Teaching to Learn and Learning to Teach: Development of a Learner-Centered Curriculum and Assessment Tool to Improve and Evaluate Adolescent Food Literacy

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ABSTRACT

Obesity in adolescence is increasingly prevalent and likely perpetuated by the overall poor diet quality observed in this age group. Advancement in food literacy has been indicated for improving eating patterns and subsequently reducing obesity prevalence, thus diminishing risk for chronic disease in adulthood. Food literacy includes knowledge and skills required to adopt and maintain healthy eating practices. Despite the postulated benefit to health, there is a dearth in food literacy programming for adolescents. Consequently, the objective of this dissertation was to understand the most effective approach and to develop a food literacy program for high school-aged adolescents. This was achieved through three specific aims: validation of an age-appropriate nutrition knowledge assessment; establishment of an effective pedagogical approach; and development of an innovative curriculum.

The first aim of this dissertation was accomplished through testing an existing nutrition knowledge questionnaire for validity and reliability with high school-aged adolescents. Sections of the original questionnaire pertaining to nutrition advice and nutrients in food were administered to groups of students at four high schools. Participants were stratified by whether they had known previous nutrition education ($n = 174$) or not ($n = 136$). Upon eliminating one question, for demonstrating poor item difficulty, the questionnaire was determined to have good internal consistency reliability (Cronbach $\alpha = 0.83$). Additionally, results of an independent samples t-test suggested that the questionnaire displayed construct validity with the nutrition education group scoring significantly higher than the no nutrition education group ($P < 0.0001$).

The second aim involved testing the effectiveness of implementing experiential garden-enhanced nutrition curricula with adolescents as cross-age teachers for younger youth. Adolescents were initially trained during a 2-day workshop and completed weekly reflections

following teaching sessions. During these reflections, adolescents provided commentary on practices that worked well while facilitating the curricula and aspects that needed improvement in subsequent sessions. Fidelity to the curricula was collected through detailed observations. While the goal for adequate fidelity is 80%, adolescents were only able to achieve 45% overall fidelity. Lesson components that were the most insufficiently delivered included those requiring increased content knowledge and additional pedagogical training.

Findings from the cross-age teaching study provided impetus for the final aim of this dissertation, which involved developing a food literacy curriculum specifically for high school-aged adolescents. In addition to filling the need for more food literacy curricula for this age group, the resulting curriculum could be utilized in training adolescents to be component cross-age teachers. The curriculum was developed utilizing Backward Design and includes Social Cognitive Theory and Constructivism as theoretical frameworks. Learning concepts were drawn from food literacy components and attributes as defined in the literature and encompass three overarching topics of agriculture, nutrition, and cooking. After expert committee review, the curriculum was pilot tested in two rounds in low-income communities. Results from the pilot tests led to modification of lesson procedures to increase efficacy for achieving learning objectives. The final curriculum, *Teens CAN: Comprehensive Food Literacy in Cooking, Agriculture, and Nutrition*, includes 12 modules featuring learner-centered lessons and application activities.

The work presented in this dissertation provides two novel materials, a nutrition knowledge questionnaire and food literacy curriculum for high school-aged adolescents, and additional considerations into application of cross-age teaching. Taken together, these results lend to a succinct food literacy program with the potential to improve knowledge and skills that

contribute to healthy lifestyle behaviors. Testing of the program utilizing a two-tiered cross-age teaching approach, with college interns educating adolescents and then mentoring them to teach younger youth, began in the 2019-2020 school year. However, due to the COVID-19 pandemic, the implementation had to be suspended. Preliminary data indicated that college interns were delivering *Teen CAN* with high fidelity. Data assessing improvement in adolescent measures could not collected and education of younger youth was yet to be conducted. The college internship was adapted for the 2020-2021 school year to involve creation of online enhancements to accompany *Teens CAN* modules. Future directions include testing the newly developed virtual components and, when safe, restarting implementation of the two-tiered cross-age teaching model.

CHAPTER 1

Literature Review

Introduction

Adolescence is a critical period of development, defined by navigating challenging social circumstances and cementing identity as youth transition into emerging adulthood.[1] Adolescence is also a time of immense growth—second only to the first year of life—and as such, nutrient requirements increase substantially.[2] Data from the National Health and Nutrition Examination Survey (NHANES), which surveys representative samples from varying age groups of the United States, are collected every fiscal year, referred to as a cycle, on an array of health-related topics including overweight and obesity status.[3] In youth, overweight and obesity status is commonly classified by age- and sex-specific body mass index (BMI) percentiles, determined by growth charts developed by the Centers for Disease Control and Prevention using historical data from national surveys.[4] Measurement at or above the 85th percentile and below the 95th percentile on the age- and sex-specific growth charts indicates overweight status, while measurement at or above the 95th percentile indicates obesity.[5,6] Severe obesity in children and adolescents is defined by a BMI percentile at or above 120% of the 95th percentile.[6] As identified by NHANES, rates of childhood and adolescent obesity have more than tripled since the 1970s and severe obesity rates have more than quintupled within the same timeframe.[7,8] Data collected from the 2015–2016 NHANES cycle indicated that 18.5% of youth aged 2–19 years in the United States were obese, of which 5.6% were classified as severely obese.[7] Adolescents aged 12–19 years, the age range utilized throughout this review to define adolescence, had the highest prevalence of obesity at 20.6%, compared to 18.4% for youth aged 6–11 years and 13.9% for children aged 2–5 years.[7] Even more concerningly, youth from different ethnic groups are disproportionally obese, with Mexican American, Hispanic, and non-Hispanic black youth having above average prevalence of obesity.[7,8]

Consistently, overweight or obese children and adolescents are more likely to have elevated BMIs as adults.[6,9,10] Adolescents with BMIs above the 85th percentile are more likely to be obese by age 35 than their normal weight counterparts.[6] The probability of being overweight or obese as an adult increases with both youth BMI percentile and age, with obese adolescents being at the highest risk for obesity during adulthood.[6,9,11,12] In particular, youth who are obese during their teenage years have an over 90% likelihood of being overweight or obese at 35 years.[9] A study that combined several national datasets to model obesity trajectories from childhood through to middle age found that overweight or obesity at age 18 increased the risk of being obese in adulthood and that risk for adult obesity was more accurately assessed in adolescents rather than younger age groups.[12]

Similar to adults, obesity in adolescents impacts all major organ systems and often contributes to morbidity.[13,14] Adolescent obesity promotes inflammation and increases the risk of chronic disease development into and throughout adulthood.[15] Compared to those who are of normal weight, adolescents who are obese are at increased risk for adverse health effects, including cardiovascular risk factors such as hypertension, dyslipidemia, and endothelial dysfunction,[16-21] and metabolic risk factors including insulin resistance and hyperglycemia.[16,22-26] These risk factors persist throughout adolescence and into adulthood.[14,16,21,25-31] The diminished cardiometabolic health status that often digresses throughout adolescence is associated with the adoption of poor dietary and physical activity behaviors.[27]

Factors Contributing to Adolescent Obesity

Diet Quality

Diet quality can be measured to better understand overall eating patterns. One common method for assessing diet quality is through the generation of Healthy Eating Index (HEI) scores, from either food frequency questionnaires or 24 h recalls.[32] Currently NHANES utilizes two 24 h recalls to collect dietary information; however, prior to 2002, only one 24 h recall was collected.[33,34] The HEI allows for the assessment of overall diet quality as well as individual dietary components, including those recommended to be limited in the diet.[35,36] Higher HEI scores indicate an eating pattern more congruent with dietary recommendations than lower scores, and are based on a coordinating edition of the Dietary Guidelines for Americans, which is updated in accordance every five years.[32,35] The current method of the HEI was first created to coincide with the Dietary Guidelines for Americans, 2005 and MyPyramid recommendations.[37] This version of the index assessed diet quality through adequacy, or moderation, of 12 components as a ratio of overall energy intake.[37] Many of these components were carried forward into the subsequent version of the HEI in 2010, although milk, meats and beans, and calories from solid fats, alcoholic beverages, and added sugars were renamed to dairy, total protein foods, and empty calories, respectively.[35] The remaining components were modified in this update to better reflect updated dietary recommendations, including the inclusion of seafood and plant proteins and adding refined grains as a component to limit.[35] For the most recent update, HEI-2015, the only component change was the splitting of empty calories into saturated fat and added sugars.[36] Therefore, HEI-2015 is a composite score of 13 components to assess how well individuals meet key recommendations outlined in the 2015–2020 Dietary Guidelines for Americans.[32,36,38] As with previous versions, an overall HEI-2015 score ranges from 0 to 100, with 100 representing an eating pattern exactly aligned with recommendations.[32,36]

Youth in the United States do not meet dietary recommendations and adolescent diet quality is of particular concern. An expansive analysis of NHANES data covering seven cycles, from 1999 to 2012, included over 17,000 adolescents aged 12–18 years, out of a total of over 38,000 youth aged 2–18 years.[33] This study assessed adolescent diet quality utilizing HEI-2010, as well as analyzing trends over time.[33] Consistent with other analyses,[33,39-42] overall diet quality was shown to decrease with age as adolescents persistently had significantly lower overall HEI scores compared to younger youth.[33] Furthermore, results indicated that adolescents 12–18 years had an average overall HEI score of 48.4 out of 100 in the 2011–2012 NAHNES cycle, which was a significant increase from the average overall score of 40.4 observed during the 1999–2000 cycle.[33] On trend with overall diet quality improving over time,[33] the overall HEI-2015 score for adolescents 12–18 years was 52.0 in a more recent analysis.[42] Although overall diet quality scores have significantly improved over time for adolescents, the current scores are still considered low.[33,42]

Many countries, including the United States, have food-based dietary guidelines that include recommendations for food group consumption.[43] The majority of countries that have food-based dietary guidelines use five food groups, including starchy staples (grains for MyPlate in the United States), fruits, vegetables, dairy foods, and protein foods. While these guidelines may be more understandable to the general public, they do not provide recommendations for the consumption of specific nutrients. Most recent analyses of dietary data collected from NHANES show that, in general, adolescents are able to meet recommendations for protein including having better consumption of seafood and plant sources of protein compared to younger age groups.[42] However, these analyses also suggest that adolescents are not meeting recommendations for fatty acids.[42] The HEI-2015 scoring for fatty acids is based on a ratio of polyunsaturated and

monounsaturated fatty acid relative to saturated fatty acid intake.[36] With an average score of only 3.7 out of 10, it is likely that adolescents generally consume higher levels of saturated fatty acids in comparison to unsaturated fatty acids.[42] Additionally, the overall poor diet quality of adolescents is driven by the inadequate consumption of components considered more healthful, such as fruits, vegetables, and whole grains.[39-42,44] Analyses suggest that adolescents only consume about half the recommendations for fruits and vegetables[39,41,42] and with an average HEI score of 1.32 out of a possible 10, were consuming below the whole grains recommendation in one analysis.[39] The inadequate intake of these food groups perpetuated dietary fiber to be recognized as a nutrient of concern in 2015–2020 Dietary Guidelines for Americans.[45] Another recommendation outlined in the 2015–2020 Dietary Guidelines for Americans is to shift away from consuming added sugars.[45] Before becoming a singular category in HEI-2015,[36] added sugars were included in the HEI-2010 "Empty Calories" component, along with solid fats and alcohol, and are calculated negatively into the overall score.[35] While data from NHANES 2005–2010 suggested that adolescents had high consumption of empty calories,[39] a separate analysis utilizing data from NHANES 1999–2012 showed a substantial decrease in empty calorie consumption over time.[33] Although this trend was an improvement, empty calorie consumption in adolescents still exceeded recommendations in both studies[33,39] and adolescents were only meeting about half the recommendation for reducing added sugar consumption in a more recent study using HEI-2015.[42]

Socioecological Influences

In addition to developmental changes, adolescence is a period of social change, with adolescents progressing toward increased autonomy, and perhaps may result in the establishment of dietary habits.[2,46] The Social-Ecological Model describes that food choices can be influenced

from several different levels, spanning from intrapersonal factors to policy and systems.[47,48] These sectors of influence can have differential effects on an individual's risk for overweight or obesity.

Ethnicity and socioeconomic status (SES) are two factors that are associated with youth obesity rates. The prevalence of obesity is higher in Hispanic and non-Hispanic black youth compared to non-Hispanic white youth within the same age group.[49] In 2016, the prevalence of obesity for Hispanic and non-Hispanic black adolescents aged 12–19 years were 25.9% and 25.0%, respectively, which was substantially higher than the 17.2% observed in non-Hispanic white adolescents.[49] The prevalence of severe obesity was also highest among these groups, with 11.6% of Hispanic adolescents and 11.5% of non-Hispanic black adolescents being considered severely obese, compared to only 6.7% of non-Hispanic white adolescents.[49] In line with these values, data collected through NHANES suggest that non-Hispanic black adolescents typically have the lowest overall diet quality scores compared to other youth.[33,41,42] However, Mexican-American and Hispanic adolescents tend to have the highest overall diet quality and component scores compared to other groups,[33,41,42] which is surprising given the high prevalence of overweight and obesity observed in Hispanic youth.[7] Similar results were found in a study assessing the diet quality of high school students utilizing HEI-2010, with Hispanic students having higher overall HEI scores compared to non-Hispanic white youth.[50] One potential explanation for this observation is the lack of physical activity opportunities for adolescents from some ethnic/racial minority groups and communities of lower SES. Analyses of NHAHES 2007–2016 data showed that adolescents from low-income families participated in less physical activity than more affluent adolescents.[51] This association may be the result of reduced access to parks, playgrounds, and exercise facilities, which is more prevalent in less advantaged

communities[52]; a problem that is even more prevalent in communities where the population is predominantly of an ethnic/racial minority group.[53] A nationally representative study found that neighborhoods primarily comprising ethnic/racial minority and low SES groups were half as likely to have access to a physical activity facility on their block.[53] This is a substantial disadvantage given that the assessment also found that access to one of these facilities significantly decreases the odds of adolescent overweight.[53]

An analysis that included 10 years of NHANES data sought to better characterize the role SES plays in modifying diet quality of Mexican-origin youth.[54] For this study, high or low SES was estimated with consideration for education and income-to-poverty-ratio.[54] As in other analyses of NHANES data,[33,41,42] Mexican-origin youth of the same generation as non-Hispanic white youth had higher overall diet quality, as determined by HEI-2010 scores.[54] Interestingly, the average HEI score for overall diet was significantly lower in third-generation Mexican-origin youth from low SES families compared to first and second generations.[54] This decrease in overall diet quality as generation progressed was perceived to be from acculturation and the increased consumption of empty calories, as is more customary in a typical American diet.[54] The trend in later generations having poorer diet quality was attenuated by SES as no significant differences in diet quality were observed between generations from high SES families.[54] Unlike the association found with Mexican-origin youth, overall diet quality scores from NHANES data have either shown no difference between the highest and lowest income youth[41] or were occasionally significantly associated with income level, but the direction of this association was not consistent over time.[33] Despite this, lower income households tend to have a higher prevalence of obesity than higher income households.[55] Similarly, there is, generally, an inverse relationship between head of household education attainment and youth obesity.[55] In 2016, youth

obesity prevalence was highest for those whose head of household did not receive a high school diploma.[49]

Youth from lower SES families are also more likely to experience food insecurity.[56-58] Food security can be categorized into one of four ranges: very low, low, marginal, and high food security.[59] Classification into one of these ranges is determined by how often a family or individual experiences distress involving food selection or alters eating patterns due to insufficient resources to obtain food.[57,59] The United States Department of Agriculture monitors food insecurity rates utilizing an annual survey. Most recent estimates have shown a continuous decline in the percentage of food insecure households since 2011.[57] While low-income families and households with children, in particular non-Hispanic black and Hispanic households, remain at percentages above the national average,[57] this shift in prevalence is promising given that household food insecurity is related to overweight and obesity in youth.[56,58,60,61]

Adolescence is marked by increased autonomy and a transition from spending the majority of time with parents to away from home with peers.[46,62] While parents still provide guidance on certain matters, peers assert more influence on superficial concerns, especially as adolescents enter teenage years.[62] This influence in regard to eating behaviors may be perpetuated by a desire to fit into a particular peer group, among other complex factors.[63] Peer influence is evident in adolescent selection and consumption of food,[63] with mixed observations on whether the tendency is toward encouragement or discouragement of consuming healthy foods.[63] Peers, especially friends, can have a beneficial effect on adolescent eating patterns. One study found that adolescent diet quality scores were positively related to healthy food choices made by peers.[46] Another study found that healthful aspects of best friends' eating patterns can be influential for adolescents and result in consumption of significantly more vegetables, whole

grains, and dairy.[64] While statistically significant, the increases observed in this analysis were not substantial, with adolescents consuming an additional 0.09, 0.14, and 0.08 servings of vegetables, whole grains, and dairy, respectively.[64] In practice, the 0.08 serving increase in dairy would be roughly equivalent to 0.5 ounces of fluid dairy or about one tablespoon of milk. A cross-sectional study assessing youth and adolescent diet quality, observed no relationship between overall HEI-2010 score and friend support for eating healthy or unhealthy foods.[65]

Despite increased autonomy, parents still play a role in shaping adolescent eating. Parents influence adolescent eating patterns through food procurement and by modeling and supporting healthy eating behaviors.[46,66-69] In the cross-sectional analysis mentioned previously, parental offering of food considered unhealthy was associated with decreased diet quality scores.[65] However, 40% of the sample also indicated that their parents rarely or never offered unhealthy foods, thus modifying their availability and accessibility.[65] If high-fat foods and sweets are not being offered, then consumption may be limited allowing for higher adolescent diet quality. Furthermore, the availability of fruits and vegetables in the home is correlated with adolescent fruit and vegetable consumption.[67,70]

Adolescent Stress and Adiposity

Physiological Stress

Adolescence is known to be a stressful developmental period, and emerging research supports the need to address psychosocial stress as a factor in obesity prevention and management.[71-74] The psychosocial stress arising from poor body image and social ostracization, especially associated with adolescent obesity, may further promote stress and corresponding health-compromising coping mechanisms.[75] Stress is broadly defined as the body's response to a

real or perceived threat beyond the ability to cope.[76] A perceived threat activates the neuroendocrine hypothalamic-pituitary-adrenal (HPA) axis, ultimately resulting in the secretion of cortisol from the fasciculata of the adrenal cortex.[77] Cortisol binds to receptors found in the peripheral and central nervous system, where its objective is to mobilize and redistribute energy stores to maintain homeostasis and minimize incurred damage to the individual until the threatening stimulus has passed.[78] Outcomes of chronic HPA-axis activation include effects on gluconeogenesis and glycogenolysis,[79] lipolysis,[80] insulin resistance,[81,82] and compromised reproductive functions.[83]

Cortisol is essential for organism survival.[84] However, the effects of chronic stress are systemically deleterious, as glucocorticoid receptors are ubiquitously spread throughout body tissues, such that nearly every organ system is affected.[85] Under chronic stress, the characteristic negative-feedback nature of the HPA-axis may become dysfunctional, which increases the risk of developing a host of metabolic and affective disorders.[85] Prolonged stress contributes to allostatic load, where the body develops new "set points" including, but not limited to, higher blood glucose, stress sensitivity, and reactivity.[86] Chronic psychosocial stress promotes metabolic derangement including adiposity, as well as abnormal eating behaviors including over- or under-eating, and preferentially selecting highly palatable foods.[87] Furthermore, prolonged stress also confers increased risk for developing numerous chronic diseases, including metabolic syndrome,[88] diabetes mellitus,[89] cardiovascular disease,[90] obesity,[71] and mental health disorders.[91]

Adolescent Stress

Adolescents are especially vulnerable to the negative effects of stress, at least partially due to the sensitization of the HPA-axis that occurs during this period.[92] Adolescence is a

developmental period marked by heightened stress reactivity and sensitivity, increased emotionality, and increased incidence of both risk-taking and harm-avoidant behaviors.[93] Adolescents typically experience heightened stress sensitivity and prolonged reactivity in a sex-dependent manner, with basal and stress-responsive cortisol typically higher in females.[94] Many of the affective and behavioral signatures typical of adolescence can be explained by rapid gonadal hormone development and non-linear neurodevelopment.[95] In adolescents, limbic brain regions involved with motivation, instant gratification, and reward develop much more rapidly than do cortical regions involved in inhibitory control.[93] Thus, limbic brain circuitry is more likely to predominate over less mature cortical regions during emotionally salient contexts.[96] The effects of stress on metabolism and food choice plus the psychosocial stress experienced by adolescents with obesity are critical points for consideration.

Stress-Motivated Eating Behavior

Both animal and human studies have demonstrated that the majority of individuals preferentially select highly palatable foods when stressed, whether-or-not they exceed their caloric requirements.[87,97] This once conferred evolutionary advantage, as additional calories increased the likelihood of escaping from or fighting—and thus surviving—what were historically acute physical threats.[98] Modern stress is largely chronic and psychogenic in nature rather than physical.[98] These chronic stressors, coupled with a more sedentary modern lifestyle, result in an evolutionary mismatch; the body employs conserved response mechanisms to psychosocial stress, which involve increased drive to seek out palatable foods meant to aid in fighting or fleeing a threatening situation.[76] Repeated exposure to psychosocial stressors, and the

resultant consumption of such highly palatable foods in our modern environment may, ultimately, increase the risk of developing overweight and obesity.

Adolescents are at increased risk of partaking in unhealthy behaviors, especially in emotionally salient contexts.[95] Maturation in brain regions involved in reward seeking may underpin the drive for palatable food consumption in adolescence.[99] In fact, the repeated consumption of palatable foods in this critical window of neurodevelopment may derail normal maturation processes, thus predisposing the adolescent brain to abnormal eating behaviors.[99] Palatable foods eaten under stress are typified by sweet taste and tend to be foods high in rapidly digesting, simple carbohydrates.[100] The physiologic signals that arise from consuming palatable foods rich in simple carbohydrates orchestrate cognitive, metabolic, and behavioral responses to stress, which, over time, may increase obesity risk.[101,102] Importantly, sweet taste is instantly rewarding, and may promote reinforcement learning—even in the absence of post-prandial metabolic signals, which can also contribute to overconsumption and obesity.[103] This was exemplified when rats given oral administration of sucrose solution demonstrate reduced stress responses, whereas intragastric gavage of sucrose had no such effect.[104] In humans, this attenuation of stress in response to consuming palatable foods high in simple carbohydrates has been shown when exogenous carbohydrate consumption before a combined mental and physical stress challenge mitigated effects of stress.[105]

Metabolic Effects of Palatable Food Consumption

Stress-related emotional eating in the absence of hunger involves the motivation and reward-associated brain networks that override homeostatic feeding cues originating from the hypothalamus.[106] The post-ingestive metabolic signals arising from continually exceeding caloric requirements for weight maintenance promote increased energy storage and reduced expenditure,

and these effects are exacerbated under stress.[107] Postprandial effects of consuming palatable foods include blood glucose elevation, which is met by an increase in insulin secretion.[108] Effects of insulin in tandem with the effects of cortisol on disruption of glucose and insulin homeostasis, further promote energy storage, especially in the visceral region.[109] In addition to promoting glucose homeostasis, insulin also interacts with neuropeptides to increase energy expenditure and reduce food intake in the absence of stress.[110] The neuroendocrine axes orchestrating stress and energy balance overlap, with notable neuropeptides and hormones involved in energy balance also influencing stress regulation.[111]

Leptin is an adipocyte-derived hormone with anorectic effects and has been shown to dampen HPA activity associated with chronic stress.[112] Leptin has both central and peripheral targets, where combined effects with insulin and other anorexigenic hormones result in, but are not limited to, alterations in food intake, glucose and lipid metabolism, pancreatic islet B-cell secretion, reproductive function, immunity, and energy expenditure.[113,114] In the fed state, centrally acting leptin is secreted from the arcuate nucleus of the hypothalamus, then activates neurons associated with increased satiety and energy expenditure, and inhibits neurons associated with increased food intake and weight gain.[115] Circulating leptin concentrations are often high in individuals with obesity, thus suggesting a state of leptin resistance.[112,116,117] Whereas leptin deficiency can be corrected with exogenous recombinant leptin administration, leptin resistance is not attenuated with the introduction of additional hormones.[118] With respect to stress, one study showed that a seven-day glucocorticoid treatment intervention resulted in increased food intake despite increased serum leptin levels.[119] Conversely, another study demonstrated that high glucocorticoids after a social stressor were associated with transient increases in plasma leptin, thus resulting in temporarily suppressed appetite and food

consumption under stress.[120] Hypercorticism is oftentimes observed in obesity, and glucocorticoids are known to restrain the effects of leptin.[121] Thus, psychogenic stress promotes metabolic dysregulation directly and indirectly through its influence on hormones and neuropeptides involved with energy balance.

Obesity-Associated Psychogenic Stress in Adolescents

Obesity can be a stressful state due to weight stigma[122] and adolescents who experience stress related to social ostracization are more likely to rely on food-related coping mechanisms.[123] This behavior is immediately rewarding and may contribute to temporary solace and improved mood,[124] however, repeated intake in excess of caloric needs will result in weight gain, thus perpetuating the cycle.[125] Psychogenic stress as a result of weight stigma may contribute to disordered eating habits in adolescents.[126] A prospective cohort study collected 10 waves of data from 1420 participants and found that victims of bullying in childhood and adolescence had an increased likelihood of developing anorexia nervosa and bulimia.[127] Furthermore, adolescents experiencing weight-related stigma are at increased risk of engaging in secretive eating, characterized by eating in solitude to avoid being seen by others.[128] Secretive eating is correlated with binge eating and the onset of other eating disorders, and may be related to depression and poor body image.[128] In a cross-sectional study examining 577 youth, those endorsing secretive eating experienced greater eating-related psychopathology.[128] Additionally, it was found that adolescents experience more dietary restraint and purging than younger youth.[128]

Sex differences, personality types, cultural and familial normative beliefs, self-worth, and learned coping mechanisms all inform the extent to which an individual internalizes and copes with psychosocial stress.[129] For example, neuroticism partially accounted for associations

between depression and chronic life stress in 603 adolescents in a study exploring risk factors for emotional disorders.[130] Furthermore, depression was associated with chronic life stress in females only, and low extraversion partially accounted for associations between social phobia and chronic life stress.[130] With regard to sex differences, female sex hormones contribute to higher stress sensitivity and sustained stress responses.[94] Adolescents are at an increased risk for dieting with the goal of weight loss,[131] and those who experience personal factors such as weight concern, body dysmorphia, and depression are more likely to develop disordered eating behaviors 10 years later.[132] One study found that body image dissatisfaction in adolescent females was associated with self-esteem.[133] Females are also at higher risk of developing eating disorders.[134] Finally, restrained eaters, those who consciously elect to restrict intake of food quantity or food types,[135] are at higher risk of emotional eating compared to unrestrained eaters.[136]

Obesity and Cardiometabolic Disease in Adolescents

Cardiovascular Disease

Cardiovascular disease (CVD) is the number one cause of death in the United States.[137] By the year 2030, the percentage of the population suffering from CVD is projected to approach 44%.[138] Although CVD is generally perceived as a disease of adulthood, studies suggest that atherosclerosis often begins in childhood or adolescence.[26,139,140] Cardiovascular risk develops as a culmination of the atherogenic process over the lifespan.[20,26,28,141] Progression of atherosclerosis is related to the number and intensity of cardiovascular risk factors, which develop in childhood and track into adulthood[21,26,142] and may be independent of adult weight.[143] It is estimated that 70% of obese children and adolescents ages 5–17 years have at least one

cardiovascular risk factor.[144] Risk factors—for example, hypertension and dyslipidemia—are directly, positively associated with the presence and severity of early atherosclerotic lesions in adolescents and young adults.[20,140] Obese children have been observed to have significantly impaired arterial elasticity and endothelial function.[21] In addition, obesity in youth is associated with increased cardiac mass and intima-media thickness in adulthood.[145-147] Out of the cardiovascular risk factors, obesity is the most predictive of future disease[22,142] and adolescent obesity is projected to yield an increase in coronary heart disease in adulthood.[26]

The Bogalusa Heart Study, a long-term epidemiologic study of cardiovascular disease risk factors beginning in childhood, assessed cardiovascular risk factors, including serum lipid concentration, blood pressure, and BMI, in children and adolescents, following them from youth into adulthood.[22,141,142] Findings suggest that intensity of cardiovascular risk in youth predicts subclinical atherosclerosis and adult morbidity and mortality.[27,142] The Pathobiological Determinations of Atherosclerosis in Youth Study, another large-scale study of atherosclerosis in adolescents and young adults (15–34 years) also assessed the presence and extent of early atherosclerotic lesions in relation to cardiovascular risk factors in subjects who underwent autopsy.[148] Their results were in agreement with those from the Bogalusa Heart Study; intimal lesions were present in the aorta of all subjects aged 15–19 years and severity increased with age.[148] Other studies report that specifically an android fat distribution, or central adiposity, is correlated with dyslipidemia and arterial stiffness in youth.[20,21] Tounian et al.[21] suggested that android fat distribution, dyslipidemia, and insulin resistance may be primary contributors to these vascular impairments. Obese youth had significantly higher levels for each of these parameters,[21] which aligns with several other studies examining lipid profile, blood pressure, and glucose and insulin concentrations in obese youth.[144,149-151]

Severity of obesity is also relevant.[14,152] In a large-scale, cross-sectional study utilizing data from NHANES 1999–2012, researchers observed that all cardiometabolic risk factors were elevated as severity of obesity increased in adolescents.[153] When controlling for age, race/ethnicity, and sex, greater severity of obesity yielded increased risk of dyslipidemia, hypertension, and elevated glycated hemoglobin level.[14]

Type 2 Diabetes Mellitus

Similar to CVD, insulin resistance and type 2 diabetes mellitus (DM) are obesity-related complications previously thought to develop in adulthood that are becoming increasingly more prevalent in younger populations.[25,154,155] As with adults, central adiposity in youth is associated with insulin resistance.[21] The first metabolic abnormality seen in obese youth is hyperinsulinemia.[156] The decrease in insulin sensitivity that occurs with puberty further compounds insulin resistance in obese adolescents.[23] In addition to the inflammatory response, adiponectin is considered to partially explain the relationship between obesity and type 2 DM.[157] Due to its negative association with insulin resistance,[158] adiponectin has been considered an insulin-sensitizing adipokine[157,159] and is inversely related to adiposity.[150,160] Obesity is also strongly, negatively correlated with adiponectin level in adolescents, as well as in children and adults.[161,162] Lower levels of adiponectin are associated with increased levels of insulin resistance in obese adolescents[163] such that most youth with insulin resistance are overweight or obese.[158] In addition to obesity and insulin resistance, low adiponectin levels in youth are also associated with hypertension and dyslipidemia and may therefore predict the clustering of these symptoms of metabolic syndrome.[24,164] The presence of these risk factors in obese children and adolescents compounds the risk for the development of subsequent type 2 DM and CVD in youth.[150]

Compound Risk: Obesity, Diabetes, and Cardiovascular Disease

The diagnosis of DM is an established risk factor for vascular disease and the early development of CVD.[26] The metabolic abnormalities in energy utilization that are associated with DM cause diabetic dyslipidemia.[165] Also, the chronic hyperglycemia often seen in combination with obesity results in damage to the vasculature.[166] For this reason, adolescents with obesity are at significantly increased risk for accelerated atherosclerosis.[26] Children with the described cluster of metabolic abnormalities were more likely to have type 2 DM and clinical cardiovascular events after a follow-up of 25 years.[30,31] Even in absence of the metabolic abnormalities, there is a strong association between obesity in adolescence and subsequent development of the metabolic syndrome cluster in adulthood,[26] which may be attributed to obesity-induced chronic inflammation.[167] Pro-inflammatory adipokines—for example, leptin—have been implicated in the development of both obesity-related type 2 DM and CVD.[154] Obesity-induced insulin resistance is also associated with increased carotid intima-media thickness[168] and endothelial dysfunction in obese adolescents.[169,170]

Intervention Opportunities

Without intervention, it is projected that most youth will be overweight or obese and likely suffering from chronic diseases in adulthood given current expected trajectories.[11,12,25] Diet and lifestyle modification in adolescence or earlier is essential in the prevention of the development of chronic diseases in adulthood. The concept that youth are in the subclinical stages of cardiometabolic disease, which may be exacerbated by stress, emphasizes the need for early intervention.[14,18,27,150,171-173] The abnormal accumulation of lipids in the vascular wall is a reversible stage in the atherogenic process,[26] making the early stages of atherosclerosis, which often appear in youth, an ideal opportunity for intervention. Early identification and intervention

may attenuate clinical manifestation and improve long-term health outcomes.[26] Analyses of results from several prospective longitudinal cohort studies found that risk for hypertension, dyslipidemia, atherosclerosis, and type 2 DM in obese youth who became non-obese by adulthood were similar to those who were never obese.[142,147,174,175] These findings suggest that weight management in youth, adolescence, and young adulthood may at least partially diminish cardiometabolic risk in adulthood.[29] Weight loss coupled with lifestyle modifications, including stress reduction, increased physical activity, and improvements in diet, is often sufficient to improve insulin sensitivity and can thereby assist in the prevention or control of type 2 DM without the need for exogenous insulin administration.[154,176,177]

According to the United States Burden of Disease Collaborators, the primary risk factor related to disease burden was found to be suboptimal diet.[178] It has been recommended that interventions geared toward improving adolescent dietary behaviors are thoroughly planned in advance to ensure that they are designed, implemented, and monitored appropriately for the targeted population.[179] In designing interventions, the most successful have been developed in line with a theoretical framework, most commonly the Social Cognitive Theory (SCT).[179] The SCT is utilized in nutrition interventions due to its consideration for improvement of individual factors, such as self-efficacy and knowledge, as well as environmental factors, when facilitating behavior change.[180] Utilizing SCT as the guiding theoretical framework also aids in designing behaviorally-focused interventions that modify the environment while also being developmentally appropriate for the intended participants, which have also been implicated as elements of successful nutrition interventions.[179]

Nutrition interventions for adolescents are frequently implemented through comprehensive school-based interventions and multicomponent programming, as recommended

by the Academy of Nutrition and Dietetics, Society for Nutrition Education and Behavior, and School Nutrition Association.[181] Multicomponent school-based interventions have shown promise for improving dietary intake and health status of children and adolescents.[182] Multicomponent programs commonly include nutrition education implemented in the classroom; modifications to school policies and the food environment; and methods for parental involvement.[182]

Further recommendations include adjustments to the school environment in order to facilitate acquisition of healthful behaviors and the promotion of evidence-based nutrition education that includes opportunities for youth to grow and prepare food.[181] Programs that incorporate garden and cooking components are important given their potential for translatable and long-term effects. Gardening experience during childhood is valuable as it has been associated with significantly higher fruit and vegetable consumption during late adolescence compared to older adolescents with no prior gardening experience.[183] Furthermore, frequent gardening is beneficial in that gardening weekly or even monthly has been associated with high fruit and vegetable consumption compared to infrequent or no gardening.[183] A recent survey of high school students found that adolescents who had a home garden or experience with community gardening or farming were significantly more likely than others without experience to try new fruits and vegetables.[184] Additionally, adolescents with a home garden were more likely to consume adequate amounts of vegetables.[184] As for inclusion of cooking, a review of programs that incorporate cooking found that participation in these programs has the potential to beneficially impact youth knowledge, skills, and behaviors related to nutrition in addition to cooking.[185] It has been found that participation in food preparation during adolescence was

associated with a continuation of enjoyment and involvement in food preparation as an emerging adult.[186]

In accordance with these recommendations, several recent interventions targeting youth dietary habits have included garden components[187-193] and cooking components.[189,191-195] While the age range in most of these studies included ages prior to adolescence,[187,188,191,193,194,196] methods utilized and findings from these studies may have application for adolescents. Compared to controls, programs that included a gardening component resulted in greater willingness to try vegetables,[187,188,197] preferences for vegetables,[187,188,197] and reported vegetable consumption.[187,190] Similarly, participants in a nutrition program geared toward cooking had improvements in reported fruit and vegetable post-intervention consumption.[194] This program also resulted in increased reported nutrition knowledge, cooking self-efficacy, and cooking at home after completing the intervention.[194] Programs that included both gardening and cooking components observed that, compared to controls, participants had significantly higher fruit and vegetable[193] and nutrition knowledge.[196] Additionally, youth participating in the programs were significantly more likely correctly identify vegetables,[196] consume fruits and vegetables daily,[193] and be willing to try new foods.[191]

The emerging concept of food literacy takes recommendations for the incorporation of growing and preparing food further. Broadly, food literacy is defined as the interconnection between the knowledge, skills, and behaviors necessary for procuring, planning, and preparing healthful food.[198] Food literacy is quite complex, encompassing several components including elements of nutrition, health, agriculture, food systems, food safety, and cooking.[198-200] Three reviews of adolescent food literacy programs have been conducted recently.[201-203] Two of these reviews highlight the need for a reliable and validated questionnaire to assess food literacy as a

whole, given that none of the studies reviewed supplied such an assessment.[201,203] Varying interpretations of food literacy prior to establishment of a definition[198] limited the ability to develop an assessment to encompass the complexity of food literacy. With this and contrasting study designs, all three reviews noted difficulty in determining inclusionary criteria for articles and interpreting results.[201-203] Given the limitations of previous adolescent food literacy programs, Brooks and Begley compiled a list of recommendations for future programs, including the development of adaptable school-based food literacy programs for older adolescents.[202]

Future Directions

Interventions are needed to aid in the reduction and prevention of adolescent obesity. As obesity is a complex health concern with numerous contributing factors, effective intervention strategies may require a multifactorial approach aimed at reducing stress and cardiometabolic risk factors while also empowering adolescents with the knowledge and skills necessary to make informed and healthful dietary choices. Some studies have suggested that mindfulness interventions for adolescents may be feasible for decreasing distracted eating[204] and reducing stress and depressive symptoms,[205] which can aid in reducing and preventing obesity. Additionally, interventions that include exercise and calorie restriction components can be effective at reducing obesity and cardiometabolic risk factors.[206,207] These methods—in combination with multicomponent school-based interventions and skill-building health education programs, such as those that promote food literacy—warrant further research. However, a thorough review of the literature consistently demonstrates a gap with respect to adolescent food literacy education. Given that food literacy education is a comprehensive approach to target the upstream behaviors leading to obesity and related comorbidities, the timeliness of a program to

combat this issue is critical. Aligning with the above recommendations,[202] guided by SCT,[180] and the definition established by Vidgen and Gallegos,[198] a food literacy curriculum for high school-aged adolescents has been developed.[208] The curriculum, *Teens CAN: Comprehensive Food Literacy in Cooking, Agriculture, and Nutrition* (*Teens CAN*), includes experiential lessons within twelve modules that comprise opportunities to advance food literacy.[208] *Teens CAN*[208] will be incorporated into an existing multicomponent program, the Shaping Healthy Choices Program,[189] to provide an intervention aimed at improving diet quality and the overall health status of children and adolescents. While this is one suggested approach, the ultimate goal is to mitigate the effects of childhood and adolescent obesity. Resources including time, money, and effort should be allocated toward this type of obesity prevention programming.

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STATEMENT OF PURPOSE

Adolescents in the US, on average, have poor diet quality and do not consume recommended amounts of fruits, vegetables, and whole grains. This suboptimal eating pattern is likely contributing to the elevated prevalence of obesity observed in adolescents aged 12-19 years compared to younger youth. Prevalence of obesity in this age group has consistently risen over the past three decades and is highest in youth from underserved backgrounds. Nutrition education that features experiential curricula developed utilizing theory has been implicated as a best practice for intervention. An emerging concept called food literacy incorporates knowledge and skills related to healthy eating. This concept incorporates nutrition education in addition to understanding food sources, procurement, and preparation. Although high school-aged adolescents are at an increased need for food literacy intervention given the trend toward poor diet quality, programs developed for older adolescents are uncommon. Therefore the purpose of this dissertation was to develop a food literacy program for high school-aged adolescents.

The approach for this dissertation was to develop an assessment tool, teaching method, and curriculum specifically for high school-aged adolescents to be utilized within the food literacy program. Chapter 2 of this dissertation describes the testing of an existing nutrition knowledge questionnaire to assess whether it could be validly and reliably used with adolescents. Chapter 3 includes a pilot test to assess feasibility of adolescents facilitating garden-enhanced nutrition curricula as cross-age teachers for younger youth. Chapter 4 details the development and pilot testing of a food literacy curriculum, featuring experiential lessons and application activities within agriculture, nutrition, and cooking.

CHAPTER 2

Validity and Reliability of a Nutrition Knowledge Questionnaire for High School-Aged Adolescents

Introduction

The prevalence of childhood and adolescent obesity has progressively increased over the last 3 decades.[1] Adolescents aged 12–19 years had the highest prevalence, with data showing about 20% classified as obese in 2016.[1] The elevated prevalence of adolescent obesity may be due in part to the overall poor diet quality of adolescents in the US,[2] which includes consuming less than half of the recommended amounts of total fruits and vegetables.[3-5] School- and community-based nutrition interventions have been implemented to improve diet quality and reduce childhood and adolescent obesity. Assessment of nutrition knowledge is an important measure for these types of interventions because higher nutrition knowledge has been positively correlated with fruit and vegetable intake in adults.[6,7] However, confident assessment of nutrition knowledge cannot be achieved without valid and reliable measurement tools for the intended target population.[8,9]

A review of the literature demonstrated a paucity of updated questionnaires that specifically measured general nutrition knowledge with high school-aged adolescents in the US. Although some questionnaires have been used for nutrition knowledge assessment in adolescents,[10-24] these questionnaires were either very specific to the intended intervention,[13,21,23] were not rigorously tested for various types of validity and reliability,[12,16,19,21,23] or were not tested in the US.[10,11,13-18,20,22-24]

The General Nutrition Knowledge Questionnaire,[25] developed and assessed for adults in the United Kingdom, is a widely used nutrition knowledge measure. Adapted primarily from the General Nutrition Knowledge Questionnaire, Jones and colleagues[26] developed a nutrition knowledge questionnaire relevant for a US adult population. The Jones questionnaire contained 4 sections: advice about nutrition from experts, nutrients in foods, health benefits of foods, and diet

and disease relationships.[26] Following several rounds of assessment and revision, the questionnaire demonstrated internal consistency reliability, test-retest reliability, and construct validity for measuring nutrition knowledge in California adults.

Although rigorously tested and found valid and reliable for adults, the extent to which the Jones questionnaire[26] was appropriate for an adolescent population was unknown. Therefore, the objective of this study was to determine the validity and internal consistency reliability of the Jones nutrition knowledge questionnaire[26] for high school-aged adolescents. The primary purpose of evaluating the questionnaire in an adolescent group was to determine if the tool would be a valid and reliable measure of nutrition knowledge in a subsequent nutrition intervention.

Methods

An updated version of the Jones questionnaire,[26] with references to MyPyramid replaced with MyPlate, was retrieved from the corresponding author and contained 50 questions that pertained to general nutrition knowledge (advice about nutrition from experts and nutrients in foods). The remaining questions were specific to diet and disease relationships, which was not the aim of the adolescent questionnaire. The 50 general nutrition questions were administered via paper copies to 4 convenience samples of students during Fall 2016 through Fall 2019 at suburban, rural, and urban high schools in Northern California and a private school in Hawaii. Convenience sampling was used in this study by working with teachers interested in having their class participate in the study.

Every student from each class who was present on the day of questionnaire administration completed a questionnaire. No questionnaires were left behind with the teacher,

and no make-up questionnaire administrations were held. Students were grouped for analyses into either “Nutrition Education” or “No Nutrition Education” based on known evidence of prior nutrition education. Before completing the questionnaire, all students were informed verbally of the task, and that participation was voluntary. Students self-reported their current age and school name on the questionnaire. The first sample consisted of ninth-grade students without any known prior nutrition education and 10th-grade students who had received nutrition education as part of their required health class in the previous school year. The second sample consisted of 10th-grade students at the beginning of the school year who had not yet taken health class. This sample also included high school students in the 11th and 12th grades who had completed health class in previous years. The third sample included high school students of varying grade levels who had just completed participation in nutrition education programming provided by a University of California Cooperative Extension nutrition educator.

Finally, the fourth sample included high school-level students attending a private school with a mandatory food and nutrition course. The questionnaire was administered during finals week to 11th- and 12th-grade students who had just completed the course and to ninth- and 10th-grade students who had yet to take the course. The questionnaire was only administered in English, and all participants were English literate. Most students completed the questionnaire within 20 minutes and received a $10 gift card as an incentive for participation. All procedures were approved as exempt by the University of California, Davis Institutional Review Board, and school administrators provided letters of support to approve student participation.

The questionnaire was administered and scored by nutritional science doctoral students. Students were encouraged to complete all questions and were given a *not sure* option for each question. The percentage of correct answers was calculated for each student, and the mean

percentage of correct answers was calculated for each group. *Not sure* responses and skipped questions were coded as incorrect. To refine the questionnaire, item discrimination was assessed. Questions with an item-total correlation of less than 0.2, indicating low item discrimination, were identified.[27] Recommendations, when considering item difficulty, suggest the elimination of questions that either group scored less than 20% or greater than 80% correct.[27] However, the students that were expected to score higher on the questionnaire were not as highly educated in nutrition as the high knowledge participants from the original questionnaire development study, all of whom completed college-level nutrition education.[26] Thus, *a priori*, the range for the present study was adjusted to compensate for anticipated lower overall scores, and questions that either group scored less than 10% or greater than 80% correct were identified. Given the variation in known previous nutrition education provided at each school, a *post hoc* linear regression analysis was also conducted to control for school when assessing the association between group and mean percentage of correct answers. Data were analyzed using SAS 9.4 software (SAS Institute Inc, Cary, NC, 2013) with statistical significance set at $P < 0.05$.

Results

A total of 310 questionnaires were completed by students and included in the analyses; 136 with no known prior nutrition education and 174 with previous nutrition education. The group with no known prior nutrition education included students aged 13–16 years, with a median age of 14 years. The group with prior nutrition education included students aged 14–18 years, with a median age of 17 years (data not shown).

Although individual demographic data were not collected, selected school-level demographics for the school year in which data were collected were retrieved from the California

Department of Education: Educational Demographics Unit[28] for the California schools and are presented in the Table. Limited school-level demographics (Table) were retrieved from the most recent Hawaii Association of Independent Schools Private School Enrollment Report[29] instead of the school year in which data were collected, given that this information is not made available until the following school year. Three of the participating schools were predominantly Hispanic or Latino, with over 50% identifying as Hispanic or Latino of any race at each school. The eligibility for free and reduced-price meals can provide a general representation of the income level with respect to the student population; a school in which 50% or more of the students are eligible for free and reduced-price meals is considered low-income. The first high school had 47.3% free and reduced-price meal eligibility and was considered middle- to low-income. The second and third high schools were both considered low-income, with 99.6% and 89.3% free and reduced-price meal eligibility, respectively. The fourth school did not participate in the National School Lunch Program and thus free and reduced-price meal eligibility was not available.

The only missing data were skipped questions, which occurred infrequently and equivalently in both groups. Analyses of item discrimination and item difficulty identified 2 questions that did not meet predetermined thresholds for inclusion. Although 1 of these questions exceeded the item difficulty threshold, with 81% of students selecting the correct answer, the question was retained for content relevance and for demonstrating acceptable item discrimination (0.3; data not shown). The second identified question had low item difficulty, with 17% of students answering the question incorrectly and was found to be negatively correlated with total score (data not shown). Furthermore, this question was determined not to be essential for assessing general nutrition knowledge and was eliminated from the questionnaire resulting in 49 questions.

Two-tailed t-tests on the modified questionnaire showed a statistically significant difference in mean percentage of correct answers between groups for the full questionnaire ($P < 0.0001$) and for both subsections ($P < 0.0001$), demonstrating construct validity for the full questionnaire and each subsection independently. The association between group and mean percentage of correct answers remained significant when controlling for school ($P < 0.0001$).

As shown in the Figure, the group with prior nutrition education had a significantly higher mean percentage of correct answers (46.7 ± 2.2, mean ± 2 SEM) on the full questionnaire compared to the mean percentage of correct answers (34.9 ± 2.4, mean ± 2 SEM) of the group without prior nutrition education. The Nutrition Education group also scored significantly higher on the "advice about nutrition from experts" subsection and the "nutrients in food" subsection compared to the No Nutrition Education group (Figure). The questionnaire also demonstrated good overall internal consistency reliability (Cronbach $\alpha = 0.83$).[27] In addition, the 2 sections of the questionnaire, advice about nutrition from experts and nutrients in foods, demonstrated adequate internal consistency reliability when assessed individually (Cronbach $\alpha = 0.78$ and Cronbach $\alpha = 0.72$, respectively).[27]

Discussion

Building on the extensive testing conducted by Jones and colleagues,[26] results from the present study suggest that the adapted questionnaire is valid and reliable for measuring nutrition knowledge in adolescents 13–18 years. The Jones questionnaire[26] was predominantly developed from the General Nutrition Knowledge Questionnaire, which was developed to assess the general nutrition knowledge of adults in the United Kingdom.[25] The questionnaire is widely used and has been adapted and modified for use internationally,[30] including in the US by Jones and

colleagues.[26] The present study aimed to adapt the Jones questionnaire further[26] and expand its use to adolescents. Although the adaption of the General Nutrition Knowledge Questionnaire for adolescents has been completed in Germany[10] and Portugal,[11] the present study using the Jones questionnaire[26] is the first to do so in the US. Although there is mixed opinion on the association between nutrition knowledge and dietary behavior, the potential for a weak correlation could be due to the misrepresentation of nutrition knowledge from unvalidated assessment tools.[25] Future studies should use valid and reliable measures to ensure that collected data accurately reflect the nutrition knowledge of participants.[9,25] Furthermore, if such a tool does not already exist for the intended demographic, researchers should commit to completing satisfactory validity and reliability testing.[9]

The Jones questionnaire[26] was adapted and tested for validity and internal consistency reliability in this study to be used in a subsequent nutrition and youth leadership intervention. The intervention aimed to determine the efficacy of implementing curricula from the *Shaping Healthy Choices Program* (SHCP),[31] in nontraditional educational settings, such as the *4-H Youth Development Program*, using teenagers as cross-age teachers for younger youth. The SHCP is a research-tested multicomponent, school-based program that has shown significant improvements in nutrition knowledge, vegetable identification, reported and observed vegetable intake, physical activity, and body mass index through intervention with upper elementary-aged youth.[32-34] The questionnaire was employed to assess whether teenage teachers had improvements in nutrition knowledge scores after facilitating the SHCP curricula.

This study does have limitations. Although participating schools were asked whether nutrition education was delivered to students to differentiate participants into the 2 groups, the researchers did not directly observe the education. Therefore, specific details of topics covered,

length of time dedicated, and pedagogical approaches are unknown. However, the probable variance in nutrition education between sites may indicate that the questionnaire is useful for assessing adolescent nutrition knowledge within a variety of programs.

Furthermore, the analyses conducted in this study may be limited. The time since completing nutrition education was not collected for the Nutrition Education group and could not be included in the linear regression. Inclusion was not limited to a certain period of time because finding high school-aged adolescents who received nutrition education was challenging. Thus, students were included though convenience sampling by the teacher's assurance that they had previously completed nutrition education. Data were also not collected to assess test-retest reliability to reduce participant burden and limit diverted classroom time. Although the Jones questionnaire[26] was found to have test-retest reliability, there is a possibility that it may not have been retained with the different age group. In addition, readability assessments were not performed, and therefore, although not apparent during questionnaire administration, unknown literacy challenges may have existed. Another potential limitation exists in the study sample. Individual-level demographic data were not collected from participants limiting the ability for assessing inferential statistics and comparing samples to the populations from which they were drawn. Although individual demographic data were not collected in this study, school-level data for the California schools suggest that participants were mostly Hispanic or Latino and of low to middle socioeconomic status. Although similar data were not publicly available for the Hawaii school, anecdotally, students attending the school were of Hawaiian ancestry and predominantly of low to middle socioeconomic status. This particular school offers reduced tuition costs due to support from endowments and provides scholarships to the majority of students. Although this questionnaire was tested with a diverse sample, future studies should retest the questionnaire for

validity and reliability in the appropriate target population if participant demographics vary greatly from this study.

Implications for Research and Practice

Although this nutrition knowledge questionnaire was tested for use in the subsequent intervention, this study adds to the literature, providing a questionnaire that can be used in other studies measuring nutrition knowledge in an adolescent population. The questionnaire was tested in a large and presumably diverse sample of adolescents with varying nutrition education, increasing its utility and likeliness of being employed in future studies without modification. The strength of the results inspires confidence in the ability of this tool to detect changes in nutrition knowledge using different educational strategies or interventions and offers an assessment for adolescents aged 13–18 years, which is an understudied age group in need of nutrition intervention. However, data to help understand the extent of external generalizability, such as participant-level demographics, were not collected in this study. The potential lack of wide generalizability should be considered when using the questionnaire in future studies.

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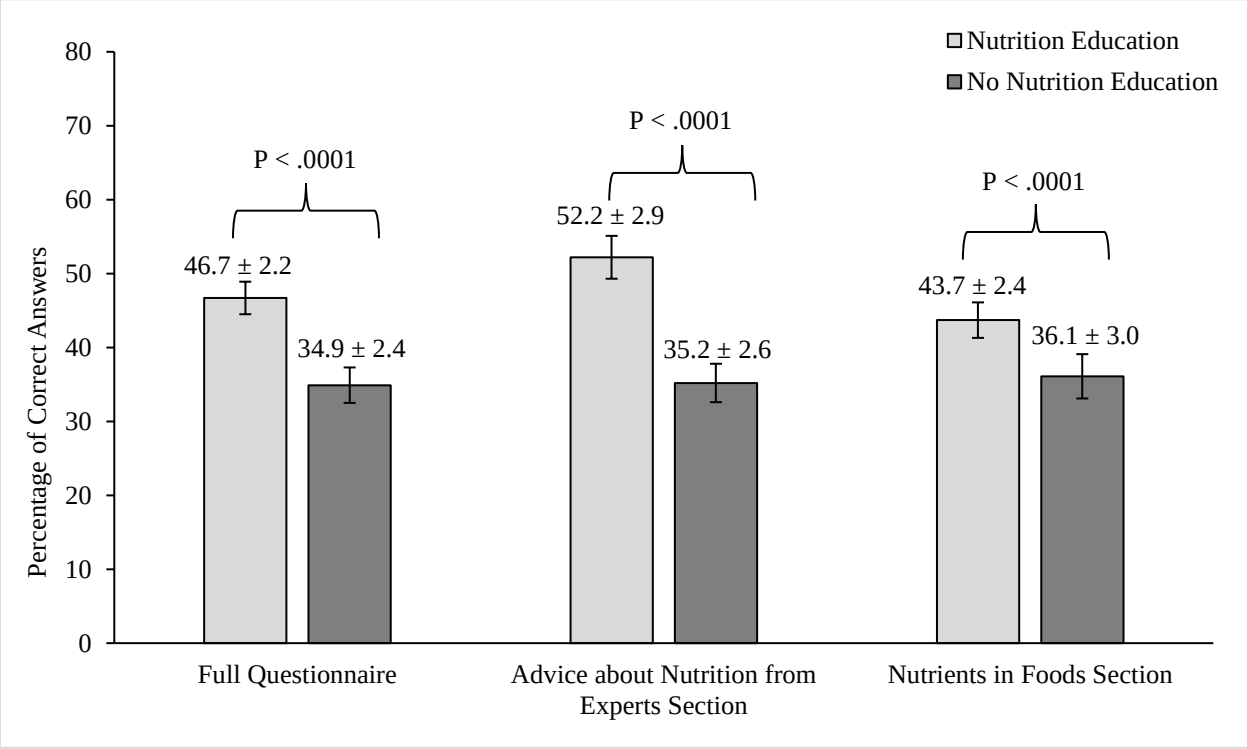
Table. Selected High School-Level Demographics for Participating Schools

Demographic	**School 1[a,b] Students (n = 70)**	**School 2[a,c] Students (n = 45)**	**School 3[a,c] Students (n = 17)**	**School 4[d,e] Students (n = 178)**
Location	California	California	California	Hawaii
Community	Suburban	Rural	Urban	Suburban
School Type	Public	Charter	Public	Private
Enrollment, no. of students	1,115	241	1,511	1,800
Ethnicity/Race (%)				
Hispanic or Latino of any race	52.5	53.1	78.5	NA
White, not Hispanic	37.9	35.7	0.9	NA
African American, not Hispanic	2.1	1.7	2.1	NA
Filipino, not Hispanic	1.8	0	6.8	NA
Asian, not Hispanic	0.8	4.1	9.7	NA
Other[f]	4.9	5.3	2.1	NA
Meal Eligibility (%)				
Free and reduced-price meal eligibility	44.1	99.6	89.3	NA

NA indicates not available.

[a]Data retrieved from the California Department of Education: Educational Demographics Unit[28]; [b]Data presented are for the 2016–2017 school year; [c]Data presented are for the 2017–2018 school year; [d]Data retrieved from the Hawaii Association of Independent Schools[29]; [e]Data presented are for the 2018–2019 school year; [f]Includes American Indian or Alaska Native, Pacific Islander, ≥2 races, and not reported.

Figure. Mean percentage of correct answers (mean ± 2 SEM) on the full nutrition knowledge questionnaire and both subsections for participants who had prior nutrition education (Nutrition Education; n = 174), and those who did not have known prior nutrition education (No Nutrition Education; n = 136)



CHAPTER 3

Lessons Learned: Implementing the Shaping Healthy Choices Program with Teenagers as Teachers

Introduction

Childhood and adolescent overweight and obesity is an epidemic in the United States with prevalence continuously increasing over the last 35 years.[1] As of 2016, 35.1% of youth aged 2 to 19 years were classified as overweight or obese, with an overweight rate of 16.6% and an obesity rate of 18.5%.[1] For youth, obesity tends to increase with age, as adolescents aged 12 to 19 years have the highest rates.[1] These rates are concerning because childhood obesity is associated with increased risk for adulthood chronic diseases.[2-5] One possible explanation for the elevated prevalence of obesity is that youth typically have poor overall diet quality.[6,7] This is further compounded by youth tending to not meet recommendations for fruit and vegetable consumption.[6,7] With this, one potential approach to reducing youth obesity is increasing fruit and vegetable consumption. It has been suggested that integrated comprehensive nutrition programs are most effective for improving youth health.[8]

One project aligned with youth obesity prevention tactics is the Shaping Healthy Choices Program (SHCP), which is a comprehensive, multi-component program aimed at improving youth nutrition and health outcomes.[9] The SHCP features garden-enhanced nutrition curricula[10,11] that were designed using social cognitive theory[12] and constructivism[13] as theoretical frameworks. The curricula feature lessons and cooking demonstrations that follow the 5-Step Experiential Learning Cycle[14,15] to educate youth about foods grown around the world, cardiovascular health, general nutrition, and consumerism.[10,11] In addition to nutrition education, the SHCP promotes youth well-being through school-wide efforts to increase fruit and vegetable consumption and establish school-site wellness committees.[9] The SHCP has been evaluated and was found to significantly improve youth body mass index percentiles; nutrition knowledge; physical activity behaviors; and vegetable availability, identification, and consumption in upper

elementary-aged youth.[16-18] These results were observed when the curricula were implemented with high fidelity.[19] Fidelity has been defined as "the extent to which the critical components of an intended program are present when that program is enacted."[20] Assessment of fidelity can be carried out utilizing a variety of methods and entails evaluation of both adherence to the intended program and competence of the facilitators.[21,22] It is important to assess fidelity in different interventions and programs to provide context for participant outcomes.[20,21,23-25]

The SHCP has shown success at improving youth health status. However, the program curricula have only been implemented using one method with trained adult educators delivering nutrition lessons in traditional classroom settings. To expand its reach, the SHCP should thus be implemented more broadly in out-of-school settings, such as within the 4-H Youth Development Program (4-H). The 4-H program is well-established nationwide and features enrichment programs and opportunities aimed at supporting child and adolescent development.[26] The 4-H program frequently delivers enrichment in a variety of subjects utilizing teenagers as cross-age teachers for younger youth. Cross-age teaching allows for teenagers to become specially trained to deliver a specific curriculum to youth typically 2 or 3 years younger than themselves.[27] It has been found that teenagers can be effective teachers when provided adequate resources and support.[28] To ensure the success of the teenagers-as-teachers model, Lee and Murdock[28] suggested that programs be designed including 10 essential elements:

- dedicated adults who support teenagers,
- active teenager recruitment,
- strong curriculum,
- initial teenager training,
- ongoing training and support,

- attention to details,
- recognition and reward,
- team building,
- setting teenagers up for success, and
- feedback and evaluation.

Cross-age teaching is not only beneficial for younger youth, but also provides educational, developmental, and emotional benefits for teenage teachers.[27,29-31] In nutrition education programs specifically, use of teenage teachers can be just as effective as—or in some regards even more effective than—adult educators.[32] Therefore, the objective of this study was to assess the feasibility of implementing the SHCP curricula in 4-H using a teenagers as cross-age teachers approach.

Methods

This project was conducted twice over 2 years starting in October 2016 and ending June 2018. Teenagers aged 14 to 18 years and younger youth ages 9 to 13 years were recruited from existing 4-H clubs, local schools, and other community-based programs in a rural Northern California community. For the 1st year, teenagers were trained in an initial 2-day, 10-hour training to become cross-age teachers. The 1st day of training included team building activities to help teenagers become acquainted with fellow teenage teachers; an introduction to youth developmental stages and learning styles; an overview of the SHCP curricula and intended pedagogical approach; and a brief demonstration of one lesson. The second day of training included a more in-depth demonstration of how to facilitate inquiry-based and experiential lessons using another lesson from the SHCP curricula. This type of modeling was provided only

at the initial training so that fidelity to the curricula given this amount of training could be assessed. The 2nd-year training was very similar, but also included returning teenage teachers modeling curricula lessons. The 1st implementation year was utilized for a feasibility study to determine whether teenagers could be effective facilitators for an adapted version of the SHCP. The 2nd implementation year was intended to determine whether the program could be sustained within the participating 4-H club.

Educational sessions with younger youth were held about twice per month for 6 months and met on Sunday afternoons for 90 minutes, as chosen by participants and their parents. Educational sessions were held at a local community center and nearby community garden. These spaces were chosen in an effort to connect youth with their community and increase civic engagement, which is purported to have beneficial effects on adolescent development.[33] The SHCP garden-enhanced nutrition curriculum *Discovering Healthy Choices*[11] was adapted for implementation in an out-of-school setting. The accompanying cooking demonstration-based curriculum *Cooking Up Healthy Choices*[10] was unmodified for this implementation. Teenage teachers volunteered to either lead or assist with facilitation prior to each educational session. Remaining teenage teachers not facilitating the lesson participated in the lesson activities as their own group separate from younger youth groups. Following lesson activities, 15 minutes were allotted for teenage teachers and project staff to complete both written and oral reflection-on-action discussions using a plus/delta format, as previously utilized by Linnell et al.[34] For these discussions, teenage teachers were openly prompted to describe features of the implementation that went well and should be continued for subsequent lessons (plus), as well as aspects of the facilitation needing improvement or modification for future lessons (delta). These discussions included addressing facilitator practices, implementation of lesson components, and participant

engagement. This time was also allocated for providing teenage teachers a brief overview of the next educational session and assigning lead and co-facilitators.

The intent of this study was to assess the feasibility of program implementation through collection of both quantitative and qualitative data for teenagers and younger youth during the first year of implementation to assess the impact of being an educator and being educated by a teenage teacher, respectively. Participant data collected and assessment tools utilized are detailed in Table 1. Nutrition knowledge was collected using age-appropriate, validated questionnaires both for teenagers[35] and younger youth.[36] Self-efficacy for teaching nutrition was measured using a questionnaire originally adapted by Linnell et al.,[34] which was updated to be specific to the SHCP and use the retrospective post-then-pre-test method.[37] A measure of civic responsibility was also collected from teenagers using the retrospective post-then-pre-test method and was measured using a reliable questionnaire developed as part of the 4-H Youth Development Program Healthy Living Measures.[38] Data on vegetable identification and preferences in younger youth were collected using an approach adapted from previous use[9,34] to include taste-testing of six vegetables and open-ended follow-up qualitative prompting in a one-on-one interview style. Dietary intake in teenagers was measured using an online automated multiple-pass 24-hour recall system.[39] Participant demographics were completed by participants' parents, following a method similar to Scherr et al.[9]

In addition to data collected from participants, previously developed structured observation sheets[34] were utilized during the first year to collect observations of lesson implementation (Supplemental material). Two trained observers—a graduate and undergraduate student—worked together and used the structured observation sheets at each educational session to measure program fidelity on a 0- to 2-point scale: 0 (*not implemented at all*) and 2

(*implemented completely as intended*) for each lesson and lesson component. Fidelity for each lesson was calculated by totaling the implementation points earned for the observed lesson and then converting the score to a percentage. Fidelity for each lesson component was calculated by averaging the scores received for that component across all observed lessons and then converting the average score into a percentage. The lesson components included opening questions; procedure; sharing, processing, generalizing; follow-up prompting; and concept discovery or introduction. *Opening questions* prime the participants for the *procedure*, wherein participants collaborate in small groups to complete structured learning activities.[15] The *sharing, processing, and generalizing* steps then allow participants to reflect on their experiences and analyze real-world application with the assistance of *follow-up prompting*. Lastly, with *concept discovery or introduction*, the facilitator ensures that key learning objectives have been met. Observers provided commentary to help provide context for lesson component fidelity score. Observations were collected only when there was enough time to complete the lesson as described in curriculum. Teenage teachers were made aware at the beginning of the study that fidelity observations would be collected throughout the project. However, due to the potential for direct observation to alter implementation fidelity,[21] specific fidelity scores were not shared with teenage teachers and observations were taken discreetly. Without disclosing specific scores, to limit the teenage teachers from feeling tested, fidelity to the lesson components was included by project staff in the reflection-on-action discussions mentioned previously. Along with project staff encouraging continuation of practices that resulted in adequate lesson component fidelity, suggestions for improving facilitation of lesson components implemented with inadequate fidelity were also included in discussion. Fidelity observations were not collected for cooking demonstrations due to teenagers' lack of proper food safety and cooking skills which required

adult intervention. This adult intervention thus invalidated any fidelity observations that would have been collected on the teenage teachers' ability to facilitate the cooking demonstrations.

All youth had to either already be enrolled in 4-H or enroll in 4-H to take part in the study. All procedures for this study were approved by the University of California, Davis Institutional Review Board.

Program

The model utilized in this study was developed using the 10 essential elements for successful teenagers-as-teachers programs identified by Lee and Murdock.[28] Table 2 outlines each of the 10 essential elements and indicates how this project met each one. A Cooperative Extension (CE) academic (titled advisor in California) who oversaw the project and facilitated the first day of teenager training provided adult support. Additionally, one CE staff member organized the logistics of the project and was present at each day of training and every educational session for both years. For the 1st year, a university researcher provided the 2nd day of teenager training and attended all educational sessions. The researcher also led the reflection-on-action discussions at the end of each educational session for the 1st year and trained the CE staff member to lead reflection discussions during the 2nd year. These reflection-on-action discussions provided ongoing support and additional team building for teenage teachers. The retrospective post-then-pre-test approach for self-efficacy and civic responsibility measurements also allowed teenagers an opportunity to reflect on their experience and provided personal evaluation.

Teenagers were actively recruited from local organizations and completed an initial training that included development of skills and an overview of the specific curricula to be taught. The curricula used in this project were very strong and included *Discovering Healthy*

Choices[11] and *Cooking Up Healthy Choices*,[10] which are research-tested and evidence-based curricula that feature several interactive lessons. The CE staff member provided attention to detail by organizing all project logistics and maintaining consistent communication with all youth and parents. Precautions were taken to ensure the safety of all youth, including adult intervention in cooking demonstrations and supervision during educational sessions. The location was within the youths' community and easily accessible. Participants and parents chose the meeting time, and dates were specifically picked to avoid scheduling conflicts with other 4-H activities. To recognize and reward participants, all youth received a reusable water bottle, commemorative 4-H pin, and certificate of completion for participating in the project. For teenage teachers, the annual 4-H registration fee ($40) was also paid and the CE staff member offered to write letters of recommendation for the teenage teachers upon request.

Results

All data shown are from the first implementation year. Although low participation was expected given that new 4-H projects in the implementation area traditionally have taken a few years to gain popularity, the sample sizes were lower than anticipated resulting in underpowered data analyses. Five teenagers (aged 14 to 15 years) were recruited and trained as cross-age teachers. One teenager dropped out of the project immediately following the initial training and another did not consent for data collection, leaving three teenage teachers included in data collection. Eight younger youth (aged 9 to 13 years) were recruited and consented to data collection. Additional recruitment measures beyond those previously mentioned were not taken as this method was standard procedure for the partner 4-H group and part of feasibility testing. As shown in Table 3, participant ages were evenly distributed and most participants were girls.

Participation and attendance were inconsistent for younger youth, with only five regularly attending educational sessions.

As previously mentioned, data were not collected for the second implementation year, as the primary focus for that year was on whether the program could continue without additional support. However, all participating teenage teachers from the 1st year returned in addition to two new teenage teachers, one of whom was a younger youth from the 1st year. Participation and attendance were again inconsistent for younger youth during the second implementation year, with only two of five consented youth regularly attending educational sessions. The other three younger youth during this phase joined half-way through the program implementation and did not provide demographic information.

Although a plethora of assessment data were collected, most could not be analyzed due to insufficient sample sizes and inconsistent attendance. However, positive youth outcomes resulting from participation in the SHCP have previously been observed with a program fidelity threshold of 80%.[19] For this project, the overall average program fidelity was 45%. Figure 1 shows fidelity for each lesson. Only Lesson 2.1 met the 80% fidelity goal, and it should be noted that this lesson was the lesson demonstrated in the in-depth 2nd-day facilitation training during the initial training. Lessons 3.1 and 7.1 were the next highest, but reached only 70% fidelity to the curriculum. All other lessons were facilitated with 60% or lower fidelity.

Regarding fidelity for each lesson component (Figure 2), procedure was the only component implemented at or above the 80% fidelity goal (84.6% average fidelity). Commentary for this component indicated that teenage teachers dedicated ample time for the procedure and followed the prescribed steps in the curriculum exactly. The time dedicated to the procedure deducted time from other components, and the low fidelity scores for the other components—

particularly follow-up prompting and concept discovery or introduction—was attributed to less time devoted to those components.

Discussion

The SHCP is traditionally implemented as a school-based intervention, but a goal at the time of its development was also for it to be implemented within 4-H. This project served as a feasibility study to determine whether the SHCP could be adapted and effectively implemented within 4-H with teenagers taking the role of cross-age teachers for younger youth. 4-H has a history of being predominantly Caucasian and has a goal to engage more diverse youth, which was a relative success with this project during the first year. Additionally, teenage teachers enjoyed participating in this project, as evidenced by all returning for the second implementation year, but lack of younger youth participation and attendance considerably affected the potential of this project and the results that could be presented. There were challenges with recruitment and retention due to youth participation in additional 4-H clubs and projects and a variety of other activities that took priority, so the sample size of this study was quite small. Because this limitation prevented collection of meaningful data on participant outcomes as well as analyses that could be completed, it limits generalizability of the results. Perhaps a new 4-H project of this nature would be better-suited to participants with fewer outside commitments and those new to 4-H. Additionally, the time and day, even though selected by parents and youth, seemed to limit regular attendance. Other 4-H projects involving nutrition that have been successful were implemented through existing after-school programs at elementary schools.[32,40,41] This allowed for the location to be convenient for participants and the timing to be advantageous to youth and parents.

Teenage teachers were able to deliver Lesson 2.1 with adequate fidelity (80%), however this was the lesson that was modeled for teenage teachers during the initial training, in which in-depth facilitation tips were also provided. Although overall fidelity was low, teenage teachers were able to effectively facilitate the procedure phase of the lessons with relatively high average fidelity (84.6%). This may be because the procedure portion includes step-by-step instructions for facilitation. Conversely, teenage teachers had the poorest fidelity for the follow-up prompting (23%) and the concept discovery or introduction (18.2%) phases. These two steps are the most challenging to facilitate, but also are important steps in experiential pedagogy to ensure that concepts are learned.[15]

Adequate fidelity is just one of the factors that can affect outcomes, with effective implementation generally being associated with better outcomes.[19,23] Fidelity does not have to be 100%, so there is room for adaptation,[20,22,23] but should be at least 80% for the SHCP given the curricula structure and previous findings.[19] The low fidelity observed in this project suggests that teenage teachers may not have been fully prepared to act as facilitators for all lessons and that additional facilitation training may improve future lesson delivery. Other studies of this nature have provided varying lengths of time allocated for the initial training ranging from 6 hours to several days.[30,32,41-43]

One curriculum designed to train teenage teachers that was developed for use in 4-H is Youth Advocates for Health (YA4-H!), which focuses on teaching professional development for teenagers.[42,44] YA4-H! can be purchased through 4-H and does not provide specific content knowledge for the program teenagers will be teaching, so it can be adapted for a variety of programs. The YA4-H! program has been widely used and shown to improve confidence, comfort, applicable skills, and perceived subject knowledge in trained teenage teachers.[42,45]

Along with insufficient facilitation training, it is hypothesized that a lack of content knowledge could have been a hindrance in the current project. Teenagers acted as cross-age teachers in another recent intervention that was designed similarly to the present study and included nutrition content training in addition to using YA4-H!.[30,45] This approach observed increases in reported nutrition knowledge and positive behaviors that were attributed to being successful in a teenage teacher role.[30,45] Although other approaches have been successful at implementing nutrition education programming utilizing teenagers as cross-age teachers, the same protocol may be insufficient for SHCP curricula because the content supersedes general nutrition.

Practitioners should consider measuring fidelity when implementing multi-component programming. Measuring fidelity for individual components of a program or curriculum implementation can be helpful in identifying possible explanations for unexpected outcomes, especially when implementing an existing program in a new context. Additionally, fidelity measurement of individual components allows for targeted training and improvement of practice over time.

Future Directions

The curricula of the SHCP are quite comprehensive and their implementation has been found to be most successful with adequately knowledgeable and confident educators.[34] Due to this, the SHCP has been implemented with the CalFresh Healthy Living, University of California Program using trained adult educators. The background content for each module of the SHCP curricula is fairly limited and may not provide enough depth for those that do not have ample content knowledge. Findings from the present study provide rationale and impetus for more extensive education and training for teenage teachers implementing the SHCP. The training

should incorporate more opportunities for teenage teachers to engage in lesson delivery and teacher skill-building as well as gaining applicable subject matter knowledge. Future directions include the development of a two-tiered, cross-age-teaching training model, wherein college undergraduate interns will be trained to educate teenagers in food literacy and cross-age teaching methodology. All education will be completed within existing after-school programs. College interns will use a newly developed curriculum, *Teens CAN: Comprehensive Food Literacy in Cooking, Agriculture, and Nutrition*.[46] *Teens CAN* differs in extent and content from other curricula in that it focuses on the food system as a whole, rather than gardening, and teaches cooking skills and food safety. Additionally, the curriculum also includes specific content on nutrition and nutrients of concern for adolescents. This approach will include a three-day training and provide background knowledge in an engaging way using modeling, role-playing, and reflection training to prepare for cross-age teaching. It is anticipated that knowledge gained from actively engaging in *Teens CAN* lessons, or another age-appropriate comprehensive nutrition curriculum, and more targeted training will allow future teenage teachers facilitating SHCP curricula to achieve higher fidelity.

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Table 1. Evaluation Tools and Metrics Collected From Participants During the 1st Implementation Year

Group	Metric	Number collected pre	Number collected post	Tool source(s)
Teenage teachers	Nutrition knowledge	3	3	Jones et al.[47]; Ruiz et al.[35]
	Self-efficacy for teaching nutrition	3	3	Linnell et al.[34]; Slattery[37]
	Civic responsibility	2	2	Furco et al.[38]
	Dietary intake	1	0	ASA24[39]
	Demographics	3	--	Scherr et al.[9]
Younger youth	Nutrition knowledge	7	7	Morris and Zidenberg-Cherr[36]
	Vegetable identification and preferences	6	4	Linnell et al.[34]; Scherr et al.[9]
	Demographics	8	--	Scherr et al.[9]

Table 2. Project Alignment With 10 Essential Elements for Successful Teenagers-as-Teachers Programs[28]

Essential element	Evidence in project
1. Dedicated adults	• Cooperative Extension academic • Cooperative Extension staff member • University researcher
2. Active recruitment	• Teenagers recruited from local high schools, other 4-H projects, and community organizations
3. Strong curriculum	• *Discovering Healthy Choices*[11] • *Cooking Up Healthy Choices*[10]
4. Initial training	• Two-day, ten-hour training • Team building, inquiry-based delivery of lessons, and overview of curricula
5. Ongoing training and support	• Reflection-on-action sessions using plus/delta format[34]
6. Attention to details	• Cooperative Extension staff member organized all project logistics • Adult intervention in cooking demonstrations • Water provided • Local and easily accessible location • Participants and parents chose meeting day and time • Dates were specifically picked to avoid scheduling conflicts with other 4-H activities
7. Recognition and reward	• Reusable water bottle, commemorative 4-H pin, and certificate of completion • Paid teenager annual 4-H registration • Letters of recommendation upon request
8. Team building	• Team building activities in the initial teenager training • Teenagers supported one another by acting as co-facilitators for lessons • Provided written and verbal feedback though reflection sessions

9. Setting teenagers up for success	• Teenagers praised upon completion of lessons • Reflection sessions always ended on something that went well • Time allocated to setup lesson and familiarize teenage teachers with lesson materials
10. Feedback and evaluation	• Feedback from the university researcher, Cooperative Extension staff member, and each other during the reflection sessions • Retrospective post-then-pre-test self-efficacy and civic engagement questionnaires

Table 3. First Year Participant Characteristics (n = 11)

Characteristic		Participants n (%)
Age (years)	9	2 (18.2)
	10	1 (9.1)
	11	3 (27.3)
	13	2 (18.2)
	14	1 (9.1)
	15	2 (18.2)
Sex	Girls	8 (72.7)
	Boys	3 (27.3)
Ethnicity/race	African-American/Black	2 (18.2)
	Caucasian/White	6 (54.5)
	Multiethnic	3 (27.3)
Household income	$59,999 or less	4 (36.4)
	$60,000 - $99,999	3 (27.3)
	$100,000 or more	4 (36.4)
Primary caregiver's education	Vocational/technical training or some college	4 (36.4)
	Associate's degree	5 (45.5)
	Bachelor's degree	1 (9.1)
	Postgraduate degree	1 (9.1)

Figure 1. First Year Fidelity to the *Discovering Healthy Choices*[11] Curriculum by Lesson

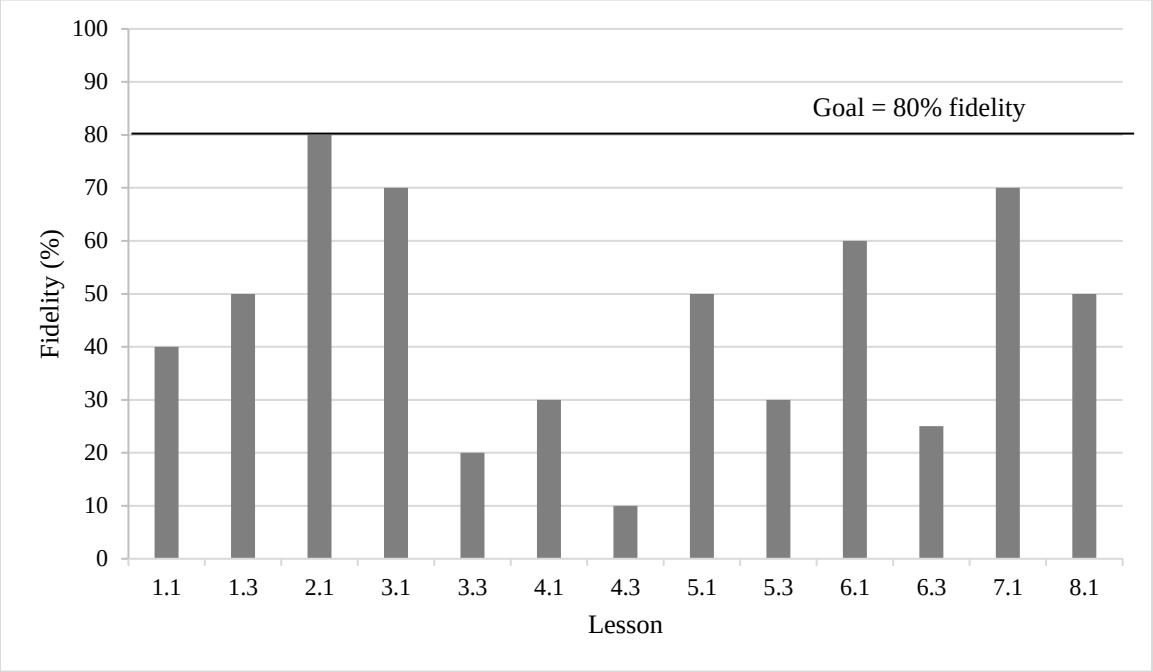
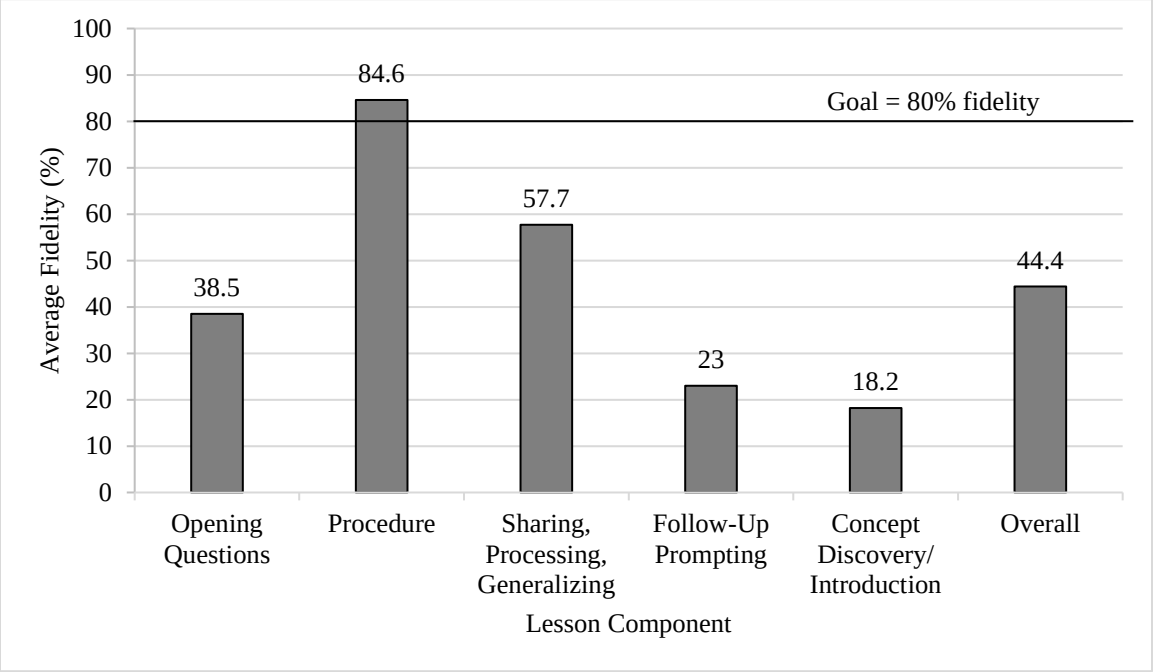


Figure 2. First Year Average Fidelity to the *Discovering Healthy Choices*[11] Curriculum by Lesson Component



Supplmenetal. Template Fidelity Observation Sheet

Observation Tool for Implementation of [Curriculum Name]

Observer_____**Educator**_____**Date**_____

Activity [#] – [Title]

Program Fidelity

Curriculum Session	Program Fidelity	Notes
Opening Questions Time started: Time ended:	Asked opening questions ❑ Did not do ❑ Partially delivered according to curriculum ❑ Fully delivered according to curriculum	
Procedure (Experiencing) Time started: Time ended:	Conducted [procedure] ❑ Did not do ❑ Partially delivered according to curriculum ❑ Fully delivered according to curriculum	
Sharing, Processing and Generalizing Time started: Time ended:	Youth shared and discussed their [product of the procedure] and what they learned ❑ Did not do ❑ Partially delivered according to curriculum ❑ Fully delivered according to curriculum Facilitator followed up with prompts ❑ Did not do ❑ Partially delivered according to curriculum ❑ Fully delivered according to curriculum	
Concept or Term Discovery/Introduction Time started: Time ended:	Concepts and terms such as [primary concepts] were discovered by the youth or introduced by the facilitator ❑ Did not do ❑ Partially delivered according to curriculum ❑ Fully delivered according to curriculum	

Adapted from Linnell and Smith

CHAPTER 4

Development and Pilot Testing of an Innovative Food Literacy Curriculum for High School-Aged Adolescents

Introduction

Obesity is a multifactorial disease that is challenging to treat, requiring several considerations and components encouraging behavioral modifications.[1] Adolescent obesity can have lasting consequences on health as it is associated with adulthood obesity and thus may affect long-term quality of life and lead to development of chronic diseases.[1-7] Prevalence of adolescent obesity has progressively increased over the last several years and adolescents consistently have the highest rates of obesity among youth.[8] In 2016, 1 in 5 adolescents were classified as obese, with prevalence of obesity highest in Hispanic and non-Hispanic Black adolescents with 25.9% and 25%, respectively.[8,9] These values were above the 20.6% average for adolescents aged 12-19 years and higher than that of non-Hispanic White youth within the same age group.[9] Providing guidance for healthy lifestyle choices may limit risk factors perpetuated by childhood obesity. Youth who reduce incidence of obesity mitigate the associated increased risk of adulthood chronic disease, instead exhibiting comparable risk to that of youth who were never obese.[4,5] This supports an urgent need to educate adolescents as they transition to experiencing more autonomy in food choices and other lifestyle behaviors that arise with emerging adulthood.[10]

Poor diet quality may contribute to the high prevalence of adolescent obesity.[3] Over 50% of youth had poor diet quality in 2016.[11] Youth are well below meeting dietary recommendations despite having quite high nutritional requirements to support a period of immense growth.[12-14] Diet quality progressively decreases as youth advance in age, with high school-aged adolescents having lower diet quality compared to youth of elementary school age.[11,15] In particular, adolescents aged 14-18 years do not meet recommendations for consumption of fruits, vegetables, and whole grains.[11,13,16] Adolescents in the lowest quartiles of intake for each food

group tend to continue having low levels of intake into adulthood.[16] Consistently and of particular concern, youth from low-income communities tend to have the poorest diet quality.[11,15]

While not the only consideration, poor diet quality of adolescents may be attenuated with advancement of food literacy.[17] Beyond the focus of traditional nutrition education, food literacy requires understanding of food procurement and preparation.[18,19] Food literacy involves having the knowledge and skills necessary to make healthy dietary choices and comprises 11 components within 4 domains[18] and 15 attributes within 5 categories.[19] Many nutrition education programs utilize some of these elements, however few incorporate all. Components of food literacy were extrapolated from surveying experts and young adults[18] and attributes were identified through a scoping review of the literature.[19] Food literacy components[18] are specific while attributes are more thematic.[19] For example, the component "determine what is in a food product, where it came from, how to store it and use it"[18] encompasses several attributes related to food selection and preparation.[19] These elements include both critical knowledge, such as understanding nutrition-related information, and functional knowledge, wherein application of knowledge through skills and choices is essential, that intersect to aid in developing and maintaining healthy food behaviors.[18-20] Education in one domain or category is not sufficient for achieving food literacy, instead scaffolding of knowledge and skills from the various topic areas is required.[19] A systematic and narrative review of food literacy programs for high school-aged adolescents found that interventions at least 4 weeks in length that included opportunities for advancement in knowledge and self-efficacy were most likely to affect short-term dietary behavior.[21] Additionally, several recommendations for implementing food literacy interventions have been identified.[22] Such recommendations include utilizing settings where adolescents normally congregate and engaging in weekly experiential activities that provide opportunities for

application of food-related knowledge and skills.[22] Furthermore, it is recommended to tailor the program approach to the specific age group being targeted and to provide opportunities that support positive youth development.[22] Despite the need, especially considering the high rates of obesity, food literacy programs targeting older adolescents are limited.[22,23] This dearth in food literacy programming prevents adolescents from gaining knowledge and skills needed to make healthy food choices as young adults and perpetuates unhealthy food practices observed during childhood.[10]

Previous findings from a study conducted within the 4-H Youth Development Program (4-H) found that adolescents did not have foundational knowledge to effectively lead garden-enhanced nutrition and cooking lessons.[24] Focus groups completed in Australia found that adolescents had some prior food-related knowledge from participation in year-long required courses, but had limited opportunities to apply that knowledge through food preparation.[25] Participants in the focus groups expressed an interest in increasing food literacy through home economics courses.[25] Home economics courses are increasingly rare in the United States and topics relevant to food literacy are often categorized into health courses. However, national Health Education Content Standards[26] include a plethora of topics that must be covered in one semester (the length of a typical health class in the United States) and thus completing food literacy education outside of the typical school day may be more feasible. Informal settings, such as afterschool programs, encourage the acquisition of knowledge through lifelong, life-wide, and life-deep learning, which incorporate the people, places, and culture that every individual brings to a learning environment, whether in or outside of a formal classroom.[27] This is especially helpful for learning concepts that directly impact learners' everyday lives and require synthesis of various prior experiences in conjunction with newly acquired information. Unlike traditional

classroom learning, which mostly applies to meeting objectives of school, such as completing exams and assignments, informal learning objectives can be directly applicable to knowledge needed for daily life activities.[28,29] With this, the objective of this project was to develop a comprehensive food literacy curriculum for high school-aged adolescents to be implemented through afterschool programs.

Methods

Curriculum Development

Developing curricula based on theories and recognizing needs of the target population are recommended for maximum efficacy.[30,31] Furthermore, curricula that focus on behavior change and skill development in addition to knowledge attainment tend to be more successful.[31-33] Therefore, Social Cognitive Theory[34] and Constructivism[35] were selected as theoretical frameworks while also considering the Social Ecological Model.[36] Social Cognitive Theory is widely utilized in nutrition interventions[31] and conceptualizes dietary change with consideration for the intersection of personal, environmental, and behavioral factors.[34] Constructivism functions through a community of learners engaged in active discourse, allowing for creating knowledge together with the goal of deep and sustained learning.[35] The Social Ecological Model[36] provided context for factors that affect food choices of adolescents at various levels including local access, peer influence, and preparation skills, among others. The food literacy curriculum was developed following systematic procedures previously utilized to design a garden-enhanced nutrition curriculum for a multicomponent school-based nutrition intervention called the Shaping Healthy Choices Program.[37,38] The process began with assembling a development team including three experts in the overarching topic areas, agriculture, nutrition,

and cooking, which were deemed necessary for development of food literacy through consolidation of the components[18] and attributes,[19] and 13 undergraduate interns. The experts collectively had extensive knowledge in curriculum development, nutrition, sustainable agriculture, food systems, garden-based education, recipe development, and cooking techniques.

To develop the curriculum with intention, Backward Design[39] was employed. The first step of Backward Design is to *identify desired results*,[39] which was implemented through determining concepts that youth should learn after participating in the curriculum lessons.[39] Interns were instructed to independently search for learning concepts by reviewing reputable resources, including peer-reviewed literature, government reports, and educational standards. Under supervision of the relevant content expert, learning concepts were grouped and consolidated into the three topic areas in addition to being reviewed for alignment with aspects of food literacy. This was proceeded by the second step of Backward Design, *determine acceptable evidence*,[39] which was employed to develop learning objectives guided by authentic assessment.[40] Authentic assessment accompanies Constructivism,[35] requiring a product or performance and encouraging collaboration while developing new knowledge that can be applied to other tasks.[40] The learning objectives were written in accordance with higher levels of Bloom's Taxonomy[41] to promote retention of knowledge and skills gained from participation in the lessons.

The final step of Backward Design is to *plan learning experience and instruction*.[39] Primary lessons were designed in accordance with the 5-Step Experiential Learning Cycle[42] and utilizing guided inquiry.[43] Experiential learning[44] was selected as the pedagogical approach to foster active learning through experience and development of skills within each lesson. Furthermore, lesson objectives were aligned so that knowledge and skills acquired during each

lesson could be applied to one another and built upon as lessons progressed. Experiential learning[44] complements constructs of Social Cognitive Theory[34] by drawing from previous experiences and encouraging learning from others participating in the experience while also building behavioral capacity and self-efficacy through achieving learning objectives. Each intern developed an experience to achieve each learning objective and facilitated their lesson with the larger group for initial feedback. Immediately following the lesson, all interns completed guided reflection documents[37,45] to facilitate constructive discussion of aspects that worked well and ones that needed improvement. Lessons were revised and implemented a second time following the same method with the full curriculum development team. Application components were also drafted to allow for learning opportunities within an agricultural space, such as a school garden, and for hands-on cooking opportunities. Additionally, home application lessons were created to extend content beyond the experience while also supporting growing and preparing food at home.

Pilot Testing

Prior to pilot testing with youth, the curriculum was reviewed by an expert committee. This committee included individuals with expertise in curriculum development and learner-centered pedagogy in addition to experts in the three topic areas. Nine members participated in the committee and were contacted based on known content knowledge and recommendations; most committee members were university and Cooperative Extension academics. Minor edits were made following the expert committee review to improve clarity and background information provided as a facilitator introduction to each lesson. No modifications were made to the lesson procedures at this time.

Pilot testing was conducted with high school-aged adolescents during afterschool hours in two low-income communities in Northern California. It was important to pilot test with representatives of the intended target audience to ensure that authentic assessments were challenging but achievable.[40,43] The first pilot took place in a suburban community at a community center in collaboration with two afterschool programs. Lessons were conducted at the community center and nearby community garden three days per week, over five weeks, to an average of 12 participants. The second pilot occurred at a high school during afterschool hours in a rural community. This pilot was delivered in the multipurpose room and school garden once a week, for 12 weeks, to an average of eight participants. Participation in both pilots was completely voluntary and concluded after all lessons were delivered. Participants of both pilots received home kits for hydroponically growing lettuce and basic cooking supplies. The curriculum lessons and application activities for both pilots were facilitated by an educator trained in learner-centered pedagogy who was not involved in the initial curriculum development. The principle author of the curriculum was also present at each pilot lesson to serve as an observer. Both the facilitator and observer completed observation sheets that were modified from the previous method[45] to include additional structure in accordance with each component of the 5-Step Experiential Learning Cycle.[42] Observations encompassed elements that worked well in helping participants achieve the predetermined authentic assessments for each lesson and areas requiring improvement. Additionally, comments regarding level of engagement, such as number of youth on-task and the proportion of youth actively completing lesson assignments, were included in the *procedure* and *sharing, processing,* and *generalizing* segments. The observation sheet also featured an open notes section where ideas for improvement could be documented. The facilitator and observer met the following day after each

lesson to compare observation sheets and come to a consensus on suggested lesson revisions. Following each completed pilot, informal group interviews were held with participants to gain qualitative insight into acceptability and enjoyment of the lessons. Revisions were made as needed and implemented at the subsequent pilot. Data were not collected from participants given that the objective of the pilot tests was to assess whether learning objectives were achieved for each lesson. Procedures for the pilot tests were approved as exempt by the University of California, Davis Institutional Review Board.

Results

The resulting curriculum is entitled *Teens CAN: Comprehensive Food Literacy in Cooking, Agriculture, and Nutrition* (*Teens CAN*). *Teens CAN* was developed to align with the components[18] and attributes[19] of food literacy in an effort to be as comprehensive as possible (Table 1). *Teens CAN* meets several California educational standards, in particular Next Generation Science Standards in regard to life and earth sciences,[46] Common Core State Standards for speaking and listening,[47] and many nutrition and physical activity Health Education Content Standards.[26]

Teens CAN started with 13 lessons, however, the first pilot test observations suggested combining two of the nutrition lessons for succinctness. While all learning concepts and objectives (Table 2) were retained, three lesson procedures were modified as the original procedures did not allow for achieving the identified authentic assessments and thus participants were unable to meet the learning objectives. Additionally, youth indicated feeling less engaged during these lessons compared to others. Insufficient time was initially dedicated to developing application activities, resulting in almost all being revised to better suit each lesson concept.

Following the second pilot, only additional minor edits to improve clarity throughout the curriculum were required. All participants of the second pilot were able to achieve the learning objectives through acceptable evidence of learning as detailed in Table 2. Further, observations indicated that youth were adequately engaged during the lessons. Results from the informal group interview suggested that youth enjoyed the learner-centered approach of the lessons. The final curriculum contains 12 modules, four within each topic area, that feature experiential and application lessons. The agriculture application activities allow for working within an agricultural space, whether a community or school garden, or another designated space for growing food. Each module can be completed within two hours and includes detailed background information and facilitation tips. While training in learner-centered pedagogy is recommended, and frequently provided for Cooperative Extension educators, these features allow for implementation with minimal experience. To accompany the curriculum, a guide for developing and maintaining an agricultural space was written and integrated into the introduction.

Agriculture lessons were designed to feature the food system, including different agricultural systems, inputs, and innovations that have contributed to establishing current practices. Aspects of urban agriculture were also incorporated, which comprises smaller-form farming in addition to community and school gardening. Agriculture applications for these lessons entail touring a local farm, or having a local producer visit the agricultural space to share information about their production and exploring inhabitants found in the agricultural space to investigate their impact on the growing environment. Another application involves working in the agricultural space with and without modern day equipment in order to understand how innovations within agriculture have shaped modern procedures. Home application activities

include interviewing individuals with roles in the food supply chain, learning more about insects and animals that are involved in agriculture, growing produce at home, and mapping out one's own neighborhood to assess food availability and access.

Nutrition lessons begin with practice categorizing foods into food groups, as defined by MyPlate,[48] and then move to identifying macronutrients and micronutrients and assessing overlaps with the food groups. The other nutrition lessons include learning how to meal plan with the nutrients of concern for underconsumption in adolescents[49] and analyzing nutrition messages in media. Agriculture application activities for nutrition lessons involve planning a snack using items grown in the agricultural space, testing soil quality, establishing a compost pile, and making sustainable pesticides using household products. Home application activities include meal planning utilizing recommendations for MyPlate[48] food group consumption and the nutrients of concern for underconsumption.[49] Additionally, home application activities entail assessing Nutrition Facts Labels on products found at home and analyzing a nutrition-related advertisement.

The first cooking lesson focuses on food safety, including proper handwashing and setting up a safe work space. Each subsequent lesson and culinary application activity begin with a reminder to wash hands that is followed with verification of practicing food safety throughout the experience. Other cooking lessons entail advancing knife skills and practice utilizing basic cooking techniques and equipment. Meal planning in accordance to shopping in season and within budgetary constraints is featured in cooking lessons as well. Recipes provided within the curriculum are vegetarian to limit food safety concerns regarding temperature and to introduce adolescents to plant-based protein sources. Use of produce grown in the agricultural space for the recipes is encouraged. Furthermore, all recipes were intentionally developed with low-cost

ingredients, including canned and frozen products, and regularly available food items as to not limit low-income communities from preparing the dishes. In addition to encouraging youth to make recipes, adapting as needed to meet family and cultural preferences, cooking home applications activities entail examining and avoiding potential food safety hazards at home. Additionally, home applications included meal planning utilizing seasonal produce and scaling recipes to feed their families.

Discussion

Teens CAN aims to improve food literacy, and consequently diet quality, of high school-aged adolescents, with the ultimate intent to reduce and prevent obesity. Being food literate requires the skills and knowledge necessary to grow, buy, and cook food while considering health, so that empowered individuals can make the healthier choice when given the option.[18,19] However, food literacy is a relatively emergent concept with accompanying limitations. While improvements in dietary outcomes have been observed in adolescent interventions aimed at improving attributes of food literacy,[17] long-term implications for diet quality and obesity prevalence are lacking.[21] Additionally, food literacy is a complex construct with multiple interrelated factors, making assessment of food literacy challenging.[19,21,50] As such, a comprehensive evaluation tool is yet to be developed for this age group.[19,50] Nevertheless, the potential of food literacy is worth exploring given that youth aware of food growing practices and regionality of produce are more likely to consume fruits and vegetables.[51] Additionally, studies have shown that youth are more likely to consume healthier diets when they are involved in the food preparation process.[52,53] This was observed during *Teens CAN* pilot testing as participants regularly harvested and sampled produce growing in their agricultural space.

Furthermore, youth who were apprehensive to taste new foods at the beginning were open to trying included recipes by the end.

The approach of *Teens CAN* includes three topic areas of agriculture, nutrition, and cooking with experiential and application lessons aimed at improving knowledge and skills related to healthy eating. *Teens CAN* is inexpensive to implement, requiring mostly printed materials provided within the curriculum and common school supplies. Also, recipes provided within the cooking lessons feature low-cost produce available year-round as well as shelf-stable items. The curriculum employs activities and concepts that require critical thinking from participants, which adolescents are capable of completing.[31] In addition to application activities that incorporate an agricultural space, each module includes home application activities to nurture further learning. These activities additionally provide opportunity for appropriate adaptions, such as those for cultural considerations, to make adoption of new practices more viable.

Teens CAN was designed and tested following a similar approach to *Discovering Healthy Choices*[54] for the Shaping Healthy Choices Program, which has similar theming and includes some food literacy components.[18,37,38] The Shaping Healthy Choices Program has shown improvements in nutrition knowledge and weight status among other healthy behaviors.[55-57] Similar agriculture concepts to that of *Teens CAN*, such as components of the food system and food security, were included in another curriculum, *Sprouting Healthy Kids*, designed for middle school students in Texas, that was found to improve participant fruit and vegetable intake.[58]

As *Teens CAN* is aimed at improving food literacy of high school-aged adolescents, findings from focus groups where adolescents ranked aspects of food literacy according to importance strongly influenced lesson concepts.[25] Adolescents ranked food and nutrition

knowledge among the most important aspects of food literacy for them to develop healthy eating patterns.[25] Focus groups identified that adolescents did not pay attention to food labels or dietary guidance due to not understanding their application.[25] With this, use of Nutrition Facts Labels and recognizing nutrients of concern, as identified within the Dietary Guidelines for Americans,[49] were focused on in the *Teens CAN* nutrition lessons. The Dietary Guidelines for Americans recommends consuming healthy eating patterns with adequate intake of essential nutrients through a varied diet that incorporates each food group.[49] Though the curriculum was written to align with the 2015-2020 Dietary Guidelines for Americans,[49] recommendations for adolescents did not substantially change with the newest edition.[59] Food cards within nutrition lessons included foods typically considered unhealthy and high in empty calories since adolescents frequently consume these foods,[13] as well as healthy alternatives to allow for comparison. Additionally, whole fruits, vegetables, and grains were heavily featured to encourage consumption as adolescents are well below meeting recommendations for these foods.[11,13,16] With adolescence being a time of increased autonomy,[14] all primary nutrition lessons and application activities were written to support adolescents planning for meeting their own nutritional needs. Furthermore, to tailor lessons to adolescents, all characters presented in lesson activities were high school-aged adolescents.

Culinary skills education has been called to be incorporated into nutrition education for application of concepts through hands-on food preparation.[60] While adolescents from the previously mentioned focus groups ranked food preparation skills as of low importance,[25] other findings suggest that limited opportunities for hands-on food skills practice are a hindrance leading to low food literacy as young adults.[10] Due to this, primary learning concepts involved enhancement of food skills and opportunities to prepare food. Adolescents also acknowledged

that while budgeting and shopping for food were not immediately important in their current life stage, these concepts would be later in life.[25] With this, budgeting and shopping for food was added as one of the cooking lesson concepts.

Cooking programs provide an enjoyable experience that introduces youth to preparing and tasting dishes containing new, frequently healthier, foods.[61,62] Culinary application activities in *Teens CAN* feature cultural cuisines, advise consumption of produce grown in the agricultural space, and allow opportunities for participants to have independence in ingredient selection. Participation in cooking programs also motivates youth to continue practicing learned food skills at home,[61] which has been associated with more nutritious eating patterns.[60] Adolescents who participate in food preparation at home are more likely to continue enjoying cooking and preparing healthier dishes as emerging adults.[63]

The application activities integrated in *Teens CAN* may indirectly improve adolescent health as community gardening experience was found to be positively associated with willingness to try fruits and vegetables in low-income high school students from an urban community.[64] Additionally, participating in farm to school related activities has been associated with willingness to try fruits and vegetables in addition to improving nutrition knowledge and self-efficacy.[65] Providing opportunities for involvement in agriculture, even if just through gardening, is important given that childhood, in combination with recent, gardening for first-year college students was found to be associated with higher fruit and vegetable consumption compared to those who have never gardened.[66] *Teens CAN* lessons introduce adolescents to agriculture concepts and encourages growing food at home through application activities. This could perhaps establish a mechanism for adolescents to continue gardening into later adolescence and adulthood.

Teens CAN has since been translated into Spanish. Having the curriculum available in Spanish helps reach more participants as almost 40% of the population in California is of Hispanic descent.[67] This allows for the curriculum to be utilized for development of language education, such as district-level programs that encourage multilingualism. Additionally, the materials allow for adolescents to engage Spanish-speaking family members with the home application materials.

Planned implementation of *Teens CAN* was designed to align with recommendations for older adolescent food literacy programs.[22] For example, *Teens CAN* may be incorporated into classroom instruction, but was conceived with the intention of being employed within existing afterschool and youth development programs over twelve weeks. Each of the twelve modules feature experiential learning activities intended to cultivate teamwork, which is important for afterschool educational programs,[68] and build knowledge, skills, and self-efficacy associated with food literacy. With *Teens CAN* primarily intended for low-income adolescents, facilitating the curriculum within afterschool programs is particularly important for introducing youth to science-based programming applicable to daily living that they otherwise would not be permitted to access.[69-71]

Another recommendation for food literacy programming is to include peer-modeling.[22] One reason for developing *Teens CAN* was to create a curriculum to be applied in training teen teachers. A study implementing the Shaping Healthy Choices Program curricula within 4-H found that teen teachers were inadequate at facilitating the curricula with satisfactory program fidelity.[24] It was postulated that teen teachers required additional training, especially in regard to curricula content, before they could be competent facilitators.[24] Following participation in Teen CAN lessons, it is anticipated that adolescents will have improvements in relevant knowledge

and skills that will enable them to effectively facilitate food literacy programming with younger youth.

Adolescents acting as teachers for younger youth, known as cross-age teaching, is a common practice within 4-H. Cross-age teaching can be beneficial for adolescents as it reinforces learning concepts for themselves in addition to building confidence in teaching.[72] In contrast to tutoring, cross-age teaching involves specific training for the teen teachers who then facilitate lessons from a given curriculum over time to a group of younger youth.[73] In particular, cooking education has been successful in a cross-age teaching model.[60,74] Cross-age teaching perpetuates observational learning and can thus improve self-efficacy for various skills, including those valuable for food preparation.[34,60,74] Additionally, these programs allow opportunities for team building and improve peer relationships[62] while also encouraging implementation of cooking skills for younger youth at home.[74] A long-term nutrition and gardening program utilizing teen teachers for elementary-aged youth provides an excellent example and highlights the scalability of a program of this nature.[75,76] Applying this model employs adolescents that are culturally competent being from the same community and living within the same contexts as the younger youth they are teaching.[76]

Adolescents have been found to be as effective, if not more effective than adult educators.[77] Cross-age teaching programs provide opportunities for community service for teen teachers in addition to opportunities for improving the health and self-efficacy of participants, whether teaching or learning, and increasing opportunities for introducing food literacy concepts to youth.[72,75,76,78,79] Beyond food literacy-related constructs, cross-age teaching is also beneficial for developing leadership, critical thinking, and problem-solving skills that are essential as adolescents mature.[80,81] Educational opportunities to advance food literacy in adolescents may

encourage healthy eating and have long-term implications for preventing obesity. These programs may be further strengthened by utilization of cross-age teaching to improve knowledge retention while also granting soft skill development in addition to improving the health of all involved.

A major limitation of this project was the inability to assess the impact of participating in *Teens CAN* lessons on dietary behavior of adolescents. A pilot to assess *Teens CAN* implementation employing a two-tiered cross-age teaching model was started just before the COVID-19 pandemic. This model included undergraduate students trained in learner-centered pedagogy to facilitate lessons with high school-aged adolescents in afterschool programs and subsequently, adolescents were to be mentored and trained by the undergraduate students to teach local elementary school-aged youth using garden-enhanced nutrition curricula. As this study was halted early on, it will be resumed when safe and allowable. This study will include multiple data collection timepoints to assess whether adolescents have improvements in food literacy relevant constructs, such as nutrition knowledge and cooking skills self-efficacy, after participation in *Teens CAN* lessons and whether outcomes are further enhanced after acting as teachers for youth. Additionally, anthropometrics and dietary intake data will be collected from both adolescents and younger youth throughout the school year. These data will provide valuable input on the effectiveness of *Teens CAN* individually and when integrated into a yearlong mentoring program.

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Table 1. Food Literacy Attributes[19] and Components[18] by Topic Area in *Teens CAN*

Lesson Topic	Attributes	Components
Agriculture	• "Food and other systems" • "Food attitude" • "Food knowledge" • "Food self-efficacy" • "Infrastructure and population-level determinants" • "Socio-cultural influences and eating practices"	• "Access food through multiple sources and know the advantages and disadvantages of these" • "Determine what is in a food product, where it came from, how to store it and use it"
Nutrition	• "Dietary behavior" • "Food attitude" • "Nutrition knowledge" • "Nutrition language" • "Nutrition literacy" • "Nutrition self-efficacy" • "Socio-cultural influences and eating practices"	• "Demonstrate self-awareness of the need to personally balance food intake" • "Determine what is in a food product, where it came from, how to store it and use it" • "Judge the quality of food" • "Understand food has an impact on personal wellbeing"
Cooking	• "Cooking self-efficacy" • "Food attitude" • "Food knowledge" • "Food language" • "Food techniques" • "Food self-efficacy" • "Food skills across the lifespan" • "Socio-cultural influences and eating practices"	• "Apply basic principles of safe food hygiene and handling" • "Determine what is in a food product, where it came from, how to store it and use it" • "Make a good tasting meal from whatever food is available" • "Make feasible food decisions which balance food needs with available resources" • "Join in and eat in a social way"

		• "Plan food intake so that food can be regularly accessed through some source, irrespective of changes in circumstances or environment" • "Prioritize money and time for food"

Table 2. Learning Concepts and Objectives for *Teens CAN*

Lesson	**Learning Concepts**	**Learning Objective (Youth will be able to…)**	**Evidence of Learning (Youth were able to…)**
Agriculture 1	Food supply chain	Organize components of the food supply chain	Complete a complex flowchart detailing steps of the food supply chain
Agriculture 2	Agricultural systems	Compare and contrast various agricultural systems	Present details of four different agricultural systems and discuss their similarities and differences
Agriculture 3	Agroecology Technology	Assemble a timeline of the various movements and advancements that have shaped the food system today	Organize various food system innovations in chronological order and utilize them as inspiration to describe potential solutions for agricultural hazards
Agriculture 4	Food availability Food access	Investigate deficits that exist in some food systems and ways to improve those deficits	Build and renovate mock neighborhoods to improve the food environment
Nutrition 1	MyPlate Food groups	Evaluate why consuming a variety of foods is needed to help an individual meet their daily food group recommendations	Assess typical eating patterns of four fictional adolescents for whether food group recommendations were met and make suggestions for better adherence to recommendations
Nutrition 2	Macronutrients Micronutrients	Investigate which foods are good sources of different macronutrients and micronutrients utilizing the information provided on a Nutrition Facts Label	Analyze various foods, each containing a Nutrition Facts Label, for nutrients either meeting or exceeding 10% daily value
Nutrition 3	Nutrients of	Evaluate why consuming a	Create realistic meal plans for fictional

	concern for underconsumption	variety of foods is needed to meet recommendations for nutrients of concern	adolescents, each with a particular dietary restriction, to include recommended nutrients of concern for underconsumption
Nutrition 4	Nutrition in media	Analyze nutrition claims in the media and critique misleading information	Discuss marketing strategies being utilized in a health advertisement and use those strategies to create a factual nutrition advertisement
Cooking 1	Food safety	Identify and avoid potential food safety hazards	Correct improper food handling practices through a charades-type game and demonstrate proper food safety techniques
Cooking 2	Cooking equipment Cooking techniques	Demonstrate proper utilization of various cooking techniques and equipment	Prepare a multi-step recipe using appropriate cooking supplies and methods
Cooking 3	Seasonality Budgeting	Plan meal options that incorporate budgetary needs and seasonal produce	Draft a grocery list, adhere to a budget, and complete food shopping for four people in a mock grocery store
Cooking 4	Recipe scaling Serving and portion sizing	Plan a meal and calculate the cost per serving of that meal	Make an individualized meal and complete a guided worksheet to calculate its cost

CHAPTER 5

Discussion

The work included in this dissertation aimed to create a program to support the development of food literacy for high school-aged adolescents while also empowering youth through increased life skills. This consisted of creating an age-appropriate measure for nutrition knowledge, given that one did not previously exist.[1] Additionally, a study was conducted to test the effectiveness of a cross-age teaching method for optimizing benefit to youth facilitating, in addition to those participating in, garden-enhanced nutrition lessons.[2] Finally, a curriculum specifically tailored to high school-aged adolescents was developed utilizing Backward Design[3] and incorporated the components[4] and attributes[5] of food literacy. As this type of educational content for high school-aged adolescents is limited,[6] much of this work was exploratory in nature and required feasibility testing. This approach resulted in carefully considered elements that maximize the benefits of working with youth in this life stage. Adolescence is a time of increased nutritional need compared to most other times in youth.[7] Yet, adolescents in the U.S. tend to have poor overall diet quality,[8] do not consume recommended amounts of fruits and vegetables,[9] and have elevated prevalence of obesity.[10] Taken together, these circumstances put adolescents at increased risk for chronic diseases and suggests a need for intervention, particularly in underserved communities.[11,12] If executed as designed, the program described in this dissertation has the potential to impart valuable life skills that allow high school-aged adolescents to make the healthiest choice when given the option.

The approach in this dissertation was to measure components of food literacy,[4] as opposed to measuring food literacy as a whole, given that a comprehensive measure for food literacy has yet to be established. However, a recent publication indicated the start of foundational work for questionnaire development and thus a comprehensive food literacy assessment tool is in the process of being created.[13] Nutrition knowledge was focused on for the

work of this dissertation due to its implications for achieving a healthful dietary pattern.[14,15] Additionally, a rigorous measure for adults in the same geographical region as the intended adolescent intervention already existed and could be used as a starting point.[16] While there were questionnaires for adolescents in other countries, the questionnaire resulting from the work presented here was the first in the U.S. for high school-aged adolescents.[1] The final questionnaire, and its independent subsections, was shown to be valid and reliable for measuring general nutrition knowledge of adolescents aged 13-18 years.[1]

Given the potential for adolescents to have increased knowledge retention,[17] a cross-age teaching approach was tested using existing curricula from a well-established program. For this study, curricula from the Shaping Healthy Choices Program (SHCP) were utilized as they have been rigorously developed[18] and the program has shown promise in reducing childhood obesity and improving nutrition-related outcomes in youth.[19-22] Fidelity to the program, indicating the degree to which steps were implemented as intended, was the main outcome of interest to assess how well adolescents could facilitate the curricula as cross-age teachers. Detailed observations showed a lack of overall program fidelity,[23] however, adolescents were able to implement the lesson procedure component with adequate fidelity.[2] This implies that while adolescents were not able to facilitate participant synthetization of concepts to ensure lesson objectives were met, they were able to effectively guide participants through lesson activity steps. These results suggest the potential feasibility for employing a cross-age teaching model, but also show that adolescents require additional training to be competent facilitators for experiential garden-enhanced nutrition education.[2]

Cross-age teaching was explored as a delivery option for the food literacy program because of the implications for improving knowledge and skills of adolescents while also

improving younger youth outcomes.[24-28] Additionally, cross-age teaching has been shown to improve adolescent leadership and social skills.[24,25,28-31] The 4-H Youth Development Program (4-H) was a natural partner for the aforementioned study given its encouragement of and clear guidance for employing a "Teens as Teacher" approach to youth development programming.[17,32] One program utilized this method in a successful and scalable 4-H nutrition education intervention.[31,33] This program was implemented over several years and featured teenage youth from the same community teaching garden-based nutrition and physical activity lessons to elementary school-aged youth.[31,33] Results from assessment of the program showed improvements in youth health-related preferences and increased self-efficacy for health behaviors in teenage teachers.[33]

In response to the need for additional content training identified in the cross-age teaching study,[2] a food literacy curriculum for high school-aged adolescents titled, *Teens CAN: Comprehensive Food Literacy in Cooking, Agriculture, and Nutrition* (*Teens CAN*), was developed. Effective curriculum development and testing follow iterative processes with each step requiring sufficient time and verification before progressing to the next phase. *Teens CAN* was developed following Backward Design[3] and features Social Cognitive Theory[34] and Constructivism[35] as theoretical underpinnings. After months of initial development of learning objectives and activities, the curriculum was pilot tested in two underserved communities in California. Results from pilot testing suggested rewriting two lesson procedures and making refinements for clarity throughout. The resulting curriculum includes twelve modules, each with experiential lessons and application activities, within the main topic areas of agriculture, nutrition, and cooking. This process was essential to the overall program given that this curriculum is the first of its kind. Food literacy as a succinct concept is relatively recent,[4,5]

making it a fairly novel topic for curricula. Furthermore, curricula aimed at older adolescents are less common given the perceived and actual difficulties for program recruitment and retention.[36,37]

While it is essential to have strong curricula, it is only one aspect of well-designed health programs for underserved communities.[38] A feasible and sustainable implementation plan is also required. One way to improve program feasibility is to make considerations for the target participants. In addition to ensuring age-appropriateness, language accessibility should also considered. With the majority of participants for this program being from Hispanic backgrounds, and many English language learners, *Teens CAN* and the nutrition knowledge questionnaire has been translated into Spanish. This was done to increase comfortability in engaging with program materials and to not limit participation due to a language barrier. This feature also aids in sustainability as the program can function as a resource for immersion schools and can be utilized by community-based programs throughout the state, such as the University of California Cooperative Extension. Additionally to aid in sustainability, the next step of this dissertation was to build on the previous study with 4-H[2] and test a two-tiered cross-age teaching model going forward. The intention of this approach was to train undergraduate student interns in learner-centered pedagogical delivery of *Teens CAN* lessons. Utilizing college students within this type of programming has been suggested given their usual closer proximity in age to high school-aged participants and likeliness to effectively complete program components.[39] After college students implemented *Teens CAN* with adolescents, they would then transition into a mentorship role to provide training, similar to their own, for adolescents to have self-efficacy for teaching elementary school-aged youth within their communities using the SHCP curricula.

While our model would have been the first of its kind, to our knowledge, for delivering food literacy programming, other health interventions have used a similar approach. The B'More Healthy Communities for Kids (BHCK) program has utilized college and high school students for providing nutrition education for youth in several low-income Baltimore communities.[28,36,39,40] This program includes several components to make systematic changes to the food environment in addition to offering nutrition education at local recreation centers.[40] The theoretical frameworks employed in the BHCK are similar to those utilized in the development of *Teens CAN*.[40] Additionally, the extensive training for educators, with a 12-hour initial training followed by regular additional training sessions, is similar to the planned training for the two-tiered model.[36,39] However, while BHCK did include both college and high school student educators, they were employed in two separate waves and were not implemented as a two-tiered approach.[28]

A two-tiered cross-age teaching model similar to the one intended here, in that it utilizes volunteer college students teaching high school students who in turn educate younger youth, has been utilized for over a decade in an Australian health education program.[41,42] The program, the Students As LifeStyle Activists (SALSA), aims to improve healthy eating and physical activity practices.[42] The SALSA program is based on Social Cognitive Theory,[34] features activity-based educational sessions, and is a cost-effective approach that has shown improvements in healthy behavioral outcomes for each age group.[41-43] The program features professionals training the college students and provides opportunities for role-playing with peers in order to gain feedback on facilitation practices.[43] As with BHCK, SALSA is also supported and sustained through partnerships with several community members, including those at the governmental level.[40-42] This is a key factor in the success of both programs and was a future goal of the two-tiered cross-

age teaching program in this dissertation to establish long-term partnerships with community stakeholders and local agencies. To support this goal, an advisory board consisting of school administrators, education specialists, and community program coordinators was established and consulted to inform critical programmatic steps and best practices.

The implementation and assessment of the two-tiered cross-age teaching model had begun in two underserved communities through established partnerships and afterschool programs in California. Twelve undergraduate interns were recruited at two universities and trained together at a workshop lead by experts in experiential learning and food literacy. The interactive workshop included role-playing to train interns in learner-centered pedagogy and reflective feedback methods through Community of Practice. At the beginning of the 2019-2020 academic year, interns began facilitating *Teens CAN* lessons with high school-aged adolescents. Unfortunately, the COVID-19 pandemic halted this study from being completed. Program fidelity was intended to be collected during each phase in an implementation science approach to assess how well each group facilitated the curricula.[44] The data that could be collected in the shortened timeframe suggested that undergraduate interns were able to facilitate *Teens CAN* with high fidelity and completed most implementation steps as intended. The remainder of the 2019-2020 school year was utilized for professional development activities for undergraduate interns given that the pandemic timeline was unknown at the time. No further activities were completed with youth.

Moving beyond the limitations of the pandemic, the research team designed a virtual internship for a new cohort of undergraduate interns for the 2020-2021 school year. The internship includes similar training to that completed during the in-person program and involves interns creating online activities to accompany *Teens CAN* modules. Similar adaptions have been

made with traditionally face-to-face programs at the college level.[45,46] Considerations have been made to offer comparable training experiences through virtual means. While not the original intention for the program, this adaption will provide online food literacy activities that can be executed in combination with the rest of *Teens CAN* in the future or can be implemented individually if virtual learning is required again in the future.

Although the two-tiered cross-age teaching model was unable to be tested, the program components and assessment tool described within this dissertation provide a promising approach for advancing food literacy of high school-aged adolescents. Additionally, the constituents of this work have utility beyond the intended food literacy program. The questionnaire can be utilized for assessing general nutrition knowledge of high school-aged adolescents within food literacy programming, as well as any other health-related intervention. Furthermore, lessons learned from the study within 4-H are applicable to other nutrition education programs employing cross-age teaching. While the *Teens CAN* curriculum was borne out of an identified need from the 4-H study, it has application beyond training for cross-age teachers and can be integrated into established traditional or informal education.

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APPENDIX

Nutrition Knowledge Questionnaire for High School-Aged Adolescents

This questionnaire is so we can get an idea how familiar people are with nutrition. This is a survey, not a test. Your answers will help us identify what nutrition advice people find confusing. For each question, please use a pen or pencil to mark an ☒ or ☑ for the answer that fits you best.

- **It is important that you complete it without the help of others.**
- **If you don't know the answer, please mark "not sure" rather than guess or look up the answer.**

These next items are about what advice about nutrition you think experts are giving.
(Please choose only one answer for each.)

1. **Which <u>one</u> of these is the current government food guide?**

☐ 

☐ 

☐ 

☐ Not sure

2. **How well would you say you know the government's food guide, called MyPlate?**
   - ☐ Never heard of it
   - ☐ Heard of, but know very little about it
   - ☐ Know some about it
   - ☐ Know a lot about it

3. **How much would you say you know about whole grains?**
   - ☐ Never heard of them
   - ☐ Heard of, but know very little about them
   - ☐ Know some about them
   - ☐ Know a lot about them

4. **As far as you know, what are whole grains?**
   - ☐ Grains that still have the bran and germ
   - ☐ Milled grains
   - ☐ Anything with added fiber
   - ☐ Refined flour
   - ☐ Not sure

5. **Based on what you know, which of these isn't usually a whole grain?**
   - ☐ Popcorn
   - ☐ Oatmeal
   - ☐ Flour tortillas
   - ☐ Brown rice
   - ☐ Not sure

6. **Based on what you know, grains are an important source of...**
   - ☐ Vitamin D
   - ☐ Vitamin K
   - ☐ B vitamins
   - ☐ Vitamin C
   - ☐ Not sure

7. **As far as you know, which of these should you look for on a label to tell if a loaf of bread is whole wheat?**
   - ☐ 100% wheat
   - ☐ Stone-ground wheat
   - ☐ Cracked wheat
   - ☐ Whole wheat is first in the ingredient list
   - ☐ Not sure

8. **As far as you know, what amount of cooked vegetables is generally considered a serving?**
   - ☐ ¼ cup
   - ☐ ½ cup
   - ☐ 1 cup
   - ☐ 2 cups
   - ☐ Not sure

9. **Based on what you know, what is the amount of vegetables MyPlate (the government's food guide) recommends an adult should eat?**
   - ☐ 1 to 2 cups each day
   - ☐ 2 to 3 cups each day
   - ☐ 6 to 7 cups each day
   - ☐ 5 to 6 cups each week
   - ☐ Not sure

10. **Based on what you know, why does MyPlate (the government's food guide) recommend people eat a variety of vegetables?**
    - ☐ To increase protein intake
    - ☐ Helps you get all your nutrients
    - ☐ It's better for the environment
    - ☐ To save money
    - ☐ Not sure

11. As far as you know, what is the amount of fruit MyPlate recommends an adult should eat?

- ☐ 1 ½ to 2 cups each day
- ☐ 2 to 3 cups each day
- ☐ 5 cups each day
- ☐ 4 to 5 cups each week
- ☐ Not sure

12. Based on what you know, fruit is an important source of which of these nutrients?

- ☐ Protein
- ☐ Vitamin C
- ☐ Calcium
- ☐ Vitamin B12
- ☐ Not sure

13. Based on what you know, what type of dairy (milk, cheese, yogurt, etc) does MyPlate recommend?

- ☐ None
- ☐ Whole milk
- ☐ Low fat and fat free
- ☐ A mix of low fat and full fat
- ☐ Not sure

14. Based on what you know, which of the following are some calcium-rich alternatives to milk?

- ☐ Calcium-fortified juice
- ☐ Canned fish with bones (such as sardines)
- ☐ Kale and collard greens
- ☐ All of the above
- ☐ Not sure

15. Why do you think MyPlate recommends eating low-fat and lean meat and poultry?

- ☐ They have more vitamins
- ☐ To keep saturated fat low
- ☐ To save money
- ☐ They have more fiber
- ☐ Not sure

16. Based on what you know, which of these is a safe way to defrost meat?

- ☐ On the kitchen counter
- ☐ In a bowl of hot water
- ☐ In the oven
- ☐ In the refrigerator
- ☐ Not sure

17. Do you agree that some foods can be high in fat but not cholesterol?

- ☐ Agree
- ☐ Disagree
- ☐ Not sure

18. How would you rate the healthfulness of each of the following types of fat?

	Healthy	*Un-healthy*	*Not sure*
a. Polyunsaturated fats	☐	☐	☐
b. Monounsaturated fats	☐	☐	☐
c. Saturated fats	☐	☐	☐
d. Omega-3 fats	☐	☐	☐
e. *Trans* fats	☐	☐	☐

19. As far as you know, how are oils like olive and canola oil different from solid fats like butter and shortening?

- ☐ Oils are usually lower in saturated fat
- ☐ Oils raise LDL (bad) cholesterol
- ☐ Oils are usually higher in saturated fat
- ☐ Oils are always hydrogenated
- ☐ Not sure

20. As far as you know, which fat do experts say is <u>most</u> important for people to eat less of?

- ☐ Monounsaturated fat
- ☐ Polyunsaturated fat
- ☐ Saturated fat
- ☐ *Trans* fat
- ☐ Not sure

These next few items are about the nutrients in foods. *(Please choose only one answer for each.)*

1. Do you agree that sunlight helps the body produce vitamin D naturally?

- ☐ Agree
- ☐ Disagree
- ☐ Not sure

2. As far as you know, which of the following has the most calories?

- ☐ 1 gram of sugar
- ☐ 1 gram of protein
- ☐ 1 gram of fiber
- ☐ 1 gram of fat
- ☐ Not sure

3. **Do you think these are high or low in salt when they are cooked without added salt?**

	High	*Low*	*Not sure*
a. Cheese	☐	☐	☐
b. Pasta without sauce	☐	☐	☐
c. Red meat	☐	☐	☐

4. **Do you think these are high or low in fiber?**

	High	*Low*	*Not sure*
a. Fish	☐	☐	☐
b. Raspberries	☐	☐	☐
c. Eggs	☐	☐	☐
d. Red meat	☐	☐	☐
e. Broccoli	☐	☐	☐
f. Baked potato with skin	☐	☐	☐

5. **Do you think these foods are high or low in saturated fat when cooked without adding fat?**

	High	*Low*	*Not sure*
a. Fish sticks	☐	☐	☐
b. Whole milk	☐	☐	☐
c. Olive oil	☐	☐	☐
d. Red meat	☐	☐	☐
e. Chocolate	☐	☐	☐

6. **A type of oil which contains mostly monounsaturated fat is...**
   - ☐ Coconut oil
   - ☐ Soybean oil
   - ☐ Olive oil
   - ☐ Palm oil
   - ☐ Not sure

7. **Based on what you know, which has more fat per serving?**
   - ☐ Hot dogs
   - ☐ Ham
   - ☐ They both have the same
   - ☐ Not sure

8. **Based on what you know, which has more fat per serving?**
   - ☐ Peanuts
   - ☐ Air-popped popcorn
   - ☐ They both have the same
   - ☐ Not sure

9. **As far as you know, cholesterol is found in...**
   - ☐ Vegetables and vegetable oils
   - ☐ Animal products like meat and dairy products
   - ☐ All foods that have fat or oil
   - ☐ Not sure

10. **As far as you know, if a product is labeled as only containing vegetable oil, it is...**
    - ☐ Low in saturated fat
    - ☐ High in saturated fat
    - ☐ Could be either high or low in saturated fat
    - ☐ Not sure

11. **Would you consider 100 milligrams of sodium to be a low or high amount for one serving of food?**
    - ☐ Low
    - ☐ High
    - ☐ Not sure

12. **Would you consider 20 grams of fat to be a low or high amount for one serving of food?**
    - ☐ Low
    - ☐ High
    - ☐ Not sure

13. **Would you consider 5 grams of fiber to be a low or high amount for one serving of food?**
    - ☐ Low
    - ☐ High
    - ☐ Not sure

14. **Would you consider 10 grams of saturated fat to be a low or high amount for one serving of food?**
    - ☐ Low
    - ☐ High
    - ☐ Not sure