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Multisite Culinary Medicine Curriculum Associates with Cardioprotective Dietary Patterns and Lifestyle Medicine Competencies Among Medical Trainees

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Keywords:	cooking, nutrition therapy, diet, lifestyle, Mediterranean diet, cardiovascular disease, prevention
Abstract:	Background: Adherence to Mediterranean dietary patterns reduces the incidence of cardiovascular disease and other major chronic diseases. We aimed to assess the association between participation in kitchen-based nutrition education and Mediterranean diet intake and lifestyle medicine counseling competencies among medical trainees.

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	<p>Methods: The Cooking for Health Optimization with Patients (CHOP) curriculum is a hands-on cooking-based nutrition education program implemented at 32 medical programs (4,125 medical trainees) across the U.S.A. Mediterranean diet intake, nutrition attitudes, and lifestyle medicine counseling competencies were assessed via validated surveys. Multivariable-adjusted logistic regression assessed the relationship of CHOP education with Mediterranean diet intake, nutrition attitudes, and lifestyle medicine counseling competencies.</p> <p>Results: Individuals participating in the CHOP program were 82% more likely to follow the Mediterranean diet compared to those receiving traditional nutrition education (OR=1.82, p<0.001). CHOP participants were more likely to satisfy daily intake of fruits (OR=1.33, p=0.019) and vegetables (OR=2.06, p<0.001), and agree that nutrition counseling should be a routine component of clinical care (OR=2.43, p<0.001). Kitchen-based nutrition education versus traditional curricula associates with a higher likelihood of total counseling competency involving 25 lifestyle medicine categories (OR=1.67, p<0.001).</p> <p>Conclusion: Kitchen-based nutrition education associates with cardioprotective dietary patterns and lifestyle medicine counseling among medical trainees.</p>



CULINARY MEDICINE AND MEDICAL TRAINEE EDUCATION

Multisite Culinary Medicine Curriculum Associates with Cardioprotective Dietary Patterns and Lifestyle Medicine Competencies Among Medical Trainees

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CULINARY MEDICINE AND MEDICAL TRAINEE EDUCATION

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2
3 **1 ABSTRACT**

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6 **2 Background:** Adherence to Mediterranean dietary patterns ~~prevents primary and secondary~~
7 ~~cardiovascular events~~ reduces the incidence of cardiovascular disease and other major chronic
8 diseases. We aimed to assess the association between participation in kitchen-based nutrition
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10 education and Mediterranean diet intake and lifestyle medicine counseling competencies among
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12 medical trainees.
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17 **3 Methods:** The *Cooking for Health Optimization with Patients* (CHOP) curriculum is a hands-on
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19 cooking-based nutrition education program implemented at 32 medical programs (4,125 medical
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21 trainees) across the U.S.A. Mediterranean diet intake, nutrition attitudes, and lifestyle medicine
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23 counseling competencies were assessed via validated surveys. Multivariable-adjusted logistic
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25 regression assessed the relationship of CHOP education with Mediterranean diet intake, nutrition
26
27 attitudes, and lifestyle medicine counseling competencies.
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31 **4 Results:** Individuals participating in the CHOP program were 82% more likely to follow the
32
33 Mediterranean diet compared to those receiving traditional nutrition education (OR=1.82,
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35 p<0.001). CHOP participants were more likely to satisfy daily intake of fruits (OR=1.33,
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37 p=0.019) and vegetables (OR=2.06, p<0.001), and agree that nutrition counseling should be a
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39 routine component of clinical care (OR=2.43, p<0.001). Kitchen-based nutrition education
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41 versus traditional curricula associates with a higher likelihood of total counseling competency
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43 involving 25 lifestyle medicine categories (OR=1.67, p<0.001).
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47 **5 Conclusion:** Kitchen-based nutrition education associates with cardioprotective dietary patterns
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49 and lifestyle medicine counseling among medical trainees.
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CULINARY MEDICINE AND MEDICAL TRAINEE EDUCATION

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5 29 **Keywords:** cooking, nutrition therapy, diet, lifestyle, Mediterranean diet, cardiovascular disease,
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For Peer Review

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INTRODUCTION

Poor quality diet is a primary driver for morbidity and mortality in the world as well as in the United States¹⁻³. Dietary risk factors are implicated in nearly 1 in 5 deaths globally and are intricately linked to prevalent cardiovascular diseases and cardiometabolic conditions, including coronary heart disease, stroke, type 2 diabetes, and obesity⁴⁻⁸. These diseases generate significant health burden placing financial stress on broader healthcare systems⁹. The lifetime risk of cardiovascular disease is near 50% for healthy individuals aged 30 or greater¹⁰, and cardiovascular disease is our nation's most expensive chronic disease, with costs expected to at least double by 2035^{9,11}. In the setting of these data, there is a need for substantive dietary interventions at both the patient and population-based levels to improve prevention and treatment and to help curb the cardiovascular disease epidemic.

Despite the intrinsic role of diet in both the prevention and pathophysiology of cardiovascular and cardiometabolic diseases, a disconnect exists between nutrition research, dietary education in medical training, and counseling patients about food consumption habits. According to recent reports, only one-half of primary care physicians regularly educate their patients about the dietary implications for their health¹². Likewise, only one-fifth of American medical schools have nutrition competency programs in their curriculums¹³, and less than one-third of medical school graduates report preparedness regarding nutrition counseling for patients¹⁴. These findings suggest a systematic deficiency of dietary education in the continuum of medical training, one that appears to negatively impact our paradigm and approach to chronic disease prevention. Society cannot effectively prevent cardiovascular and cardiometabolic disease without proper nutrition curricula infrastructure in healthcare education.

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3 99 Lifestyle medicine approaches, such as community-based culinary and nutrition
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6 100 programs, may be considered the keystone to preventing cardiovascular and cardiometabolic
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8 101 diseases amongst physicians and their patients. According to a formidable body of evidence,
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10 102 adherence to Mediterranean style diet reduces total mortality as well as risk for developing
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12 103 cardiovascular and associated metabolic diseases¹⁵⁻¹⁸. Likewise, Mediterranean diet adherence
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14 104 has also been shown to play a role in secondary prevention, reducing the risk of secondary
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16 105 cardiovascular events and slowing disease progression^{19,20}. The Mediterranean diet is a dietary
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18 106 pattern rich in fruits, vegetables, nuts, seeds, olive oil, whole grains and legumes, supplemented
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20 107 with moderate amounts of fish, dairy, and poultry, with less intake of red meat²¹.

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24 108 Previously, the Cooking for Health Optimization with Patients (CHOP) team has
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26 109 demonstrated that when compared to traditional medical school curricula, hands-on cooking and
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28 110 nutrition education for medical trainees centered upon the key principles of the Mediterranean
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30 111 diet improves students dietary habits, as well as their ability to counsel patients on nutrition²².
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33 112 Now given that over 30 sites across the United States participate in CHOP and utilize the Health
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35 113 meets Food Culinary Medicine curriculum as part of their medical student or residency
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37 114 programs, this study has a more diverse sample and thus enhanced external validity compared to
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39 115 our previously published research. Through this larger sample, the association of kitchen-based
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41 116 nutrition education with clinical lifestyle medicine counseling competencies, in addition to
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43 117 personal dietary habits, was also assessed.

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47 118 This report is an extension of CHOP, the first multi-center study on culinary medicine for
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49 119 medical trainees, providers, and patients and the largest nutrition education intervention study for
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51 120 medical trainees (clinicaltrials.gov; NCT03443635). This study details measures of
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3 121 Mediterranean diet intake as well dietary counseling and attitudes among medical trainees across
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10 124 **METHODS**

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12 125 **Study population:** CHOP-Medical Trainees (CHOP-MT) is the CHOP sub-study assessing
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14 126 medical trainees. From August 2012 to December 2018, nutritional surveys were completed
15
16 127 across 32 sites including medical schools and residency programs that offer the CHOP
17
18 128 curriculum (**Supplementary Table 1**). The current sample includes 1,219 medical trainees who
19
20 129 participated in one 32-hour CHOP course (exposure) and 2,906 medical trainees participating in
21
22 130 traditional nutrition curricula (control). All 4,125 medical trainees completed one nutrition
23
24 131 survey during medical school training. For trainees participating in CHOP curricula, this survey
25
26 132 was completed upon completion of the kitchen-based nutrition education course. With respect to
27
28 133 the control group, the survey was distributed and completed by a random sample of students not
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30 134 participating in CHOP curricula at participating institutions. Ethics approval for this research
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32 135 was obtained through the site-specific Institutional Review Boards of all participating academic
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34 136 centers.
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42 138 **Explanatory Variables**

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44 139 **CHOP Curriculum:** The fundamental curriculum is an elective 32-hour nutrition and culinary
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46 140 course delivered through a sequence of eight 4-hour modules (one 4-hour module provided once
47
48 141 per week over the course of 8 weeks). All 32 hours instruct students on evidence-based
49
50 142 principles of the Mediterranean diet, through both case-based team learning and hands-on
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52 143 cooking, as well as validated approaches for patient nutrition counseling. The programming
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3 144 translates Mediterranean diet principals for the American kitchen making the diet both more
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5 145 relevant and accessible to students and patients. The eight module topics include: 1) introduction
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7 146 to culinary medicine; 2) weight management, portion control, and breakfast; 3) dietary fats; 4)
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9 147 food allergy and intolerance; 5) dietary protein and vegetarian diets; 6) renal function, dietary
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11 148 sodium, hypertension, and flavor building; 7) dietary carbohydrates, snacks, and desserts; and 8)
12
13 149 dietary patient interventions. Each professional healthcare student module involves an online 60-
14
15 150 minute didactic program designed to introduce students to concepts of the Mediterranean Diet.
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17 151 Students participate in an in-kitchen component involving 1.5 hours of team-based case studies
18
19 152 and nutrition discussion along with 1.5 hours of hands-on cooking. The cooking component is
20
21 153 intended to demonstrate the clinical and pathophysiologic concepts from the didactic phase, in a
22
23 154 functional manner. Each module concludes with students engaging in completion and discussion
24
25 155 of clinical case studies, while consuming and sharing their prepared recipes. The CHOP
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27 156 curriculum is implemented as an elective course at participating institutions and is thus
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29 157 considered a passive explanatory variable that was not specifically allocated to participants.
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37 159 **Traditional Nutrition Education:** A random sample of trainees not participating in CHOP
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39 160 curricula were selected as controls. These control group trainees derived from all participating
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41 161 institutions in the current analysis. Traditional nutrition education through medical education
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43 162 curriculums was assumed to be homogenous across all 32 participating partner sites. There is
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45 163 presently no evidence-based nutrition education standard broadly offered within schools, and the
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47 164 most schools do not satisfy the minimum 25 nutrition hours recommended by the National
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49 165 Academy of Sciences²³.
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167 Outcome Variables

168 **Mediterranean Diet Score:** Mediterranean diet intake was assessed through a regularly utilized
169 and validated questionnaire utilized by Trichopolou and colleagues in 2003¹⁵ (**Supplementary**
170 **Table 2**). This score assesses Mediterranean diet pattern intake by allocating one point for
171 satisfying intake of protective foods, one point for restricting intake of non-protective foods, and
172 zero points in the opposite of the two latter situations¹⁵. This food frequency questionnaire
173 involves a list of nine dietary item categories central to the Mediterranean diet including,
174 monounsaturated fats, fruit, vegetables, legumes, nuts/seeds, fish, red meat, whole grains, and
175 alcohol. Survey respondents are given a score of 0 or +1 for each of the nine food components
176 using a food frequency questionnaire intended to capture dietary habits over the previous 6
177 months. A value of +1 was assigned in the following situations: 4 or more servings per day for
178 vegetables, 1 or more servings per week for legumes, 3 or more servings per week for fruit, 1 or
179 more servings per week for nuts/seeds, less than 2 and 3 servings per week of red meat for
180 women and men, respectively, 2 or more servings per week of non-fried fish, 1 or more servings
181 per day for whole grains, higher reported intake of unsaturated fats versus saturated fats, ½ to 1
182 drink or less of alcohol per day for women; 1-2 drinks or less of alcohol per day for men. In all
183 other situations we assigned a 0 for each of the nine food components. Scores were totaled for
184 each participant to yield a continuous composite score. A higher score corresponds to a higher
185 intake of Mediterranean diet components.

187 **Nutritional Attitudes, Lifestyle Medicine Counseling Competencies, and Dietary Habits:** A
188 25-item survey was developed to measure self-reported competencies in key lifestyle-medicine-
189 related topics, including competencies involving the Mediterranean diet, serving size, food

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3 190 labels, and total calories. Responses using a three-point Likert scale²⁴ were utilized to assess: 1)
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5 191 attitudes regarding the role of nutrition counseling in patients' dietary habits; and 2) total
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7 192 competency in 25 key lifestyle medicine-related topics. Personal dietary habits were measured
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9 193 using a six-point scale, which was unique and separate from the Mediterranean diet intake score.
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11 194 These latter scales were developed and modified from previously published nutrition and
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13 195 exercise scales for appropriate investigation of the novel intervention^{25,26}. Attitudes regarding the
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15 196 role of nutrition counseling in patients' dietary habits were evaluated through the following
16
17 197 survey statements: 1) nutrition counseling should be routine; 2) specific counseling can improve
18
19 198 patients' diets; and 3) physician counseling can improve patients' diets. The specific format of
20
21 199 these three surveys (nutrition attitudes, lifestyle medicine competencies, personal dietary habits)
22
23 200 are represented in **Supplementary Table 3** and **Supplementary Table 4**. The CHOP Survey
24
25 201 was developed using *criterion-related validity* by means of using the gold standard of the
26
27 202 traditional-Mediterranean Diet Score as a template for areas of interest to track for medical
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29 203 trainee behaviors for both the exposure and control groups²⁷. The CHOP Survey has been tested
30
31 204 using *hypothesis-testing validity* for tracking validity of CHOP exposure by means of using the
32
33 205 traditional nutrition curricula exposure group as a control²⁸. Surveys were completed by medical
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35 206 trainees in the exposure group 6 weeks after the date of their last CHOP curriculum class.
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37 207 Medical trainees in the control group had up to 6 weeks to complete the survey after
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39 208 electronically receiving the study surveys. The response rate for the CHOP surveys was 86%,
40
41 209 such that of the 1,418 students who participated in CHOP education, 1,219 students filled out a
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43 210 survey.

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213 **Statistical Analysis:**

214 The CHOP curriculum was studied as an observational exposure variable in this cross-
215 sectional study. Responses for nutritional attitudes, lifestyle medicine counseling competencies,
216 and dietary habits were assessed in a binary fashion in statistical analyses: nutritional attitudes:
217 strong agreement versus not; lifestyle medicine counseling competencies: complete proficiency
218 versus not; dietary habits: satisfying daily intake requirement versus not. Strong agreement and
219 complete proficiency for nutritional attitudes and lifestyle medicine counseling competencies,
220 respectively, was defined through selection of the “mostly confident to totally confident” on the
221 three-point Likert based surveys (**Supplementary Table 3**). The three-point Likert scale was
222 used to generate a response for each individual item. Satisfying daily intake was defined as
223 follows: 3-5 times per/week or more for vegetables, fruits, whole grains, and monounsaturated
224 fats; 1-2 times per/week or more for legumes and nut butters; 1-2 times per/week or less for
225 cheese or fermented dairy, non-fried fish or seafood, alcohol, and saturated fats; once per
226 month/never for red and processed meat, baked products, and calorie-containing beverages
227 (**Supplemental Table 4**).

228 Propensity score-weighted logistic regression models were used to test the association of
229 culinary medicine education on Mediterranean diet intake and nutritional attitudes, with
230 traditional nutrition education serving as the reference independent variable. Propensity score
231 methodology covets to control for unobserved heterogeneity from baseline differences as well as
232 for self-selection^{29,30}. Study participants were matched based on their survey date as a means to
233 control serial correlation as well as selection bias. Due to the dearth of validated psychometric
234 endpoints for student lifestyle counseling competencies, fully adjusted odds ratios for total
235 proficiency in each counseling category were generated. Using inverse-variance weighted meta-

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3 236 analysis (IVWM), odds ratios and 95% confidence intervals were subsequently pooled to
4
5 237 produce one effect estimate (**Figure 1**). Cochran's Q test and I² statistic were employed to test
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7 238 for heterogeneity of the effect estimate across a priori designated subgroup analysis by program
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9 239 year. Significant heterogeneity was determined using a p-value threshold of 0.10. A more
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11 240 detailed version of our statistical methodology is previously described in our previous CHOP
12
13 241 series paper involving medical trainees²².

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17 242 Sample size calculations were performed using previous treatment effect estimates of
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19 243 nutrition education on medical trainees. Power calculations demonstrated that 400 subject
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21 244 responses in total, and 100 treatment-specific responses specifically, were required to detect at
22
23 245 least a 40% greater likelihood of Mediterranean diet intake and nutrition attitudes with a power
24
25 246 of 90%. Analyses were performed controlling for time invariant unobserved traits as well
26
27 247 important covariates, including age, gender, race, prior nutrition education, special diet, school
28
29 248 year, intended specialty, medical school, and likelihood of receiving CHOP classes. There was
30
31 249 no clustering effect attributed to the CHOP curriculum exposure variable as the curriculum is
32
33 250 provided regularly throughout the year and trainee participation is not restricted to certain groups
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35 251 of individuals or to certain dates of the year. Individuals with missing exposure, outcome, or
36
37 252 covariate data were excluded from the analyses.

253

254 **RESULTS**

255 Females represented just over one-half of the study sample and individuals were on
256 average 26 years of age. Nearly one-third of the study sample participated in the CHOP
257 curriculum. (**Table 1**).

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258 Culinary medicine education shared a significant positive association with all
259 Mediterranean diet categories except wine (**Table 2**). Compared to students enrolled in
260 traditional nutrition education, participants were at least twice as likely to adhere to
261 Mediterranean diet guidelines involving monounsaturated fats ($p=0.009$), fruit ($p=0.019$),
262 vegetables ($p<0.001$), and legumes ($p<0.001$). Similarly, CHOP program participants were 33%,
263 39%, 40%, and 70% more likely to adhere to Mediterranean diet guidelines regarding fruits
264 ($p=0.019$), whole grains ($p=0.001$), fish ($p=0.002$), and red meat ($p<0.001$), respectively. Intake
265 of olive oil had the highest magnitude point estimate among all Mediterranean diet categories
266 ($OR=2.14$; 95% $CI=1.21, 3.79$).

267 **Figure 1** demonstrates the relationship between the CHOP curricula and 25 lifestyle
268 medicine counseling competency categories. Trainees were 6 times as likely to master total
269 competency regarding Mediterranean diet principles compared to students whom did not
270 participate in culinary medicine education ($p<0.001$). Likewise, students enrolled in hands-on
271 culinary medicine education were more likely to achieve proficiency in 22 additional lifestyle
272 medicine counseling categories, notably recommendations involving fiber ($OR=2.38$, $CI=1.85$,
273 3.06), serving size ($OR=2.37$, $CI=1.75, 3.21$), omega-3 fatty acids ($OR=2.00$, $CI=1.49, 2.68$), as
274 well as vegetarian diet ($OR=2.20$, $CI=1.49, 2.68$). CHOP education relationships with cholesterol
275 and eating disorder competencies were non-significant. Participants were over two times as
276 likely to strongly agree with regular nutrition counseling for patients compared to students in
277 traditional medical education curricula.

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CULINARY MEDICINE AND MEDICAL TRAINEE EDUCATION

281 **DISCUSSION**

282 CHOP-MT is a multi-center project for culinary medicine and the largest study on
283 nutrition education and medical trainees. Trainees exposed to an 8-week kitchen-based nutrition
284 education course were 82% more likely to satisfy intake of fruits, vegetables, and legumes,
285 compared to medical trainees partaking in traditional nutrition education. Similarly, hands-on
286 culinary medicine education associated with a one-third and over two-fold higher daily
287 consumption of fruits and vegetables, respectively. These results, in combination with significant
288 positive associations of the programming with over 20 total competencies in lifestyle medicine
289 counseling, suggest that teaching kitchen-based nutrition and culinary education associate with a
290 higher intake of Mediterranean dietary components and knowledge of cardiovascular disease
291 prevention among medical trainees.

292 Our findings fit into a larger context of evidence regarding the utility of nutrition-related
293 training among medical trainees. Our results are consistent with similar previous studies
294 suggesting that participation in nutrition-centered courses augments trainees' confidence in
295 dietary counseling. For example, Conroy et al. observed that nearly three-fourths of medical
296 students participating in a new preventive medicine and nutrition didactic course at Harvard
297 medical school reported improvements in personal diets following the course²⁵. This study also
298 found that students reported significant reductions in saturated fat consumption, one important
299 dietary modification that can lower serum low-density lipoprotein cholesterol and thus reduce
300 atherosclerotic cardiovascular disease risk²⁵. Likewise, even exposure to online nutrition lectures
301 among medical trainees has been noted to improve knowledge and case-based management of
302 diet for patients³¹. These data not only underline the value of incorporating nutrition education

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303 across academic medical centers, but also highlight the novelty of our current study, as this study
304 characterized the role of *kitchen-based* nutrition education in medical training.

305 As discussed earlier, the Mediterranean diet has robustly associated with reduced
306 manifestation, but also progression of CVD-cardiovascular disease in a consistent fashion^{15–20,32}.
307 Three cited barriers to adopting the Mediterranean Diet are limited knowledge, lack of cooking
308 skills, and time commitment³³. CHOP-MT has previously demonstrated that culinary medicine
309 education associates with a higher overall consumption of Mediterranean diet foods in medical
310 trainees, particularly mediated through modified consumption of seven key food categories: olive
311 oil, fruit, vegetables, legumes, fish, meat, and whole grains²². Considering the consistency and
312 replicability of these findings across 32 sites, structured, kitchen-based nutrition education
313 modules may overcome prevalent (e.g. limited knowledge and lack of cooking skills) as well as
314 seeming (e.g. time commitment) barriers to adopting a Mediterranean diet.

315 Despite the central pathophysiological as well as the preventive role of diet in
316 CVDcardiovascular disease, nutrition education teaching and infrastructure is lacking. According
317 to a national survey published in *Academic Medicine*, medical students received a mere 19.6
318 hours of nutrition training throughout all four years of medical school³⁴. Likewise, over 50% of
319 medical students report “inadequate” knowledge of nutrition³⁵. Through the CHOP-MT series,
320 culinary medicine curricula have consistently associated with a higher proficiency and
321 competency in lifestyle medicine counseling²². These relationships have a high probability of
322 benefiting future patients, as previous research has shown a positive association between
323 physician and patient preventive health behaviors^{36,37}. Given that kitchen-based nutrition
324 education, through the described curriculum, has already been implemented over 30 sites across

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3 325 the United States, our findings may serve as a platform for broader implementation of nutrition
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5 326 training in medical school.

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8 327 In addition to helping prevent cardiovascular disease, adherence to the Mediterranean diet
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10 328 may also help reduce the incidence of other major chronic diseases, including cancer,
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12 329 Alzheimer's disease, and chronic kidney disease. In a meta-analysis including predominantly
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14 330 observational data, high adherence to a Mediterranean diet was significantly associated with a
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16 331 14% lower risk of overall cancer mortality, and the most consistent protective associations were
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18 332 observed for colorectal and breast cancer³⁸. Additionally, strong inverse associations of
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20 333 individual Mediterranean diet components, including whole grains, nuts, fruits, vegetables, and
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22 334 fish, with cancer incidence and mortality have also been observed³⁹⁻⁴². Much of the health
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24 335 benefits of the Mediterranean diet may be driven by the anti-inflammatory, anti-oxidative, and
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26 336 endothelial-protective properties of ingested foods³⁸. Minimization of vascular injury via
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28 337 Mediterranean diet adherence may particularly help lower the risk of chronic kidney disease and
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30 338 Alzheimer's dementia, as vascular dysregulation has been noted as one of the first insults in the
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32 339 development of both diseases^{43,44}. In a prospective study including over 6 years of follow-up
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34 340 among a diverse cohort of 60-year old men and women, higher Mediterranean diet adherence
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36 341 associated with a 17% and 12% lower risk of chronic kidney disease incidence and estimated
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38 342 glomerular filtration rate decline, respectively⁴⁵. Likewise, high Mediterranean diet adherence
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40 343 prospectively associates with fewer structural and functional brain changes suggestive of
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42 344 Alzheimer's dementia, as measured by positron emission tomography and magnetic resonance
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44 345 imaging, among individuals as young as 30 years of age^{46,47}. These results in total suggest that
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46 346 dietary patterns rich in fruits, vegetables, legumes, nuts, and whole grains are an important
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48 347 component to chronic disease prevention and may help facilitate the likelihood of healthy aging.
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CULINARY MEDICINE AND MEDICAL TRAINEE EDUCATION

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3 348 This study has several important strengths. The multisite design afforded a unique
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5 349 opportunity to assess Mediterranean diet intake, one important protective factor for both primary
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8 350 and secondary prevention of ~~CVD~~cardiovascular disease, in a large and diverse population.
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10 351 Likewise, to our knowledge, CHOP-MT is the first study to assess kitchen-based nutrition
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12 352 education as an exposure variable, and the role it holds in medical trainee lifestyle medicine
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15 353 attitudes and counseling.

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17 354 Limitations of our study are also important to contemplate. While training is part of the
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19 355 implementation at additional sites, the programming is taught by a variety of physicians, chefs,
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21 356 and dietitians, thus raising the potential for operator bias. Measures of fidelity used to reduce
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23 357 operator bias included standardized training of CHOP curriculum instructors, including the
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25 358 distribution of curriculum manuals, curriculum guides, and case studies to ensure that the CHOP
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27 359 curriculum exposure remained consistent, regardless of the class instructor. CHOP curriculum
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29 360 classes were also randomly audited by CHOP committee members to assess the standardization
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31 361 of all modules. Two other limitations to note are that 1) this study was unable to assess the
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33 362 longitudinal relationship between culinary medicine and Mediterranean diet intake and CHOP
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35 363 curriculum exposure; and 2) propensity analysis may not have fully compensated for the
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37 364 potential situation in which individuals participating in CHOP had systematic differences in
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39 365 dietary patterns compared to those not participating CHOP, regardless of the curriculum
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41 366 exposure. These limitations will be addressed in subsequent research by administering pre- and
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43 367 post-kitchen-based nutrition education surveys each year of medical training among CHOP study
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45 368 participants, with each participant serving as his/her own control. In this way, potential selection
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47 369 bias will be decreased and also observe important *prospective* relationships between CHOP
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49 370 education and dietary habits. Furthermore, the use of food frequency questionnaires after an
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3 371 educational exposure may bias parameter estimates in favor of the exposure or desired
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5 372 information. Yet this phenomenon may not be a true bias and may instead rather simply serve as
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8 373 a proxy of effectiveness of the educational exposure. Lastly, while the CHOP curriculum is
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10 374 based on the Mediterranean diet, a dietary pattern that has consistently shown to have
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12 375 cardioprotective benefit, there are other dietary patterns that may be beneficial to consider with
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15 376 respect to ~~CVD~~ cardiovascular disease prevention. Notably, adherence to the Dietary
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17 377 Approaches to Stop Hypertension (DASH) and vegetarian dietary patterns also reduce ~~CVD~~
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19 378 cardiovascular disease risk^{48,49}. Future studies that assess the key differences among these dietary
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22 379 patterns with respect to their relationship on cardiometabolic health and lifestyle medicine are
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24 380 undoubtedly necessary.

26 381 The current study demonstrates that kitchen-based nutrition education, when compared to
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28 382 traditional nutrition coursework, associates with a higher likelihood of Mediterranean diet intake
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31 383 and lifestyle medicine counseling competence in medical trainees enrolled at 32 sites across the
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33 384 United States. While these results are encouraging, there remain practical challenges associated
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35 385 with implementing culinary medicine programs more broadly, including the dearth of kitchen
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38 386 space at medical schools and competing educational topics in an already exhaustive medical
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40 387 school curriculum schedule. There are future opportunities for medical board examiners to add
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42 388 specific nutritional topics to board exams in an effort to incentivize incorporation of nutrition
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45 389 education standards across medical institutions and hospitals. In summary, our results provide a
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47 390 platform for nutrition education reform in American medical schools, suggesting that integrating
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49 391 nutrition didactics with hands-on cooking modules in a kitchen setting provides an optimized
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51 392 design to improve medical trainee diets as well as their clinical dietary counseling skills.

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412

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414 There is no conflict of interest.

415

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17 424 **This manuscript has not been previously published and is not under consideration in the**
18
19 425 **same time or substantially similar in form in any other journal.**
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23 428 **Clinical Trials**

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26 429 Cooking for Health Optimization with Patients (CHOP)-Family Bayesian adapted randomized controlled
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28 430 trial (<https://clinicaltrials.gov/ct2/show/NCT03443635>; unique identifier: 03443635),
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Table 1. Characteristics of 4,125 medical trainees

Variable	Measure
Gender, %	
Female	51.13
Male	48.87
Race ¹ , %	
White	66.58
Non-White	33.42
Age, y, mean (SD)	25.98 (3.64)
Medical Trainee Training Level ² , %	
Pre-clinical	64.36
Clinical	35.64
Prior Nutrition Education ³ , %	14.68
Special Dietary Practices ⁴ , %	20.54
Participation in CHOP educational series ⁵ , %	29.55

CHOP = cooking for health optimization with patients

1. Non-white defined as African-American, Native American, Asian, and/or Hispanic.
2. Pre-clinical defined as medical school year levels one and two.
3. Prior nutrition education defined as formal nutrition training in undergraduate or graduate coursework
4. Special dietary practices defined by, but not limited to, gluten-free, vegetarian, Weight Watchers, and/or kosher

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5. Reflects the percent of survey respondents who were CHOP participants.

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Table 2. Propensity-score adjusted mixed effects multivariable regression of CHOP versus control on overall Mediterranean diet intake and individual food group categories

Category	OR (95% CI)	P-value
High/Medium vs. Low	1.82 (1.45, 2.29)	<0.001
Olive Oil	2.14 (1.21, 3.79)	0.009
Fruit	1.33 (1.05, 1.70)	0.019
Vegetables	2.06 (1.61, 2.64)	<0.001
Legumes	2.04 (1.49, 2.80)	<0.001
Fish	1.41 (1.13, 1.75)	0.002
Alcohol	1.40 (0.98, 1.98)	0.064
Meat	1.71 (1.33, 2.20)	<0.001
Whole Grains	1.39 (1.15, 1.69)	0.001

CHOP = Cooking for Health Optimization with Patients

Adjusted for age, gender, race, prior nutrition education, special diet, school year, intended specialty, medical school, likelihood of receiving CHOP classes, and time invariant unobserved traits.

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CULINARY MEDICINE AND MEDICAL TRAINEE EDUCATION

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Table 3. Propensity-score adjusted mixed effects multivariable regression of CHOP versus control on overall nutrition attitudes

Outcome	OR (95% CI)	P-value
Nutrition Counseling Should be Routine	2.43 (1.94, 3.03)	<0.001
Specific Counseling Can Improve Patients' Diets	1.74 (1.45, 2.09)	<0.001
Physicians Counseling Can Improve Patient's Diets	1.62 (1.31, 2.01)	<0.001

CHOP = Cooking for Health Optimization with Patients

Adjusted for age, gender, race, prior nutrition education, special diet, school year, intended specialty, medical school, likelihood of receiving CHOP classes, and time invariant unobserved traits.

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Supplementary Table 1. CHOP-Medical Trainee study sites.

Site	Frequency	Percent	Cumulative Percent
Tulane University School of Medicine, New Orleans, Louisiana	2,131	42.06	42.06
Texas College of Osteopathic Medicine, Fort Worth, Texas	276	5.45	47.50
Texas Christian University School of Medicine, Fort Worth, Texas	60	1.18	48.69
University of Illinois at Chicago School of Medicine, Chicago, Illinois	61	1.20	49.89
University of Colorado School of Medicine, Denver, Colorado	161	3.18	53.07
Western Michigan University Homer Stryker M.D. School of Medicine, Kalamazoo, Michigan	3	0.06	53.13
University of Texas Health Science Center at San Antonio, San Antonio, Texas	211	4.16	57.29
Lake Erie College of Osteopathic Medicine, Erie, Pennsylvania	229	4.52	61.81
Rutgers New Jersey Medical School, Newark, New Jersey	647	12.77	74.58
Meharry Medical College School of Medicine, Nashville, Tennessee	269	5.31	79.89
University of Chicago Pritzker School of Medicine, Chicago, Illinois	99	1.95	81.84
Michigan State College of Human Medicine, East Lansing, Michigan	20	0.39	82.24
Mercer University School of Medicine, Macon, Georgia	1	0.02	82.26
West Virginia University School of Medicine, Morgantown, West Virginia	71	1.40	83.66
University of Alabama School of Medicine, Tuscaloosa, Alabama	10	0.20	83.86
University of Tennessee College of Medicine, Memphis	96	1.89	85.75
A.T. Still University School of Osteopathic School of Medicine, Kirksville, Missouri	20	0.39	86.15
University of Utah School of Medicine, Salt Lake City, Utah	142	2.80	99.95
University of South Carolina School of Medicine, Columbia, South Carolina	1	0.02	88.97

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3	University of Texas School of Medicine, Houston, Texas	93	1.84	90.80
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5	Swedish Family Medicine Residency – Cherry Hill, Seattle, Washington	18	0.36	91.16
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7	Northwest Arkansas Community College, Bentonville, Arkansas	3	0.06	91,22
8				
9	Mississippi Gulf Coast Community College, Biloxi, Mississippi	292	5.76	96.98
10				
11	Church Health Center, Memphis, Tennessee	13	0.26	97.24
12				
13	Duke University School of Medicine, Durham, North Carolina	1	0.02	97.26
14				
15	Ohio State University School of Medicine, Columbus, Ohio	3	0.06	97.32
16				
17	Weil-Cornell Medical College, New York City, New York	10	0.20	97.51
18				
19	Open Door Family Medicine, Ossining, New York	2	0.04	97.55
20				
21	University of Central Florida College of Medicine, Orlando, Florida	1	0.02	97.57
22				
23	University of Florida College of Medicine, Gainesville, Florida	1	0.02	97.59
24				
25	University of South Carolina School of Medicine, Greenville, South Carolina	3	0.06	97.65
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27	Spectrum Health System, Grand Rapids, Michigan	119	2.35	100.00
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Supplementary Table 2. Assessment of Mediterranean diet adherence

Mediterranean Diet Category	Serving Requirement	0	+1
Vegetables (e.g. carrots, spinach, tomatoes).	4 or more servings per-day		
Legumes (e.g. beans, split peas, or lentils)	1 or more servings per week		
Fruits (e.g. oranges, apples, bananas)	3 or more servings per week		
Nuts, seeds, or nut butters (e.g. peanuts, almonds, cashews)	1 or more servings per week		
Red and processed meat (e.g. hamburgers, steak, hotdogs)	Less than 2 servings per week for women, less than 3 servings per week for men		
Non-fried fish or seafood (e.g. canned, baked, grilled)	2 or more servings per week		
Whole grains (e.g. whole wheat bread or pasta, oats, brown rice, corn tortilla)	1 or more servings per day		
Monounsaturated fats (e.g. avocado, olive or canola oils)	Higher reported intake of unsaturated fats versus saturated fats		
Alcohol	(1/2 to 1 drink per day for women, 1-2 drinks per day for men)		

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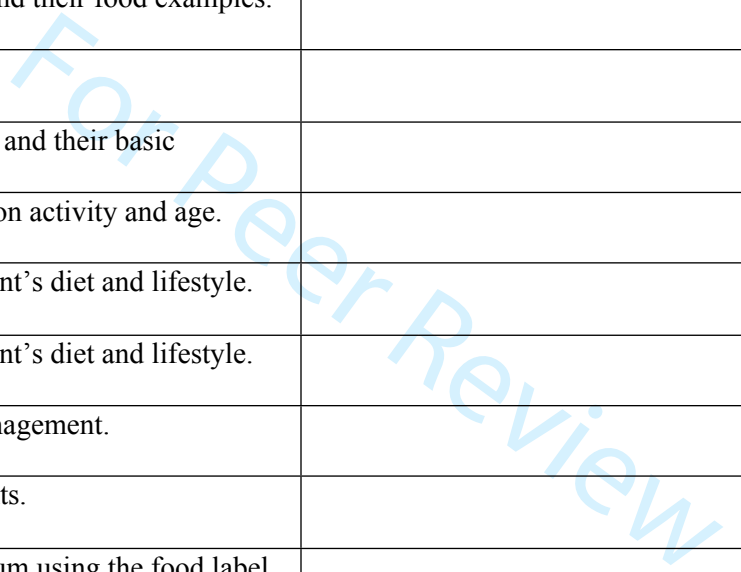
Supplementary Table 3. Assessment of nutritional attitudes and core lifestyle medicine counseling competencies

Attitudes	Not at all confident or Somewhat confident	Neither not at all confident, or totally confident	Mostly confident to totally confident
Nutritional counseling should be included in any routine appointment, just like diagnosis and treatment.			
Specific advice about how to make dietary changes could help patients improve their eating habits.			
Physicians can have an effect on a patient's dietary behavior if they take the time to discuss the problem. (5)			
Lifestyle Medicine Counseling			
Mediterranean Diet and its health effects.			
DASH diet and its health effects.			
Vegetarian diet and its health effects			
Very low-fat diet and its health effects.			
High protein/high fat diet (e.g. Atkins) and its health effects.			
Examples of a serving size from the 2011 "My Plate" guidelines.			
Definition of moderate alcohol consumption and its health effects.			
Recognizing warning signs and symptoms of patients with eating disorders.			
Role of dietary cholesterol and saturated fat in blood lipids.			

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Recommended dietary patterns for type 2 diabetes.	
Significance of modest weight loss for type 2 diabetes.	
Weight loss strategies in overweight or obese patients.	
Role of Omega-3 and -6 fatty acids in heart health and their food examples.	
Role of dietary fat types (e.g. saturated vs. other) and their food examples.	
Identifying antioxidant-rich grocery produce.	
Calories per gram of protein, carbohydrate and fat, and their basic metabolic roles.	
Role of hydration in health, and fluid needs based on activity and age.	
Celiac disease and management strategies for patient’s diet and lifestyle.	
Food allergies and management strategies for patient’s diet and lifestyle.	
The role of glycemic index and load in dietary management.	
Fiber in disease prevention, and example ingredients.	
Assessing the total calories, saturated fat, and sodium using the food label.	
Osteoporosis and prevention and treatment strategies for patient’s diet and lifestyle.	
Calculation of body mass index (BMI) and waist-to-hip ratio based on gender.	
Overall benefits of aerobic exercise on health and well-being.	



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For Peer Review

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Supplemental Table 4. Dietary habits over the last 6 months

	Once per month / Never	1-2 times per week	3-5 times per week	7 times per week (daily)	2 or more times daily
Vegetables (e.g. carrots, spinach, tomatoes)					
Legumes (e.g. beans, split peas, or lentils)					
Fruits (e.g. oranges, apples, bananas)					
Nuts or nut butters (e.g. peanuts, almonds, cashews)					
Cheese or fermented dairy (e.g. yogurt)					
Red and processed meat (e.g. hamburgers, steak, hotdogs)					
Non-fried fish or seafood (e.g. canned, baked, grilled)					
Whole grains (e.g. whole wheat bread or pasta, oats, brown rice, corn tortilla)					
Monounsaturated fats (e.g. olive oil, avocado, canola oil).					
1 alcohol serving (1 can of 12 oz. beer = 1 glass of wine = 1 shot of spirits)					
Baked products (e.g. muffins, doughnuts, pastries)					
Calorie-containing beverages (e.g. coke/soda, non-black coffee drinks, energy drinks)					
Saturated fats (e.g. butter, 2% or whole milk, margarine)					

Figure 1. CHOP-Medical Students (N=4,125): Inverse-variance weighted meta-analysis of propensity score-adjusted multi-level mixed effects regression panel analysis of 25 competency topics in nutrition counseling

