 75% or less, and "twice a week or more" vs. "once a week or less," respectively. The data were then organized into contingency tables. Pairwise comparisons were conducted on 2×2 tables derived from the overall contingency table using the odds ratio test. A repeated measures model was performed to test differences in legume counseling measures as continuous variables, and in knowledge, perceptions and attitudes toward legume counseling, within and between the study groups over time and group by time interaction. Benjamini-Hochberg correction was applied to control for multiple comparisons. The level of significance for all tests was set to 0.05. All statistical analyses were performed using whole case analysis with RStudio, version 2023.01.1.

RESULTS

Participant characteristics

A total of 308 dietitians enrolled in the study, of which 252 filled out the baseline survey and were randomized to the intervention group (n=127) or waitlist control group (n=125) (Figure 1). Three participants in the intervention arm did not attend the online workshops, thus not completing the program. The follow-up survey was answered by n=213 (84.5%) participants which were included in the final analysis (intervention group, n=109 (85.8%); control group, n=104 (83.2%)). The final sample was comprised of 98% (n=208) women, with a mean age of 41.2 ±9.1 years. Mean years in practice were 13±9.4 with 46% (n=98) of respondents holding graduate degrees. Main workplaces were HMOs (40%, n=85), hospitals (27%, n=58) and private clinics (19%, n=41) (Table 1). The most common areas of expertise were obesity (69%, n=147), diabetes (51%, n=109) and healthy eating promotion (36%, n=77). Only 42% (n=89) of the dietitians were aware of the national dietary guidelines' recommendation of daily legume intake. No significant differences were found between the study groups in any of their sociodemographic and professional characteristics (Table 1).

Baseline counseling, knowledge, perceptions, attitudes and personal consumption

Less than a third (29%, n=61) of the dietitians reported recommending to 76-100% of their patients to consume legumes daily, and nearly half (47%, n=100) recommended to increase legume consumption in general (Table 2). The mean knowledge score for the total sample was 5.17±1.21. There was a high level of agreement for the total sample for the attitudes regrading 'sustainability' and 'importance, effectiveness and time' (4.17±0.78, 4.17±0.55, respectively) and for the perceptions regarding 'adequate

protein and iron source' and 'weight and glucose management' (4.41±0.57, 4.35±0.52, respectively). A lower level of agreement was found for the 'resources, confidence and knowledge' attitude (3.36±0.73) and a low level of agreement was found for the 'management of consumption barriers' perception (2.77±0.72). No significant differences were found between the study groups in any of these baseline variables (Table 3, p groups >0.1 for all). Almost a quarter [22% (n=46)] of the sample reported consuming legumes at least four times a week, but only 5.2% (n=11) reported consuming legumes daily, with no significant differences between the study groups (Table 2).

Intervention effectiveness

Legume intake recommendations to patients

For the first outcome 'recommending daily legume consumption', the proportion of dietitians in the intervention group recommending this to 76-100% of their patients, increased from 32% (n=35) at baseline to 51% (n=56) post intervention; compared to 25% (n=26) and 27% (n=28), respectively, in the control group (Table 2). In the pairwise comparisons (Supplementary File 2, Table S1), 23.1% (n=25) of the intervention group increased recommending daily legume consumption to 76% or more of patients compared to only 16.3% (n=17) in the controls. However, the odds of increasing counseling to 76% or more of patients were not significantly different between the groups [OR 1.54 (95% CI:0.78-3.1)]. A lower proportion of the intervention group decreased their counseling to less than 76% of their patients [4.6% (n=5) intervention vs. 14.4% (n=15) control; OR 0.29 (95% CI 0.09-0.77)]. A higher proportion of the intervention group maintained counseling for 76% or more of patients compared to the controls [27.8% (n=30) intervention vs. 10.6% (n=11)

control; OR 3.25 (95% CI:1.57-7.18)] (Supplementary File 2, Table S1). In the repeated measures model 'recommending daily legume consumption' improved significantly in both the intervention group (3.73±1.1 to 4.28±0.86, p=0.001) and the controls (3.67±0.98 to 3.88±0.92, p=0.03), with a significant interaction between time and group, i.e., the improvement in the intervention group was significantly higher in comparison to the controls (Table 3, p time*group =0.014). For the second outcome 'recommending to increase legume intake', the proportion of dietitians in the intervention group recommending this to 76-100% of their patients, increased from 49% (n=53) at baseline to 66% (n=71) post intervention; compared to 45% (n=47) and 46% (n=48), respectively, in the controls (Table 2). In the pairwise comparisons, a similar pattern to the first outcome was found (Supplementary File 2, Table S1). In the repeated measures model, 'recommending to increase legume intake' improved significantly in the intervention group (4.14±1.05 to 4.58±0.64, p= <0.001) but not in the controls (4.16±0.94 to 4.32±0.71, p=0.07).

Knowledge, legume perceptions, and attitudes toward legume counseling

The scores of knowledge, attitudes toward legume counseling and legume perceptions increased significantly at follow-up in the intervention group ($p < 0.001$ for all) (Table 3). The 'Resources, confidence and knowledge' attitude improved the most and increased by 1.3 points. The included statement "I have adequate didactic resources to counsel patients regarding legume consumption" received the lowest level of agreement (2.3±1.1) out of all attitudes and perceptions at baseline and improved the most at follow-up (4.6±0.6) (data not shown). No significant differences were found between the baseline and follow-up scores in the control group, apart from an increase in the attitude score regarding sustainability (4.1±0.82 vs. 4.24±0.69, p=0.026). The

intervention groups' follow-up scores were significantly higher than those of the controls for all variables (Table 3, p groups[c]<0.05 for all), with the exception of a non-significant trend towards higher scores in perceptions regarding weight and glucose management (4.54±0.51 intervention vs. 4.42±0.49 control, p=0.087). The interaction between the trend of change over time and the group effect was significant for knowledge and attitudes toward legume counseling (Table 3, p time*group[b]<0.001 for both) but not for legume perceptions (p=0.322).

Personal legume consumption

The proportion of dietitians in the intervention group consuming legumes at least twice a week, increased from 62.3% (n=68) at baseline to 75% (n=81) post intervention; compared to a decrease from 54.9% (n=57) to 52.6% (n=55) in the control group (Table 2). In the pairwise comparisons, the intervention group had lower odds of maintaining a low legume intake of once a week or less [OR 0.46 (95% CI:0.25-0.82), p=0.04] and there was a trend towards higher odds of increasing legume intake to at least twice a week [OR 2.81 (95% CI:1.1-8.11), p=0.078] (Table 4).

Program evaluation

The scores for the evaluation of the program as a whole were 4.2±0.7 for effectiveness, 4.2±1 for compatibility to the treated population and 4.5±0.7 for general satisfaction (Supplementary file 2, Table S2). Similar scores were received for the webinar, workshop, printed patient brochure and dietitian guide separately. Lower scores were received for the digital patient brochure and recipe links. About one third (33.9%, n=37) of the participants reported distributing brochures to at least half of their clients. The use of digital resources was limited (Supplementary file 2).

DISCUSSION

This is the first study to evaluate an intervention among dietitians aimed to improve knowledge, attitudes and practices pertaining to legume counseling. The intervention was effective in improving dietitians' self-reported legume counseling practices, attitudes toward legume counseling, knowledge and personal legume consumption.

The current Israeli dietary guidelines recommend daily legume consumption. At baseline, only 29% of the overall sample recommended to most or all their patients (76-100%) to consume legumes daily. The more general recommendation of increasing legume intake is presumably easier to implement; however, even this more acceptable recommendation was provided by only 47% of the dietitians at baseline. These low rates were similar to the those found in a previous Israeli survey (30.6% and 47.7%, respectively) (35) and further affirm the necessity of the current intervention.

The intervention was effective in improving legume recommendations for daily consumption or more generally to increase consumption. For the control group, the pairwise comparison identified divergent responses. A possible explanation for the observed decline in counseling was that the follow-up survey was administered at the end of the summer, while the baseline survey was completed in the spring. Legumes are more typically consumed in the winter in dishes like soups and casseroles (45–47); therefore, dietitians may tend to decrease their legume counseling to patients during the summer. The decrease in counseling in the intervention group was negligible and significantly lower than in controls, indicating that the intervention was effective in mitigating a reduction in counseling that might be attributed to seasonality. In the repeated measures model, both groups showed a significant improvement, albeit a higher improvement for the intervention group. A possible

explanation for the improvement reported by the control group is that more than half of the dietitians were not aware of the current recommendation of daily legume intake. The invitation to participate in the study highlighted this recommendation, which may have impacted the control group directly. Lastly, although the intervention group was specifically asked not to share the contents of the intervention with other dietitians, the possibility of contamination cannot be ruled out; particularly since Israel is a small country, where it is common for dietitians to work simultaneously in several places.

Findings also show that the intervention was effective in improving knowledge and attitudes in regard to legume counseling. Specifically, the largest improvement was seen for “having adequate resources". All of the resources received high scores regarding general satisfaction. The printed brochure and dietitian guide received high scores also for effectiveness and compatibility for the treated population. The digital materials scored lower in these two parameters, which was reflected in the lower rate of dietitians reporting using them. Future cooperation with HMOs and hospitals is recommended, including integration into their computerized systems, which might potentially encourage more widespread use of the digital materials, thus supporting effective, low-cost legume counseling for the long-term.

Although the legume perception scores improved significantly in the intervention group, and no improvements were observed in controls, the interaction between time and the group was not significant, i.e., the intervention group perceptions did not improve significantly in comparison to the control. It is possible that the sample size was not adequate to detect relatively smaller changes that occurred in legume perceptions. Similarly, the sample size might have precluded finding statistical

significance in regard to changes in participant's personal legume consumption, despite seeing a trend towards improvement.

The attitude score regarding sustainability was the only score that also improved in the control group. It is possible that the survey in itself served as a form of intervention, alerting participants to this dimension (21). The overall high agreement with the need to integrate the environmental consideration into the dietitian's practice found in this study is in line with studies conducted among American (48) and European (49,50) dietitians. Furthermore, professional associations worldwide (32–34,51–54) have recognized dietitians as key agents for change in the transition toward sustainable food systems. This can be achieved through many venues including counseling for individuals or groups, menu planning and procurement for institutions, advising the food industry and working in public health, policy or academic settings.

Implication for policy and practice

Dietetic associations have acknowledged the necessity of providing adequate sustainability training and resources for dietitians (32–34,51–55). This study can potentially serve as a model for similar dietitian training programs in more countries, addressing the gaps identified in existing programs. Dietetic academic education and practical training regarding sustainability were found to be inconsistent and insufficient (30,56,57). American programs lack content regarding the linkages between human and planetary health, with only few programs addressing plant-based diets' key role in dealing with the environmental crisis (57). In addition, creating educational resources regarding legumes may help overcome dietitians' challenges in promoting sustainable diets that include lack of educational resources (48), particularly regarding sustainable food options and substitutions for use in meal and menu planning (58). It is essential to integrate legumes as a key component in dietetic

educational programs as a sustainable, healthful, minimally processed and inexpensive source of protein.

Strengths and limitations

Several limitations of this study should be noted. Data were self-reported which can lead to social desirability bias. As this study focused on dietitians, it is not possible to determine if the reported changes in counseling practices modified patients' legume intake. The follow-up lasted three months, thus the intervention's long-term effects are not known. Future studies should include a long-term follow-up. It is likely that participants were initially more interested in the topic of legumes; additionally, recruitment through professional associations and social media may have favored more engaged dietitians, potentially introducing selection bias and limiting generalizability. Nonetheless, the age and sex distribution of our sample was very similar to that of the Israeli dietitian population indicating representativity in those regards (personal communication, Ministry of Health). In addition, the sample included dietitians from varied workplaces and from all geographical regions in Israel. Lastly, present findings may be more transferable to countries where guidelines recommend legumes as a preferred protein source (e.g., Canada (17), New Zealand (59)), as national dietary guidelines supporting sustainable diets facilitate dietitians' promotion of such patterns (49). The intervention was designed to be short, online, and low-cost. In contexts without such guidelines, or for other health professionals, a more comprehensive intervention may be required. The strengths of this study include its novelty as the first study to evaluate an intervention aiming to improve dietitians' legume counseling practices, and being the first randomized controlled trial performed in high-income countries evaluating a legume promotion intervention. An

additional strength is the use of validated behavior change models in the intervention design.

CONCLUSIONS

The present study suggests that low-cost, online training can improve dietitians' legume counseling practices, attitudes, knowledge and personal legume consumption in the short term. Promoting legume consumption as a sustainable and healthy protein source is an urgent task of global importance, in which dietitians can act as key agents for change through their wide circles of influence.

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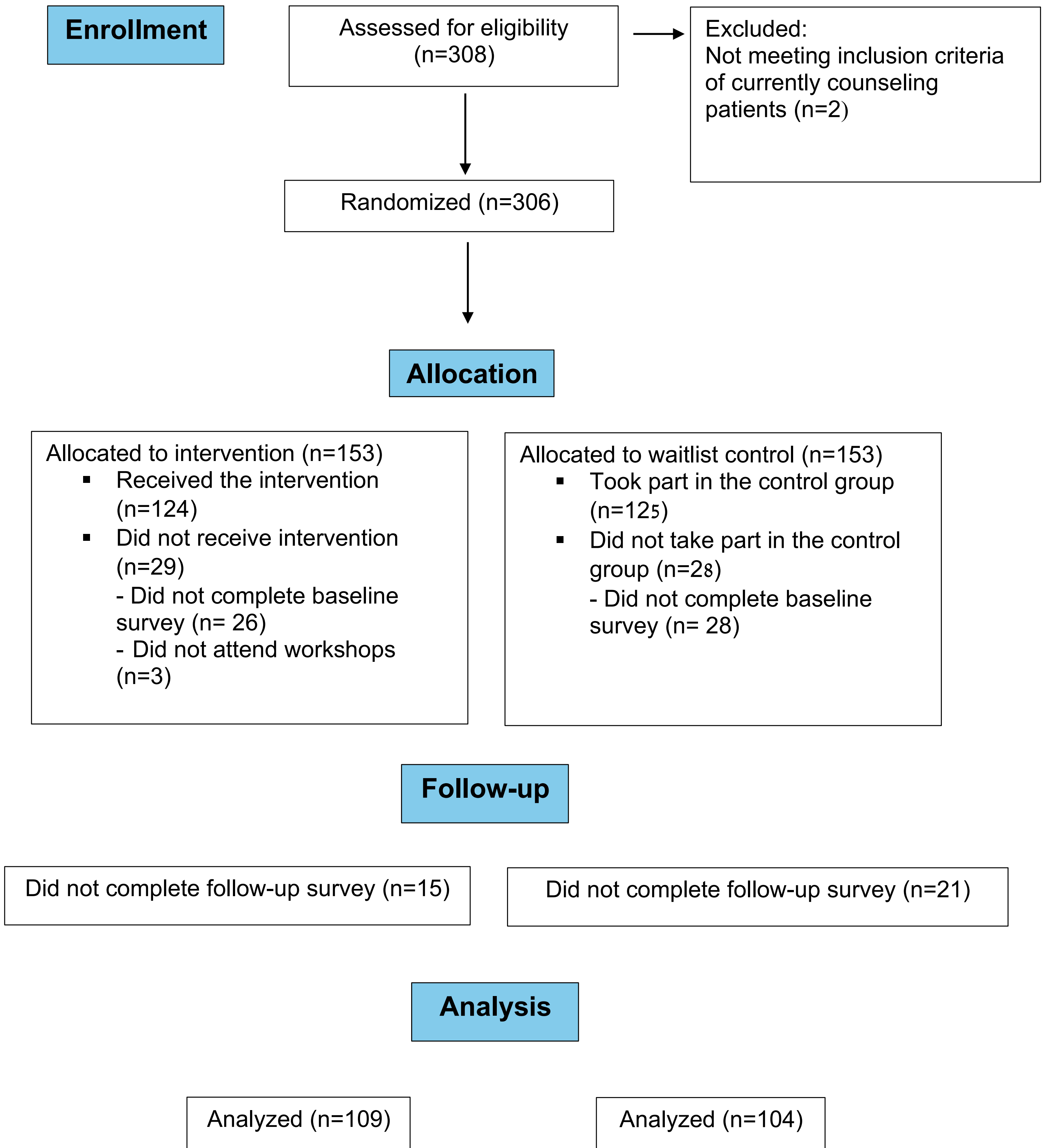

Figure 1. Flow chart of study participants

Table 1. Participants' Socio-Demographic and Work-Related Characteristics (n=213)

Variable	Total sample n=213 (n,%)	Intervention group n=109 (n,%)	Control group n=104 (n,%)	p-value*
Sex (% women)	208 (98%)	107 (98%)	101 (97%)	0.677
Age (mean ± SD)	41.2±9.1	40.3±8.7	42.1±9.5	0.160
Education - Master degree or higher	98 (46%)	46 (42%)	52 (50%)	0.254
Main workplace				
Hospital	58 (27%)	27 (25%)	31 (30%)	0.821
Health Maintenance Organization	85 (40%)	44 (41%)	41 (39%)	
Private clinic	41 (19%)	23 (21%)	18 (17%)	
Other [1]	28 (13%)	14 (13%)	14 (13%)	
Years in practice (mean ± SD)	13± 9.4	12.5± 9.4	13.6± 9.5	0.417
Number of patients per week (mean ± SD)	28.6±17.8	30±18.7	27.2±16.8	0.266
Number of meetings per patient (mean ± SD)	8.5±8.2	8.8 ±8.7	8.3±7.7	0.678
Does not provide virtual counselling	49 (23%)	23 (21%)	26 (25%)	0.936
Awareness of current legume guidelines	89 (42%)	41 (38%)	48 (47%)	0.185
Personal diet pattern				
Omnivore	88 (41%)	43 (39%)	45 (43%)	0.756
Flexitarian	82 (38%)	42 (39%)	40 (38%)	
Vegetarian+ vegan	43 (20%)	24 (22%)	19 (18%)	

* The p-values presented in the table are the original values before adjustment for multiple comparisons. The adjusted p-values are between 0.903- 0.964.
1Other: retirement home (n=9, 4.2%), public health (n=8, 3.8%), medical clinic (n=6, 2.8%), university/research institute (n= 4, 1.9%) and gym (n= 1, 0.5%).
Missing: main workplace n=1, number of patients per week n=4, number of meetings per patient n=20, awareness of the current legume guidelines n=1.

Table 2. Changes in Legume Recommendations and Personal Consumption in the Intervention and Control Groups Over Time, (n=213)

Variable	Baseline				Follow up			
	Total sample n=213 (n,%)	**Intervention group n=109 (n,%)**	**Control group n=104 (n,%)**	**p-value***	**Total sample n=213 (n,%)**	**Intervention group n=109 (n,%)**	**Control group n=104 (n,%)**	**p-value***
Recommending their patients to consume legumes daily								
To 76%-100% of patients	61 (29%)	35 (32%)	26 (25%)	0.903	84 (39%)	56 (51%)	28 (27%)	0.001
To 75% or less of patients	151 (71%)	73 (68%)	78 (75%)		129 (61%)	53 (49%)	76 (73%)	
Recommending their patients to increase legume intake								
To 76%-100% of patients	100 (47%)	53 (49%)	47 (45%)	0.903	119 (56%)	71 (66%)	48 (46%)	0.021
To 75% or less of patients	113 (53%)	56 (51%)	57 (55%)		93 (44%)	37 (34%)	56 (54%)	
Recommending their vegans, vegetarians and flexitarians patients to consume legumes daily								
To 76%-100% of patients	174 (82%)	88 (81%)	86 (83%)	0.989	184 (87%)	87 (84%)	97 (89%)	0.370
To 75% or less of patients	39 (18%)	21 (19%)	18 (17%)		29 (13%)	22 (16%)	7 (11%)	
Personal legume consumption								
At least 4 times a week	46 (22%)	28 (26%)	18 (17%)	0.154	68 (32%)	45 (41%)	23 (22%)	0.012
2-3 times a week	79 (37%)	40 (37%)	39 (38%)		68 (32%)	36 (33%)	32 (31%)	
Once a week	47 (22%)	18 (17%)	29 (28%)		40 (19%)	15 (14%)	25 (24%)	
3 times a month or less	41 (19%)	23 (21%)	18 (17%)		37 (17%)	13 (12%)	24 (23%)	

* The p-values presented in the table are after adjustment for multiple comparisons

Table 3. Changes in Legume Counseling, Knowledge, Attitudes toward Legume Counseling, and Legume Perceptions, in the Intervention and Control Groups Over Time, n=213

Outcome variable	Group	Baseline	Follow-up	*p* time[a]	*p* time *group[b]
Recommending daily legume intake	Intervention	3.73±1.10	4.28±0.86	<0.001	
	Control	3.67±0.98	3.88±0.92	0.030	0.014
	p groups[c]	0.684	0.002		
Recommending to increase legume intake	Intervention	4.14±1.05	4.58±0.64	<0.001	
	Control	4.16±0.94	4.32±0.71	0.070	0.015
	p groups[c]	0.858	0.005		
Knowledge	Intervention	5.39±1.10	6.35±0.75	<0.001	
	Control	5.27±1.32	5.29±1.24	0.855	<0.001
	p groups[c]	0.486	<0.001		
Attitudes toward legume counseling					
Resources, confidence and knowledge	Intervention	3.33±0.74	4.6±0.48	<0.001	
	Control	3.41±0.72	3.36±0.68	0.427	
	p groups[c]	0.445	<0.001		
Importance, effectivity and time	Intervention	4.15±0.56	4.35±0.53	<0.001	
	Control	4.19±0.54	4.19±0.48	0.914	<0.001
	p groups[c]	0.591	0.024		
Sustainability	Intervention	4.24±0.73	4.45±0.67	<0.001	
	Control	4.1±0.82	4.24±0.69	0.026	
	p groups[c]	0.214	0.026		
Legume perceptions					
Adequate protein and iron source	Intervention	4.44±0.57	4.73±0.40	<0.001	
	Control	4.38±0.57	4.44±0.50	0.161	
	p groups[c]	0.456	<0.001		
Management of consumption barriers	Intervention	2.78±0.71	3.16±0.58	<0.001	
	Control	2.77±0.74	2.84±0.71	0.245	0.322
	p groups[c]	0.866	<0.001		
Weight and glucose management	Intervention	4.33±0.53	4.54±0.51	<0.001	
	Control	4.37±0.51	4.42±0.49	0.170	
	p groups [c]	0.593	0.087		

[a] p-value for changes over time, from baseline to follow up, in each group;
[b] p-value for interaction between the trend of change over time and the group effect;
[c] p-value for between-groups differences (intervention vs control group) in each time point.
Legume counseling score were structured as a 1-5 Likert scale of "none" (1) to "76-100%" (5). The knowledge score was constructed by summing the number of correct answers (scale of 0-7); the attitudes and perceptions scores were structured as a 5-point Likert scale of "strongly disagree"(1) to “strongly agree" (5).
*The p-values presented in the table are adjusted for multiple comparisons.
**The composite score for the whole factor uses a converted score for these negative statements.

Table 4. Pairwise Comparisons of Dietitians' Personal Legume Consumption, n=213

Personal legume consumption	Intervention group n=109 (n,%)	Control group n=104 (n,%)	OR (95%)	p-value*
Remaining in at least twice a week	65 (59.6%)	49 (47.1%)	1.66 (0.97-2.86)	0.091
Improving to at least twice a week	16 (14.7%)	6 (5.8%)	2.81 (1.10-8.11)	0.078
Declining to once a week or less	3 (2.8%)	8 (7.7%)	0.34 (0.07- 1.21)	0.118
Remaining in once a week or less	25 (22.9%)	41 (39.4%)	0.46 (0.25-0.82)	0.040

*The p-values are adjusted for multiple comparisons.

Supplementary File 1a

Content of the Patient Brochure

a) Photos of common legume varieties available in Israel.

b) Explanations of the nutritional, health, food security and environmental benefits of legumes.

c) Answers to misconceptions regarding soy.

d) Ways of incorporating legumes into breakfast, lunch and dinner (the brochure's digital version provided links to over 30 recipes).

e) Instructions on how to cook legumes.

f) Tips for quick methods of preparation.

g) Approaches to improve digestion.

h) Link and QR code to the brochure's digital version:
https://efsharibari.health.gov.il/media/3103/legumes-flier.pdf

Supplementary File 1b

Legumes- knowledge, attitudes and counselling habits among dietitians

This survey takes approximately 10-15 minutes to complete. You are free to choose not to answer all the questions in the survey and to stop at any time.

The survey includes four sections: personal details, questions regarding legume counselling practice and attitides, knowledge questions and personal legume intake.

We thank you for your cooperation,

Personal details

Gender

- female
- male
- other
- prefer not to answer

Year of birth

Education

Bachelor’s degree

Master’s degree

Doctoral degree

Where is your primary workplace (the place you work the most hours in a typical week) ?

Hospital
Health Maintenance Organization (HMO)
Retirement Home
Private Clinic
Gym
Private Institute
Food Industry
Public Health
University / Research Institute
Other

Which conditions (or population groups) do you most often treat? (please mark up to 4 items)

obesity
diabetes
cardiovascular diseases
gastroenterology
nephrology
oncology
eating disorders
healthy eating promotion
vegetarian and vegan diets
infants and children
pregnancy and lactation
athletes
bariatrics
surgery
geriatrics
other

How many years have you worked as a dieititan?

How many patients do you see in an average week?

What is the average number of sessions for each patient?

Do you also provide virtual counselling meeting (e.g., via Zoom, WhatsApp, etc.)?

Questions regarding legume counselling practice and attitides

I recommend consumption of legumes on a daily basis:

1. To almost all of my patients (76%-100% of my patients)
2. To most of my patients (51%-75% of my patients)
3. To some of my patients (26%-50% of my patients)
4. To a few of my patients (up to 25% of my patients)
5. To none of my patients (0% of patients)

I recommend consumption of legumes on a daily basis to patients who are vegan\vegetarian or rarely eat meat:

1. To almost all of my patients (76%-100% of my patients)
2. To most of my patients (51%-75% of my patients)
3. To some of my patients (26%-50% of my patients)
4. To a few of my patients (up to 25% of my patients)
5. To none of my patients (0% of patients)

I recommend that patients increase their legume consumption:

1. To almost all of my patients (76%-100% of my patients)
2. To most of my patients (51%-75% of my patients)
3. To some of my patients (26%-50% of my patients)
4. To a few of my patients (up to 25% of my patients)
5. To none of my patients (0% of patients)

Please indicate your level of agreement with the following statements:
Scale of 1-5: strongly disagree (1 point)- strongly agree (5 points)

Note: The following ten statements were later reduced by factor analysis to three factors: 'Resources, confidence and knowledge'; 'Importance, effectiveness and time'; 'Sustainability'.

Counselling patients regarding legume consumption is important for me. (Importance, effectiveness and time)

Counselling patients regarding legume consumption is important for my colleagues. (Importance, effectiveness and time)

I have sufficient knowledge to counsel patients regarding legume consumption. (Resources, confidence and knowledge)

I am not certain in what context it would be suitable to bring up the topic of legume consumption in a counselling session. (Importance, effectiveness and time)

I am confident in my ability to counsel patients regarding legume consumption. (Resources, confidence and knowledge)

I have enough time to counsel patients regarding legume consumption. (Importance, effectiveness and time)

I have adequate didactic resources to counsel patients regarding legume consumption. (Resources, confidence and knowledge)

In my opinion, counselling patients regarding legume consumption is ineffective (does not result in higher consumption). (Importance, effectiveness and time)

Dietary choices have a significant impact on the environment (i.e., greenhouse gas, water and soil resources). (Sustainability)

The environmental factor should become one of the dietitian's considerations when consulting patients. (Sustainability)

Please indicate your level of agreement with the following statements: .

Scale of 1-5: strongly disagree (1 point)- strongly agree (5 points)

Note: The following ten statements were later reduced by factor analysis to three factors: 'Adequate protein and iron source'; 'Management of consumption barriers'; 'Weight and glucose management'.

I perceive legumes to be:

Satiating (Weight and glucose management)

Suitable for persons with diabetes (Weight and glucose management)

A good source of iron (Adequate protein and iron source)

A good source of protein (Adequate protein and iron source)

Hard to digest (Management of consumption barriers)

Not suitable for children (Adequate protein and iron source)

Promotors of weight loss (Weight and glucose management)

A replacement for a meat dish (Adequate protein and iron source)

A cause of intestinal gas (Management of consumption barriers)

Time consuming to prepare (Management of consumption barriers)

Knowledge questions

The amount of protein in one egg is similar to that of half a cup of cooked chickpeas True\ False\ Don't know

The amount of iron in half a cup of cooked beans is higher than that of 150 gr of cooked turkey breast True\ False\ Don't know

Legumes are an environmentally friendly source of protein in comparison to animal protein True\ False\ Don't know

Legumes may help reduce LDL cholesterol levels True\ False\ Don't know

Dietary guidelines worldwide define legumes as an inferior protein source in comparison to animal protein True\ False\ Don't know

It is necessary to sprout legumes in order to receive their nutritional benefits True\ False\ Don't know

It is not necessary to combine legumes and grains in a single meal in order to obtain high quality protein True\ False\ Don't know

Questions regarding personal consumption patterns

How often do you consume legumes (not including soy milk in coffee)*?*

- Once a month or less
- 2–3 times per month
- Once a week
- 2-3 times per week
- 4-6 times per week
- Every day

Do you define yourself as a vegetarian or a vegan?

- No
- No, but I try to reduce my meat intake
- Yes, vegetarian
- Yes, vegan

The current Israeli Dietary Guidelines' recommendation of daily legume intake was emphasized in the publicity materials of the intervention program. Were you aware of this recommendation before being exposed to these materials?

The intervention group follow up survey included the following additional section evaluating the training program:

Did you watch the webinar?

- Yes, I watched it fully until the end
- Yes, I watched most of it (30 min <)
- Yes, I watched a small part of it (30 min >)
- No, I did not get to watch it

After the program had been completed, a recording of the lecture given in the workshop was sent to you for your convenience, did you watch it?

- Yes, I watched it fully until the end
- Yes, I watched most of it (30 min <)
- Yes, I watched a small part of it (30 min >)
- No, I did not get to watch it

Have you handed out the printed brochure to patients?

1. To almost all of my patients (76%-100% of my patients)
2. To most of my patients (51%-75% of my patients)
3. To some of my patients (26%-50% of my patients)
4. To a few of my patients (up to 25% of my patients)
5. To none of my patients (0% of patients)*

* Those participants were asked to provide the reason for not using the resource (as an open question).

Have you sent the digital brochure to patients (or directed patients to download it from the website)?

1. To almost all of my patients (76%-100% of my patients)
2. To most of my patients (51%-75% of my patients)
3. To some of my patients (26%-50% of my patients)
4. To a few of my patients (up to 25% of my patients)
5. To none of my patients (0% of patients)*

* Those participants were asked to provide the reason for not using the resource (as an open question).

Have you recommended patients to enter the recipe links in the digital brochure?

1. To almost all of my patients (76%-100% of my patients)
2. To most of my patients (51%-75% of my patients)
3. To some of my patients (26%-50% of my patients)
4. To a few of my patients (up to 25% of my patients)
5. To none of my patients (0% of patients)*

* Those participants were asked to provide the reason for not using the resource (as an open question).

Have you used the professional guide for dietitians during consultations to aid in visual demonstration of legume dishes and/or legume variety?

1. To almost all of my patients (76%-100% of my patients)
2. To most of my patients (51%-75% of my patients)
3. To some of my patients (26%-50% of my patients)
4. To a few of my patients (up to 25% of my patients)
5. To none of my patients (0% of patients)*

* Those participants were asked to provide the reason for not using the resource (as an open question).

Has your participation in the program led to an increase in the amount of time you devote to the subject of legumes during consultation meetings?

- Yes, in a significant manner
- Yes, slightly
- No

In your opinion, to what extent has the program and each of its components contributed to improving the effectiveness of your counselling regarding legumes to your patients (i.e., has led to an actual increase in legume intake among your patients)?

Scale of 1-5: to a small extent (1 point)- to a great extent (5 points)

Program

Webinar

Workshop

Dietitian guide

Patient brochure

Digital brochure

Recipe links

To what extent was the program and each of its components compatible with the population you treat?
Scale of 1-5: to a small extent (1 point)- to a great extent (5 points)

Program

Webinar

Workshop

Dietitian guide

Patient brochure

Digital brochure

Recipe links

What is your general satisfaction with the program and each of its components?
Scale of 1-5: very low (1 point)- very high (5 points)

Program

Webinar

Workshop

Dietitian guide

Patient brochure

Digital brochure

Recipe links

We would appreciate if you could share your general feedback regarding the program and suggestions for improvement

Supplementary file 2

Table S1. Pairwise Comparisons of Dietitians' Legume Recommendations to Patients, (n=212)

	Intervention group n=108 (n,%)	**Control group n=104 (n,%)**	**OR (95% CI)**	**p-value***
Recommending patients to consume legumes daily				
Remaining in 76%-100% of patients	30 (27.8%)	11 (10.6%)	3.25 (1.57-7.18)	0.009
Improving to 76%-100% of patients	25 (23.1%)	17 (16.3%)	1.54 (0.78-3.10)	0.216
Declining to 75% or less of patients	5 (4.6%)	15 (14.4%)	0.29 (0.09-0.77)	0.041
Remaining in 75% or less of patients	48 (44.4%)	61 (58.7%)	0.56 (0.33-0.97)	0.052
Recommending patients to increase legume intake				
Remaining in 76%-100% of patients	45 (41.7%)	28 (26.9%)	1.94 (1.09-3.48)	0.049
Improving to 76%-100% of patients	26 (24.1%)	20 (19.2%)	1.33 (0.70- 2.59)	0.390
Declining to 75% or less of patients	8 (7.4%)	19 (18.3%)	0.36 (0.14-0.83)	0.049
Remaining in 75% or less of patients	29 (26.9%)	37 (35.6%)	0.66 (0.37-1.19)	0.228

*The p-values presented in the table are adjusted for multiple comparisons.

Process Evaluation by the Intervention Group (n=109)

1. Use of the program components

For the first question “Did you watch the webinar", almost all (95.4%, n=104) reported watching the webinar until the end. Less than 3% (n=3) reported watching most of it (more than 30 minutes), and 1.8% (n=2) reported watching only a small part of the webinar (less than 30 minutes). None of the participants reported not watching the webinar at all.

For the second question regarding watching the workshop recording, more than half (53.3%, n=57) reported not watching the recording at all. Nearly a third (32.7%, n=35) watched the recording until the end, with 9.3% (n=10) and 4.7% (n=5) reporting watching most of it, or a small part of it, respectively.

Regarding handing out the printed brochure to patients, only 14 (12.8%) reported handing it out to more than 76% of their patients. Almost the same number (n=15, 13.8%) reported not providing the brochure to any of their patients, with the main reasons reported that the brochure was not relevant to their work because they provide virtual consultation (n=4) or because of their patient population (e.g., children, English speakers) (n=4); an additional n=4 reported forgetting to bring the brochures to the clinic or not being used to handing out material.

Regarding sending the digital brochure to patients (or directing them to download it from the website), only 8 (7.3%) reported sending it to more than 76% of their patients, and 48 (44%) reported not sending it to any of their patients, with the main reasons reported that they preferred to hand out the printed brochure (n=17); they forgot that a digital version of the brochures was also provided to them (n=9); they work in Health Maintenance Organizations (HMOs), and do not have the option of emailing exterior

materials to patients (n=7); an additional n=7 reported that it was not relevant for their treated population (e.g., older persons, ultra-orthodox Jews).

Regarding recommending patients to enter the recipe links in the digital brochure, only 14 (12.8%) reported recommending it to more than 76% of their patients. Approximately a third (n=37, 33.9%) reported not recommending it to any of their patients, with the main reasons reported that they forgot (n=14); they have their own recipes that they are used to give to patients (n=10), and n=7 reported that it was not relevant for their treated population (e.g., dialysis patients, older persons, ultra-orthodox Jews).

Regarding using the professional guide for dietitians during consultations (to aid in visual demonstration of legume dishes and/or legume variety) only 10 (9.3%) reported using it with more than 76% of their patients. Approximately a quarter (n=26, 24.1%) reported not using it with any of their patients, with the main reasons reported that they did not see a need for it (n=11); they used the patient brochure (n=5) and that they forgot
(n=4).

2. Evaluation of the program components

Table S3 provides the rating of the participants for the intervention as a whole, and each of the intervention components, on a Likert scale of 1-5, in regard to their impact on improving legume counselling effectivity, compatibility with their patient population, and general satisfaction.

Table S2. Participants' Evaluation of the Program Components (n=109)

	Improving legume counselling effectivity[1] (mean ± SD)	Compatibility to the treated population[2] (mean ± SD)	General satisfaction[3] (mean ± SD)
Program as a whole	4.2±0.7	4.2±1	4.5±0.7
Webinar	4.1±0.9	4.1±1	4.5±0.7
Workshop	4.2±0.8	4.2±1	4.5±0.7
Dietitian guide	4.0±1.1	4.1±1.2	4.5±0.8
Patient brochure	4.1±1.0	4.2±1.1	4.5±0.7
Digital brochure	3.5±1.3	3.7±1.4	4.2±1.0
Recipe links	3.6±1.2	3.8±1.4	4.3±0.9

5-point Likert scale from " to a small extent " (1) to "to a great extent" (5).
[1] "In your opinion, to what extent has the program and each of its components contributed to improving the effectiveness of your counselling regarding legumes to your patients (i.e., has lec an actual increase in legume intake among your patients)?"
[2] "To what extent was the program and each of its components compatible with the population y treat?"
[3] "What is your general satisfaction with the program and each of its components?"

Almost all reported that the participating in the program increased the amount of time they devote to legumes during consultations, with 37.6% (n=41) reporting the time devoted to legume counselling increased in a significant manner, and 56.9% (n=62) reported it increased slightly. Only n=6 (5.5%) reported that the time they devoted to this topic has not increased.

Half of the participants (N=59, 54%) provided also general feedback and suggestions for improvement. Most provided overall high positive feedback, e.g., "The program was exceptional ", "It was very interesting and enjoyable", "The program should become a

part of BSc. Nutritional Science curriculum", "I don't know whether there is something to improve in the program, in my opinion it was excellent ". Few provided specific examples of how the program was successful. For example, a few mentioned that the program has led to a higher personal or household legume consumption, or that there was high compliance from patients in regard to incorporating legumes in their diets, and very positive feedback from patients regarding the brochure.

A few made specific suggestions for improvement of the intervention: 1) incorporating the digital brochure within the HMOs software to enable sending it directly to patients; 2) adding additional reminders; 3) additional content regarding specific considerations for children and for diabetic patients; and 4) adding a cooking workshop/ having one of the sessions as a face-to-face meeting.

3. Discussion

A substantial gap exists between dietary recommendations worldwide and actual legume intake. This dissertation presents the possibility of using dietitians as effective agents for change in promoting legume consumption. The distinct need to increase the intake of legumes among Israelis was confirmed after conducting secondary data analyses of the Israeli Health and Nutrition 2014-2016 MABAT Adult Survey. Legume consumption was found to be well below the current recommendations of the Israeli Dietary Guidelines. In the next stage, Israeli dietitians' knowledge, attitudes and practices regarding legume counselling and consumption were evaluated. Results revealed that recommendations to patients regarding the frequency and amount of legumes to be included in the diet, along with dietitians' personal consumption, also did not meet current guidelines. The factors associated with recommending legumes to patients were the dietitians' higher personal legume intake, not working in hospitals, more favorable perceptions regarding barriers toward legume consumption and more favorable attitudes toward legume counseling pertaining to importance. Based on these findings, an evidence and theory-based online intervention was developed. The online program included a prerecorded webinar, small-group interactive workshops and provision of counselling brochures for patients and a professional guide on legume counselling for dietitians. The intervention was found to be effective in improving dietitians' self-reported legume counseling practices, attitudes toward legume counseling, knowledge and personal legume consumption.

Data regarding legume consumption in Israel were collected a decade ago, between 2014-2016; currently available data from nationally representative surveys in other countries are also from these years (43,45) or earlier (44,46,47). The lack of updated nationally representative data hinders the ability to effectively monitor changes in legume consumption over time. A possibly more accessible and continuous way to estimate legume consumption may be purchase data (97). However, a shortcoming of this approach is that these data are based upon retail sales only, thus purchases from the food service sector, including restaurants and catering services at workplaces are not registered (43,97). Purchase data also may not reflect actual consumption rates (98). It can be postulated that legume consumption in Israel, as well as in other high-income countries, has somewhat increased over the last decade. The rising awareness regarding

the health, environmental and ethical attributes of food choices may have led to a higher intake in dry legumes or minimally processed legumes (e.g., frozen legumes and tofu) (99). Conversely, it is important to note that there has been a concurrent increase in meat substitute intake, many of which are based on soy or pea isolated proteins (100,101); these legume-based products are considered as ultra-processed foods, and therefore are not in line with current dietary recommendations (4,31). Lastly, the rise in demand for gluten-free products in high-income countries may have led to a higher consumption of legume flours and minimally processed legume products (e.g., legume-based pasta) (102). Nonetheless, considering that dietitians tend to have better eating habits than the general public (103), and the low legume intake reported by dietitians in this study, it is highly likely that current legume intake in Israel is well below the guidelines.

The low legume intake found in this study may reflect an overall inadequate adherence to the Mediterranean diet, as legumes are an integral component of this dietary pattern (104,105). The diets of Mediterranean populations have been shifting away from traditional patterns (106,107). While there are no nationally representative data on adherence to the Mediterranean diet among the adult population in Israel, a recent study of a large sample of Jewish and Arab women reported moderate adherence, with a mean Israeli Mediterranean Diet Adherence Scale (I-MEDAS) score of 9 out of 17 (108). According to nationally representative surveys, adherence to the Mediterranean diet was predominantly low to moderate among older adults (27% and 62%, respectively; MABAT Zahav 2005-2006) (109). Among adolescents, moderate adherence was most common (45%), while high adherence was observed in fewer than half of participants (43%) (MABAT Youth 2015-2016) (110). The Mediterranean diet also possesses a socio-cultural dimension (111), that encompasses culinary activities related to shared food preparation, the intergenerational transmission of food-related knowledge, and the time devoted to meal preparation as an integral part of daily life. In this study more than half of legume consumers reported consuming legumes as hummus with an average intake of one tablespoon. These spreads are commonly available as ultra-processed products, typically high in salt and refined vegetable oils, and containing food additives. Consequently, this form of legume intake deviates from the traditional Mediterranean diet, which emphasizes home cooking based on raw ingredients (112). The decreasing adherence to the Mediterranean diet is indeed concurrent with an increasing adoption of

Western diets, characterized by high intake of refined grains, meat and ultra-processed foods (113). Factors that may explain this nutritional transition include urbanization, the progressive globalization of food supply and the enhanced commercial availability of food (especially of animal origin) (113,114).

The most recent Israeli dietary guidelines include legumes in a category of foods recommended for consumption at least once a day, along with olive oil, tahini, nuts, and milk and milk substitutes. In this study, more than half of the dietitians were not aware of the recommendation of daily legume intake. A knowledge gap regarding dietary guidelines was also identified among European dietitians, who reported a lack of updated national dietary guidelines as a considerable barrier to sustainable dietary patterns promotion (115), despite the fact that a high percentage of European countries include sustainability recommendations in their guidelines (116,117). A possible explanation suggested for this discrepancy was that sustainability is included in dietary guidelines in an ambiguous way that lacks clear messages on why and how it should be included in healthy diets (116). Similarly, it is possible that the inclusion of legumes alongside other types of food that lack a clear commonality obscured their unique and distinct role as the sole source of protein and iron recommended for daily consumption in the Israeli dietary guidelines (other sources are recommended as follows: "chicken, turkey, fish and eggs: diversify on a weekly basis", "beef: up to 300 grams a week"). The recommendation of daily legume intake was highlighted in the invitation to participate in the study. It is possible that being exposed to the recommendation for the first time may have served as a minor form of intervention, that sufficed to induce a change of behavior in some of the sample. Additionally, simply reporting that one is eating more legumes, or counseling more patients, may reflect a social desirability bias. This is a possible explanation for the improvement in legume counseling reported by the control group.

The intervention was effective in improving attitudes in regard to legume counselling, with the largest improvement seen for “having adequate resources". At baseline, this statement received the lowest level of agreement out of all attitudes and perceptions, similarly to the findings of the preceding survey (118). A lack of adequate didactic resources was also reported by Canadian dietitians (78). The intervention provided extensive resources for professionals to use with their patients. All of the resources

received high scores regarding general satisfaction. The printed brochure and dietitian guide were well received and were considered both effective and compatible for the treated population. The digital brochure and recipe links scored lower in these two parameters, which coincided with the lower rate of dietitians reporting using them. A possible explanation for these findings is the low number of the dietitians that reported virtual counselling on a regular basis, The rate of dietetic online counseling in the US dramatically increased during the COVID-19 pandemic (119), it can be estimated that some of the pandemic adoption has persisted, however there are no available data regarding current dietetic online counseling rates worldwide. In addition, health maintenance organizations (HMOs), commonly limit emailing exterior materials to patients and even internet access. It was expected that the printed brochure would be used more, considering its high scores in all three evaluation parameters. It is possible that the brochures were handed out sparingly due to the limited amount provided to each participant.

A potential explanation for the overall limited resource usage may be that dietitians adapted their counselling approach according to the client's level of motivation and capability. Different pulse consumer types were identified in a Canadian study, along with corresponding messaging strategies to increase their pulse intake (56). Quick and basic recipes were recommended to those recognizing pulse’s various benefits but lack knowledge of how to prepare them, and to those who had low consumption mainly due to lack of exposure to pulses (56). Dietitians in this study may have preferred to provide clients who demonstrated a lower level of motivation or experience in preparing legumes, with basic guidance and easy cooking tips, such as adding legumes to soups and salads, or preparing well known and easy to make dishes (e.g., majadra). This more simplistic approach may have been intuitively perceived as more suitable for those clients than providing the elaborate brochure. Therefore, future interventions might consider providing adaptive patient educational material that can be tailored to the patients’ personal needs and level of motivation and capability. Perceived cooking abilities were found to be a key facilitator to legume consumption both directly and via indirect routes (e.g., reducing the importance of enjoyment and sensory properties for consumption) (120); thus, providing clients a positive initial cooking experience may be of considerable importance. For individuals determined to have a greater affinity towards legumes, the Canadian authors recommended providing a wide variety of new

and different pulse recipes (56). American and Puerto Rican studies (74,121) also reported legumes' culinary versatility as a motivator for consumption among this type of consumer. The potential of introducing new kinds of pulses to generate interest and excitement was also suggested (74). Similarly, dietitians in this study may have found the brochure as an effective resource for this type of client. The brochure provided over 30 recipes divided into ten dish categories, such as 'soups' and 'casseroles' and also less familiar options such as 'egg substitutes' and 'bread alternatives' (122). Additionally, its cover featured photos of 16 common legume varieties available in Israel. The intervention group participants were asked about the proportion of patients to whom they provided each of the didactic resources (76-100%; 51-75%; 26-50%; 25% or less; none); only those who responded 'none' were further asked to provide the reason for not using the resource (as an open question). It is possible that directing this question also to participants who chose the lower categories (i.e., 25% or less and 26-50%), would have provided additional useful data that may have enabled a better understanding of how to better tailor the brochures to dietitians' counselling needs.

The intervention was solely online, due to consideration of maximizing enrollment and attendance by diminishing place and time barriers. An additional factor was the lower cost of an online format. An interest in a cooking workshop was identified in the preceding survey when dietitians were asked to rate their interest in themes to be included in a future training (118). It is possible that a cooking workshop would have enhanced the effectivity of the intervention, however budget limitations did not allow us to rent a venue, or hire a chef. Chefs are in an advantageous position to provide culinary education due to their culinary knowledge and skills, in addition to their ability to evoke enthusiasm for cooking and eating enjoyment (123). Therefore, it may be ideal for a chef to deliver a cooking workshop, along with a support of a dietitian providing the nutritional aspect. The attendance rate of the online workshops was very high (97.6%). In contrast, the hypothesized lower attendance rate in a face-to-face cooking workshop could result in the formation of two intervention groups (i.e., one that received a cooking workshop, and one that did not). Detecting the differences in effect between the groups would require a considerably larger sample size, which presented further limitations. The cost-effectiveness of holding a cooking workshop is possibly lower in countries with a culinary culture that includes legumes, such as other Mediterranean (104) and Latin American (49) countries. Conversely, dietitians in countries that lack

legume based traditional dishes may significantly benefit from including a cooking workshop in the training. For example, Dietitians of Canada recognized the need for dietitians to be familiar with plant-based cuisines from a variety of cultures to support creative and tasty approaches to clients' dietary change towards sustainable diets and to provide recommendations that are culturally relevant (91). In such cases, there may be an objective need for a workshop to provide relevant cooking and preparation skills, in addition to exposing the participants to the taste of legume-based dishes. In an age where on-line and television cooking shows are widespread, this may serve as an additional avenue for promoting legume consumption.

This research's primary aim was promoting legume consumption in Israel using dietitians as agents of change. Data regarding changes in patients' legume intake were not collected. However, they were reported indirectly by the participants providing a high score for counseling effectivity (i.e., an increase in legume intake among patients) following the intervention. Moreover, the effectiveness of dietetic consultation for diet quality improvement is well established (124–126) and it can potentially offer specific benefits in regard to legume intake promotion, due to clientele. Women seek nutrition counselling more frequently than men (127), and constitute approximately two thirds of clients receiving dietetic consultation in Israel's largest HMO (personal communication, Division of Community Medical Services, Clalit Health Services, Tel Aviv). In comparison to men, women have a higher awareness and better knowledge of nutrition (127,128), they are more likely to be frequent eaters of plant proteins (129), to have a more favorable attitude towards sustainable foods (130), and to intend to increase their intake of plant foods and decrease meat consumption (131,132). These characteristics may position women as a target audience with high compliance for increasing legume consumption. The estimated rate of Israeli adults who have ever received dietetic counselling is 36% (133), similar to the 32% rate reported in Australia (134). This rate suggests that dietetic counselling has a considerable reach among the population, particularly as individual food choices may have rippling effects on wider circles. In case the client does not live alone, legume consumption of the entire household is likely to be positively affected (135). This effect is probably more pronounced for women, as the majority of grocery shopping, meal planning and cooking are performed by them, positioning them as nutritional gatekeepers (136,137). An additional broad and long-term effect may be conferred for clients who have children, since healthy eating habits

formed in childhood and adolescence are associated with healthy eating behaviors in adulthood (138), and this positive association was also reported in regard to legume intake (61).

In order to achieve a wider population impact, legume consumption should be promoted also by dietitians in varied roles throughout the food system including counseling for groups, menu planning and procurement for institutions, advising the food industry and working in public health (e.g., nutritional education for children), policy or academic settings (83,91). It should be noted that it is common for dietitians in Israel to work simultaneously in several places; therefore, although this intervention focused on dietitians who counsel individuals, it may have also had additional effects in the above-mentioned venues. It was beyond the scope of this study to make these evaluations. It is also plausible that the patient brochure had an independent contribution for legume promotion, since the Israeli Ministry of Health (MOH) printed a substantial number of copies for its own use, providing them to dietitians working in the public health sphere. The Ministry also placed the brochure in its affiliated website, both in a digital version (122) and in a version compatible for production by printing houses (139), thus enabling independent printing by other stakeholders. Lastly, the needed change in legume consumption patterns should be ideally supported by media campaigns and enabled by policies implementing the current Israeli dietary recommending as a standard in canteens in schools, universities, hospitals and other establishments. Campaigns promoting pulse intake were carried out in France in the past decade (97,140). Pulse purchases increased by 8.4 % after the FAO International Year of Pulses campaign in 2016 (97). A later campaign promoting pulses and whole grain intake was found in a prospective survey to improve pulse consumption and knowledge regarding pulses among participants with low pulse intake (140). Policies setting nutrition standards in schools (141) and workplaces (142) were found to be effective in increasing fruit and vegetable intake (141,142), whole grain intake (141) and in improving overall dietary intake (142). It is possible that legume intake could be similarly improved in these settings.

The overall high agreement with the need to integrate the environmental consideration into the dietitian's practice found in this study is in line with studies conducted among American (143) and European (115,144) dietitians. Furthermore, dietetic associations

have recognized dietitians as key agents for change in the transition toward sustainable food systems, and have acknowledged the necessity of providing adequate sustainability training and resources for dietitians and dietetic students (82,83,86–88,90–92). This study can potentially serve as a model for similar dietitian training programs in more countries, addressing the gaps identified in existing programs. Dietetic academic education and practical training regarding sustainability were found to be inconsistent and insufficient (145–147). American programs lack content regarding the linkages between human and planetary health, with only a few programs addressing plant-based diets' key role in dealing with the environmental crisis (147). The two leading barriers to adopting a plant-based diet in high-income countries are concerns of nutritional deficiencies and not knowing what to eat as part of a plant-based diet (148). Indeed, shifting towards more plant-based diets might lead to lower intake or bioavailability of some nutrients (e.g., iron and zinc) (9,31) and to increased intake of processed meat alternatives, which may be nutritionally inadequate (82,101). Dietitians can play an essential role in addressing these barriers and concerns by promoting legumes as a prominent protein source, therefore ensuring the nutritional adequacy of this shift. In addition to the health aspect, choosing unprocessed or minimally processed legumes over processed meat alternatives also provides environmental advantages (31,149) and is more affordable (80), thus enabling a shift in the population's dietary patterns without increasing social inequalities. As mentioned previously, a lack of adequate didactic resources regarding legumes was reported in this research (prior to the intervention) (118), and also by Canadian dietitians (78). Creating educational resources regarding legumes may help overcome dietitians' challenges in promoting sustainable diets that include lack of educational resources (143) particularly regarding sustainable food options and substitutions for use in meal and menu planning (150). The necessity for international networking and collaboration to highlight and disseminate examples of sustainable food systems educational activities has been recognized (88,145,151). Peer reviewed publications evaluating innovative models and establishing effective approaches for integrating sustainability into dietetic training programs are specifically needed (152). This study is the first one to evaluate an intervention aiming to improve dietitians' legume counseling practices. Further interventions regarding this vital issue are warranted and should ideally be conducted as well-constructed studies to evaluate their effectivity. The three stages of our research may serve as a model for a comprehensive process, integrating the use of validated behaviour change models.

Future studies may be advised to take into consideration the seasonal factors when defining the timing of the baseline and follow up surveys, since legumes are more typically consumed in the winter (43,60,153). As mentioned previously, it is recommended to explore the cost effectiveness and participant compliance in regard to a cooking workshop as an additional intervention component. Lastly, studies should ideally include a long-term follow-up to explore the sustainability of legume counselling.

Strengths and limitations

Despite the key role legumes possess in sustainable and healthy diets, the research regarding legume intake and effective ways to increase it is limited. The main strength of this research is its contribution to filling some of these present gaps. This is the first study to evaluate an intervention aiming to improve health professionals' legume counselling practices, and the first randomized controlled trial performed in high-income countries evaluating a legume promotion intervention. Validated behavior change models were used to design the intervention and its preceding survey, which is the first study to evaluate the factors that may influence adequate legume counselling. Lastly, this is the first study to comprehensively estimate and characterize legume consumption in a Mediterranean country.

This research had several limitations. Firstly, the data regarding legume consumption in Israel were collected between 2014- 2016. Secondly, a single 24-hour recall may be limited by day-to-day variation in food intake and may not fully represent participants' habitual diet. In major national nutrition surveys such as the American NHANES and the Australian Health Survey two non-consecutive 24-hour recalls are routinely used to better estimate usual dietary intake. In the preceding dietitian survey, a higher response rate would have improved our ability to generalize our findings to all Israeli dietitians. Nonetheless, it is likely that our sample overrepresented dietitians who are more interested in the issue of legume consumption. Thus, the true rate of legume counselling is expected to be even lower than was found, further affirming the necessity for an intervention. Selection bias is a recognized limitation in survey research and may be more pronounced in online surveys, where respondents may not fully represent the target population. In particular, online formats may lead to the underrepresentation of older individuals or those less comfortable with digital technologies. However, in the present study, the age distribution of the respondents closely resembled that of the

overall Israeli dietitian population, suggesting that the sample was representative with respect to age .The intervention questionnaire did not include a question regarding sub-populations (e.g., Arabs, The Union of Soviet Socialist Republics (USSR) or Ethiopia immigrants, Ultra-Orthodox Jews, or the general Jewish population) that dietitians also counsel. It is not clear whether the sample in this study is representative of dietitians treating these sub-populations. The survey questionnaire's sections of 'legume perceptions' and 'attitudes toward legume counseling' were slightly modified in the intervention questionnaire, due to the need to remove two statements that were ambiguous (i.e., "Easier to include lentils in the daily diet in comparison to other legumes"; "I would like to include more legume consumption recommendations in my practice"). Identical questionnaires would have enabled us to perform the factor analysis on the same statements for the second time, and to examine whether they would be grouped into the same factors, thus further validating our analysis. For the intervention, and due to time limitations, the small group workshops did not include content regarding cultural tailoring of the counselling to different sub-populations. However, it is important to note, that the patient brochure is currently being translated to Arabic by the Israeli Ministry of Health. This process will also include cultural adaption of its recipes carried out by an Arab dietitian. The intervention's reported effectivity should be interpreted in light of the study's design limitations. Firstly, the data were self-reported, therefore subjected to social desirability bias that may have led to more favorable practices and attitudes being reported. Secondly, data regarding changes in patients' legume intake were not collected. Lastly, although the three-month follow-up allowed the assessment of short-term changes following the intervention, it may not capture the sustainability of behavior change over time. Early improvements may reflect increased awareness or initial motivation, which can diminish in the absence of continued reinforcement. Factors such as fading recall of educational content, declining motivation, and competing professional demands may contribute to attenuation of effects. Future studies with longer follow-up periods and repeated measurements are warranted to assess maintenance of change and long-term effectiveness.

Implications for future research and practice

It is advisable to conduct future research among the study population in order to evaluate the intervention's long-term effects. Additionally, future research should consider conducting analyses stratified by employment setting to better understand whether the intervention

effectiveness varies across different professional contexts. Lastly, legume consumption should be studied also in future MABAT Adult Surveys to detect possible changes in legume consumption patterns among the Israeli population. It is recommended that the MOH subsidize the implementation of the training program and the provision of educational materials for dietitians working in HMOs and hospitals, including integrating the patient brochure into their computerized systems; thus, potentially encouraging its widespread use, supporting effective, low-cost legume counseling for the long term. Depending on each institution's budget and needs, face-to-face sessions may be offered, including a cooking workshop. It is also recommended to spread the program (i.e., links to the recorded webinar and workshop; digital patient brochure and professional guide) in various dietitian forms, such as the electronic mailing list of ATID- the Israeli Dietetic Association and relevant Facebook groups for dietitians. Lastly, given its role in setting the requirements for professional clinical certification of dietitians, the MOH is encouraged to define legume-related content for inclusion in dietetic internship curricula and to incorporate relevant questions into the licensure examination. Accordingly, it is advisable that the MOH issue recommendation regarding legume-related content to be incorporated into undergraduate nutrition science curricula and provide these academic institutions with the program's brochures for distribution to nutrition students.

Conclusions

This research demonstrated that legume consumption in Israel is well below current guidelines. A low-cost, online training can improve dietitians’ legume counseling practices, attitudes, knowledge and personal legume consumption. Promoting legume consumption as a sustainable and healthy protein source is an urgent task of global importance, in which dietitians can act as key agents for change through their wide circles of influence. This RCT is the first study to evaluate the effectivity of an intervention aiming to improve dietitians' legume counselling practices, potentially serving as a model for similar dietitians’ training programs worldwide.

4. Appendices- Professional Guide for Dietitians

איך נשלב קטניות בתזונה היומית?

ניתן לשלב קטניות בכל ארוחה ביממה ובמגוון סוגים של מנות, לדוגמה:

ארוחת בוקר/ערב

במקום ביצים: שקשוקת טופו, מקושקשת טופו וחביתה מקמח עדשים או קמח חומוס.

סלטים: סלט בטטה ועדשים, סלט שעועית אדומה אושחורה בסגנון מקסיקני וסלט "טונה" מגרגירי חומוס.

מרקים: מרק אפונה, מרק מינסטרונה עם שפע של שעועית לבנה ומרק חרירה עם חומוס ועדשים.

טיפ: אפשר להעשיר כל מרק וסלט ירקות במנת קטניות כתוספת עשירה בחלבון.

ממרחים: חומוס, 'חומוס' מעדשים כתומות ו"גבינה" מטופו.

תחליף נטול גלוטן ללחמים: טורטייה מקמח עדשים, קרקרים מקמח חומוס ו"פיתות" מעדשים.

ארוחת צהרים

תבשילים: מג'דרה, אורז ושעועית לבנה ברוטב עגבניות, קוסקוס עם שפע חומוס ומרק ירקות ומוקפץ עם טופו ואטריות אורז.

טיפ: מומלץ להעלות את כמות הקטניות בתבשילים המוכרים למשל: יחס של 1:1 בין העדשים לאורז במג'דרה (או אף יותר מהעדשים). יש לציין שהחלבון בקטניות הינו איכותי וכמותו גבוהה פי 2-3 מאשר בדגנים. לכן אין הכרח תזונתי לשלב קטניות ודגנים באותה ארוחה כדי לקבל חלבון מלא, בניגוד למה שנהוג לחשוב.

קציצות והמבורגרים: המבורגר עדשים, פלאפל אפוי וקציצות טופו ברוטב חריימה.

מליות: בוריטו עם שעועית אדומה או שחורה, סמבוסק חומוס ובורקס פילו במילוי טופו ותרד.

במקום בשר טחון: עדשים או טופו מפורר ב: ספגטי בולונז, קובה, לזניה וירקות ממולאים.

שילוב קטניות במנות מוכרות:
הוספת קטניות מעלה משמעותית את הערך התזונתי של המנה, ומסייעת בהנגשה לאכלנים בררנים. העדשים הכתומות הנימוחות מצטיינות במיוחד במשימה:

- מרק כתום עם בטטה, גזר ודלעת
- פירה כתמתם עם תפוחי אדמה
- ממולאים יחד עם אורז
- שילוב קמחי קטניות בקציצות של ירקות או בפשטידות
- קציצות בשר - להחליף חלק מהבשר בעדשים טחונות (אפשר להתחיל ברבע מהכמות ובהמשך להתקדם לחצי מהכמות ומעלה).

איך מבשלים קטניות?

1.השרייה. שוטפים את הקטניות ולאחר מכן מניחים אותן בכלי גדול עם הרבה מים (לא חמים) למשך 10-12 שעות. מומלץ להחליף את המים לפחות פעם אחת, ובימים חמים, להכניס את הכלי למקרר. שימו לב, עדשים ומש אפשר להשרות רק ל-2-3 שעות ואף זה לא הכרחי אם רוצים לחסוך בזמן.

2.סינון ושטיפה. שופכים את הקטניות למסננת ושוטפים אותן תחת מים זורמים.

3.בישול. שמים את הקטניות בסיר עם הרבה מים, מביאים לרתיחה ולאחר מכן מבשלים על אש קטנה עד התרככות.

קיצורי דרך במטבח

קטנות ומהירות. עדשים כתומות מתבשלות תוך 15-20 דקות, ויתר העדשים ושעועית מש תוך חצי שעה.

הכינו מראש. השרו ובשלו כמות גדולה של קטניות, חלקו למנות והקפיאו לשימוש זמין בעתיד. ניתן להפשיר בקלות מנה לפי הצורך, להוסיף למרק, לסלט או לטחון לממרח. ניתן להקפיא גם לאחר ההשרייה, ובשימוש העתידי לבשל את הקטניות יחד עם יתר רכיבי המתכון.

לקנות מוכן. ברשתות השיווק תמצאו מגוון קטניות קפואות וזמינות לשימוש. מוצרים מהירים נוספים הם טופו, קמחי קטניות, פסטות ודפי לזניה על בסיס קטניות. בעדיפות נמוכה, ניתן להשתמש בעת הצורך בקטניות באריזות ואקום ובקופסאות שימורים. מומלץ לשטוף את הקטניות מנוזלי השימור לפני השימוש כדי להפחית תכולת נתרן.

דרכים לשיפור עיכול ומניעת גזים

מתחילים בקטנה. נתחיל בקטניות הקטנות והקלות לעיכול: עדשים (במיוחד הכתומות) וטופו בכמות מתונה.
בהדרגה נעלה את הכמות הנאכלת ונתנסה גם עם יתר הקטניות.

חלף עם הרוח. ככל שהופכים את אכילת הקטניות להרגל, מערכת העיכול מסתגלת אליהן ועם הזמן הגזים פוחתים ואף נעלמים.

משאירים בהשרייה. ככל שההשרייה ממושכת יותר כך גם תועלותיה יותר משמעותיות: • הפחתת גזים • קיצור זמן בישול • העלאת הערך התזונתי.
מומלץ להאריך את ההשרייה (קטניות קטנות - לפחות 12 שעות וקטניות גדולות - לפחות 24 שעות) תוך החלפה של המים לפחות פעמיים.

מחליפים את מי הבישול. לאחר רתיחת המים מסננים את הקטניות ומוזגים מים חדשים. אפשר לחזור על התהליך פעם נוספת במידת הצורך.

מתבלים. התבלינים הבאים עשויים לסייע גם כן בשיפור עיכול:
זרעי שומר, זרעי אניס, קימל, קינמון, כמון, ג'ינג'ר והל.

מנביטים. ההנבטה מעניקה את אותן התועלות של השרייה, רק בשיעור גבוה יותר. חשוב לציין, שבמהלך הנביטה כמות החלבון הולכת ופוחתת באופן הדרגתי, כך שכמותו תלויה בגיל הנבט:
נבטים בוגרים וארוכים הינם דלים בחלבון, ולכן מסווגים כירקות ולא כקטניות.
'נבטוטים' (נבטים שרק החלו לנבוט ובעלי 'שורשון' קצרצר) הינם דומים לקטניות בתכולת החלבון שלהם.
הקטניות הקלות ביותר להנבטה הן שעועית מש ועדשים. ניתן לאכול את נבטוטיהן ללא בישול; אך לטובת הקלה על העיכול, יש לבשלן במשך 5-10 דקות.

כיצד מנביטים?
1. משרים במשך 8-12 שעות
2. מעבירים למסננת, שוטפים היטב, מכסים בצלחת או במגבת ומניחים במקום מוצל מעל לכלי להוצאת עודפי הנוזלים.
3. שוטפים את הקטניות 2-3 פעמים ביום, עד ליציאת שורשון קטן וקבלת 'נבטוט'.

טבלת ערכים תזונתיים ל-100 גרם קטניות מוכנות לאכילה

	אנרגיה (קק"ל)	חלבון (ג')	שומן (ג')	פחמימות (ג')	סיבים (ג')	ברזל (מ"ג)	סידן (מ"ג)	אבץ (מ"ג)	משקל כוס לאחר בישול (ג')
עדשים	115	9	0.4	12	7.9	3.3	19	1.3	198
חומוס	164	8.9	2.6	19.8	7.6	2.9	49	1.5	164
שעועית לבנה	138	9.7	0.4	18.6	6.3	3.7	90	1.4	179
שעועית מש	105	7	0.4	12	7.6	1.4	27	0.84	202
שעועית בובס	115	7.8	0.4	13.9	7	2.4	17	0.9	188
אפונה	117	8.3	0.4	12.8	8.2	1.3	14	1	196
פול	110	7.6	0.4	14.2	5.4	1.8	43	1.2	170
תורמוס	119	15.6	2.9	7	2.8	1.2	51	1.4	166
פולי סויה	172	18.2	9	2.4	6	5.1	102	1	172
אדממה	121	12	5.2	3.7	5.2	2.3	63	1.4	160
טופו	140	15	8	2	2.3	1.6	86-400	1.6	-

* הנתונים לקוחים מתוך אתר הUSDA.

המתכונים לכל המנות בעלון ורבים אחרים ב:
beans.co.il

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תקציר

היתרונות הבריאותיים והסביבתיים של צריכת קטניות (שעועית, עדשים, אפונה וסויה) באים לידי ביטוי בהמלצות תזונתיות ברחבי העולם. בישראל, ההנחיות התזונתיות ממליצות על צריכת קטניות מדי יום; עם זאת, קיים פער ניכר בין ההנחיות לבין הצריכה בפועל של קטניות, בעיקר במדינות מערביות, לרבות בישראל. פיתוח תוכניות התערבות יעילות המקדמות צריכת קטניות כמקור מרכזי לחלבון ולמיקרו-נוטריינטים הינה משימה בעלת חשיבות עולמית. קהל יעד בעל משמעות מיוחדת הוא הדיאטניות, בהיותן הגורם המקצועי האחראי על יישום ההמלצות התזונתיות בקרב האוכלוסייה. לדיאטניות תפקיד מרכזי בשינוי דפוסי תזונה הן ברמה האישית והן ברמה הקהילתית. מטרות המחקר היו לתעד את צריכת הקטניות בפועל בישראל; לאפיין את הרגלי הייעוץ הנוכחיים של דיאטניות ישראליות בנוגע לצריכת קטניות; ולפתח ולהעריך תוכנית התערבות שתשפר את הרגלי הייעוץ של הדיאטניות כסוכנות שינוי מרכזיות.

בהתאם למטרות אלו, הפרק הראשון של עבודת דוקטורט זו בחן את צריכת הקטניות באוכלוסייה הישראלית באמצעות ניתוח נתונים משני של סקר הבריאות והתזונה הלאומי 2014–2016 (מב"ת מבוגרים), שהינו מדגם מייצג ארצי של האוכלוסייה הבוגרת (n=2808).

נמצא כי צריכת הקטניות הינה נמוכה משמעותית מהרמה המומלצת. קטניות נצרכו על ידי 31.1% (n=874) בלבד מהמשתתפים והצריכה החציונית היתה כ־¼ כוס. מבין הצורכים, יותר ממחצית (52.9%, n=462) דיווחו על צריכת חומוס, כאשר גודל המנה הממוצעת היה כף אחת. צרכני קטניות היו בעלי סיכוי נמוך יותר לסבול ממחלות רקע [יחס סיכויים מתוקנן (aOR) 0.54 (95% CI: 0.78–0.37),], והיו בעלי סיכוי גבוה יותר להיות גברים [aOR 1.41 (95%CI: 1.65–1.2] ולהיות ילידי ישראל [(aOR 1.24 (95%CI: 1.01-1.51].

ממצאים אלה מדגישים את הצורך המובהק בקידום צריכת קטניות בכלל האוכלוסייה הבוגרת, ושימשו כבסיס לקביעת הצורך בהתערבות עתידית.

הפרק השני בחן את הידע, העמדות וההרגלים לגבי ייעוץ בנושא קטניות וצריכתן בקרב דיאטניות ישראליות (n=309) באמצעות סקר חתך מקוון. רק 47.4% (n=146) מהמשתתפות דיווחו כי הן ממליצות לרוב או לכל מטופליהן להגביר את צריכת הקטניות. גורמים שנמצאו קשורים בהמלצה לצרוך קטניות היו תפיסה של פחות חסמים לצריכת קטניות [aOR 1.92 (95%CI: 2.96–1.24] ועמדות חיוביות כלפי החשיבות הייעוץ בנושא קטניות [(aOR 1.95 (95%CI: 3.4–1.12].

גורמים שנמצאו כבעלי קשר הפוך להמלצה על צריכת קטניות היו צריכה אישית נמוכה של קטניות [(aOR 0.38 (95% CI 0.15-0.94] ועבודה בבתי חולים [(aOR 0.43 (95% CI 0.19-0.98].

ממצאים אלו הצביעו על כך שישנו צורך ברור בעידוד דיאטניות לכלול קידום קטניות כחלק מהרגלי הייעוץ שלהן. בהתבסס על ממצאים אלה פותחה התערבות מקוונת המבוססת על מודלים לשינוי התנהגות the Capability, Opportunity, Motivation – Behavior (COM-B) model ו- Theoretical Domains Framework (TDF). שניהם מודלים אינטגרטיביים ומבוססי ראיות לשינוי התנהגות. ההתערבות כללה: א. וובינר מוקלט בנושא היתרונות של צריכת קטניות בהיבט הבריאותי, הסביבתי ושל בטחון תזונתי; ב. סדנאות מקוונות בקבוצות קטנות לפיתוח מיומנויות בהתמודדות עם חסמים לצריכת קטניות; ג. עלונים עבור מטופלים ומדריך מקצועי לייעוץ על קטניות עבור דיאטניות .מטרת הפרק השלישי הייתה להעריך את ההתערבות מבוססת התיאוריה והראיות אשר פותחה במטרה לשפר את הרגלי הייעוץ, הידע, העמדות והצריכה האישית של

דיאטניות בנושא קטניות. המחקר השתמש במבנה של ניסוי מבוקר אקראי. דיאטניות (n=213) גויסו והוקצו אקראית לקבוצת ההתערבות (n=109) או לקבוצת ביקורת מושהית (n=104) (wait-listed control). הנתונים נאספו בבסיס ושלושה חודשים לאחר ההתערבות באמצעות סקר חתך. התוצא הראשי היה שיעור הדיאטניות שהמליצו למטופלים לצרוך קטניות מדי יום, כפי שנמדד בסולם ליקרט 1–5 ((1) לאף אחד ; (2) עד 25% ; (3) 26–50% ; (4) 51–75% ; (5) 76–100%). שיעור הדיאטניות בקבוצת ההתערבות שהמליצו ל־76–100% מהמטופלים לצרוך קטניות מדי יום עלה מ־32% (n=35) בבסיס ל־51% (n=56) לאחר ההתערבות, לעומת 25% (n=26) ו־27%(n=28) בהתאמה בקבוצת הביקורת. ההמלצה על צריכה יומית של קטניות השתפרה באופן מובהק בשתי הקבוצות (בקבוצת ההתערבות : 3.73±1.1 ל־4.28±0.86 ;p=0.001, בקבוצת הביקורת : 3.67±0.98 ל־3.88±0.92 ,p=0.03) עם שיפור גדול יותר בקבוצת ההתערבות (p=0.014). הידע והעמדות השתפרו באופן מובהק בקבוצת ההתערבות (p<0.001) אך לא בקבוצת הביקורת, למעט בעמדה כלפי קיימות (p=0.026). צריכת הקטניות האישית עלתה באופן מובהק רק בקבוצת ההתערבות, עם סיכוי נמוך יותר לשמר רמת צריכה לא מספקת של פעם בשבוע או פחות
[aOR 0.46 (95%CI: 0.25-0.82)]. לסיכום, קיים צורך מובהק בהגברת צריכת הקטניות בישראל. תוכנית התערבות מקוונת שפרה באופן משמעותי את הרגלי הייעוץ של דיאטניות לקידום צריכת קטניות, את עמדותיהן, את הידע ואת צריכתן האישית. שימוש בדיאטניות כסוכנות שינוי לקידום תזונה בת-קיימא עשוי להיות גישה יעילה ובעלת עלות נמוכה לעמוד בהמלצות התזונתיות הישראליות.

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