IMPLEMENTATION AND HEALTH OUTCOMES OF A SOCIAL SUPPORT-ENHANCED COOPERATIVE EXTENSION DIABETES PREVENTION PROGRAM

by

HANNAH KATE WILSON

(Under the Direction of ALISON C. BERG)

ABSTRACT

Translation of the CDC's evidence-based Diabetes Prevention Program (DPP) lifestyle change program from the clinic to other settings such as communities can increase public health impact of type 2 diabetes (T2DM) prevention efforts among the 1/3 of the U.S. population with prediabetes. However, adaptations are often made during translation due to real-world challenges faced during implementation in community contexts, like Cooperative Extension Services (CES). This dissertation explores outcomes of DPP participants in the context of a state CES, as well as barriers and facilitators to implementing the program as intended. Three studies were conducted and focused on: 1) DPP participant health outcomes (weight, physical activity, diet quality, health-related quality of life) and the relationship of engagement in a social media enhancement with participant outcomes; 2) the relationship of participants' social support and food security status with health outcomes; and 3) barriers to and facilitators of DPP implementation outcomes in the context of CES, as well as strategies to promote implementation. Overall findings were that participants lost a clinically meaningful amount of weight on average (5.2% ± 5.0% of initial body weight lost [N = 60]) and increased their physical activity, with few changes in diet quality and no relationship to engagement in the social media group. Participants' social support from

family and friends for healthy eating influenced weight loss and some components of diet quality, while the sample size of food insecure participants was too small to detect many relationships. Evaluation guided by the Consolidated Framework for Implementation Research revealed numerous facilitators, as well as some barriers, to Reach, Effectiveness, Adoption, Implementation, and Maintenance of the DPP in CES. At the conclusion of the present study, eight CES professionals had already begun or had plans to begin a second DPP cohort within the next 6 months. Together, these studies provide insight into the effectiveness of the DPP in CES, as well as facilitators to capitalize on and barriers to address to promote implementation of the DPP in the community setting of Cooperative Extension Services.

INDEX WORDS: Prediabetes, Diabetes Prevention Program, National Diabetes Prevention Program, Prevent T2 Program, Overweight, Obesity, Implementation, Implementation Science, Consolidated Framework for Implementation Research, RE-AIM, diet quality, physical activity, social support, food security, social media

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DEDICATION

This dissertation is dedicated to my parents – Sam and Kim Wilson – your unwavering love, patience, and wisdom helped me persevere to the end; to my brother and sister-in-law – Caleb and Meghan Wilson – your humor and confidence in me gave me courage to do this; and to my dearest friend – Elizabeth Klingbeil – I am extraordinarily lucky to have a friend like you.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Introduction

With approximately one third of the U.S. population living with prediabetes and 5-10% of these individuals developing type 2 diabetes mellitus (T2DM) each year, the need for increased dissemination of diabetes prevention interventions is imperative [1]. Lifestyle change programs like the CDC's National Diabetes Prevention Program (DPP) lifestyle change program have reduced rates of T2DM in samples of the prediabetes population by up to 58% [2, 3]. The DPP addresses key lifestyle factors known to increase risk for T2DM, including overweight and obesity, poor diet quality, and inadequate physical activity (PA). Recently, the CDC has overseen dissemination of the program in not only clinical contexts but also community contexts, including Cooperative Extension Services (CES) [4]. In clinical trials, the DPP resulted in clinically significant weight loss (average 7%), improved diet quality, and increased PA [2, 3, 5]. However, there is limited evidence of the effects of the DPP on these health outcomes and others, including health-related quality of life (HRQoL), when implemented as intended in community contexts such as CES. Similarly, implementation research on implementation contexts, strategies, and outcomes of community translations of the DPP, particularly within CES, is limited. Thus, there is a critical need to determine DPP outcomes in programs implemented as intended, as well as implementation barriers and facilitators, within community settings such as Extension.

Chapter 1 is a review of the literature that provides background and rationale for this dissertation research. This review addresses the high prevalence and incidence of type 2 diabetes mellitus (T2DM) and prediabetes in the U.S., along with lifestyle factors associated with T2DM risk addressed in the Diabetes Prevention Program (DPP), including physical activity and diet quality. Also discussed is the infrastructure of the Cooperative Extension Service (CES) and its potential fit as an effective delivery system for DPP dissemination and implementation. This dissertation study was conducted as part of a larger study funded by the UGA Presidential Interdisciplinary Seed Grant Program titled, Creating a Healthier Georgia through Diabetes Prevention (Principal Investigator: Alison C. Berg, PhD, RDN, LD, Co-investigators: Ellen M. Evans, PhD, Joan Koonce, PhD).

Chapter 2 is a manuscript to be submitted to the *Journal of Nutrition Education and Behavior* that investigates DPP participant outcomes in the context of a state CES. Relationship of engagement in a social media group with participant outcomes is also discussed.

Chapter 3 is a manuscript to be submitted to the *Journal of Nutrition Education and Behavior* that investigates the relationships of social support and food security status with DPP participant outcomes in the context of a state CES.

Chapter 4 is a manuscript to be submitted to *Implementation Science* that investigates barriers and facilitators to DPP implementation as intended in the context of a state CES. Barriers and facilitators of DPP Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) are assessed using the Consolidated Framework for Implementation Research (CFIR).

Chapter 5 summarizes the findings of Chapters 2-4, providing final conclusions and implications for practice and future research.

This dissertation research provides insight into the effectiveness of the DPP in CES, as well as facilitators to capitalize on and barriers to address to promote Reach, Effectiveness, Adoption, Implementation, and Maintenance of the DPP in CES. Revisions or enhancements to the DPP Prevent T2 curriculum's nutrition and physical activity content should be considered, perhaps in the form of detailed nutrition handouts, food demonstrations or recipe tastings, or an organized group physical activity component. Other state Extension services may consider utilizing the implementation strategy of technical assistance calls as a strategy to promote DPP implementation in their context, as well as the other facilitators and barriers identified based on their stage of DPP implementation. Chronic disease prevention through health behavior change is a challenge influenced by a variety of factors, most recently the COVID-19 pandemic. Future research should continue to investigate strategies to enhance DPP participant outcomes and promote greater dissemination of the DPP.

Literature Review

Prediabetes is a prevalent disease in the U.S. that increases risk for type 2 diabetes mellitus (T2DM), a common chronic disease associated with numerous complications and high costs [6]. Approximately one third (84.1 million, 33.9%) of U.S. adults 18 years of age and older have prediabetes, with middle-aged and older adults 45 years of age and older having the highest prevalence (45-64 years old: 34.3 million, 40.9%; ≥65 years old: 23.1 million, 48.3%) [6]. In addition, men have a higher prevalence of prediabetes than women (men: 44.5 million, 36.9%; women: 39.5 million, 31.1%) [6]. Prediabetes increases risk for T2DM, with 5-10% of individuals with prediabetes progressing to T2DM each year [1]. T2DM is associated with numerous complications and coexisting conditions when not properly managed, including neuropathy, nephropathy, diabetic ketoacidosis, lower extremity amputations, high blood pressure, and major

cardiovascular diseases such as ischemic heart disease and stroke [6, 7]. In 2014, 7.2 million (327.2 per 1,000 individuals with diabetes) hospitalizations listed diabetes as a diagnosis at discharge [6]. As a result of these complications and coexisting conditions, in addition to any medications necessary for disease management, T2DM is associated with a high financial burden. In 2012, the direct and indirect financial burden of diagnosed diabetes was estimated to be $245 billion [6]. Per person with diagnosed diabetes, medical costs were estimated to be $13,700, about 2.3 times higher than average medical costs of individuals without diabetes after adjusting for age and sex, with $7,900 of that being directly related to diabetes [6]. In light of these health and financial consequences of T2DM, there is a need for dissemination of effective diabetes prevention efforts among individuals with prediabetes or otherwise at high risk for T2DM.

Pathophysiology and risk factors for prediabetes and T2DM

Pathophysiology of prediabetes and T2DM

T2DM is characterized by insulin resistance and hyperglycemia [8]. Progression to T2DM involves multiple stages, however, with prediabetes developing in the last stages before T2DM manifests [8]. The first stage is characterized by insulin resistance (impaired insulin signaling) with euglycemia (normal glucose levels) [8]. Because insulin signaling is impaired, the pancreatic β cells must secrete more insulin to maintain normal blood glucose levels, leading to hyperinsulinemia [8]. Thus, hyperinsulinemia with euglycemia develops [8]. In the second stage, the pancreatic β cells are no longer able to fully compensate for the insulin resistance, leading to slightly elevated fasting blood glucose (FBG) and post-load blood glucose levels (typically 89-116 mg/dL) [8]. When fasting blood glucose is no longer able to be maintained below 100 mg/dL, an individual is considered to have impaired fasting glucose (IFG) and prediabetes is diagnosed, according to the American Diabetes Association prediabetes diagnostic criteria [8, 9]. Impaired

glucose tolerance (IGT) 2 hours following a 75-g oral glucose load may also be observed during this period, with IGT being diagnosed at blood glucose concentrations 140-199 mg/dL [8]. Prediabetes is diagnosed when IFG and/or IGT are present [8]. As acute insulin secretion in response to progressively higher blood glucose concentrations continues to decrease due to inability of the pancreatic β cells being able to compensate for the impaired insulin signaling, T2DM eventually manifests [8]. T2DM is diagnosed at FBG 126 mg/dL or greater and/or post-load blood glucose levels 200 mg/dL or greater [8]. Hemoglobin A1c (HbA1c), a measure of glycated hemoglobin, is also sometimes used as a diagnostic criterion for prediabetes and T2DM, although this test is a less sensitive diagnostic test for these conditions [8]. HbA1c 5.7% or greater is considered prediabetes, while HbA1c 6.5% or greater is considered T2DM [7].

Risk factors for prediabetes and T2DM

A host of factors contribute to prediabetes and T2DM risk and development. Obesity and excessive visceral adiposity are major T2DM risk factors [10]. The negative effects of obesity-associated chronic, low-grade, systemic inflammation on insulin sensitivity explains this relationship between obesity and T2DM [8, 10]. While genetic factors contribute to obesity and T2DM in some individuals, lifestyle and environmental factors are believed to contribute most to prediabetes and T2DM development [10]. Lifestyle and environmental factors related to diet and physical activity are strongly associated with prediabetes/T2DM [10]. Diets high in energy density that promote weight gain, such as the "Western" diet prevalent in the U.S., contribute to T2DM risk [10]. Furthermore, diets high in refined grains, sugar-sweetened beverages, and animal foods and low in vegetables, fruits, whole grains, and fiber are associated with obesity and T2DM [10]. Dietary patterns that align with the U.S. Dietary Guidelines for Americans, which promotes diets low in energy density; high in vegetables, fruits, and whole grains; and low in refined grains and

sugar-sweetened beverages, are associated with improved weight management and reduced T2DM risk [11].

Physical activity is another major lifestyle factor influencing T2DM risk [10]. Leisure and occupational physical activity are inversely associated with T2DM, with high total physical activity being associated with a 30% lower T2DM risk compared to low total physical activity [10]. Bouts of exercise have been shown to have positive acute effects on glucose clearance up to 2 hours following exercise [12]. These acute effects are insulin independent, being due to increases in translocation of the GLUT4 glucose transporter to the plasma membrane of skeletal muscle, increasing glucose uptake [12]. However, a single bout of exercise can improve insulin sensitivity up to 16 hours post-exercise in both insulin sensitive and insulin resistant individuals [12]. Physical activity has also been shown to promote improved insulin sensitivity in individuals at high risk for T2DM in a dose-response manner, with higher intensity physical activity promoting greater improvements in markers of insulin resistance [13]. Furthermore, weight loss achieved by increasing energy expenditure through physical activity/exercise can improve insulin sensitivity by attenuating the chronic inflammation associated with obesity that contributes to insulin resistance [14, 15].

Diabetes prevention interventions among prediabetes population

Targets of diabetes prevention interventions

In light of the known pathophysiology of T2DM reviewed above, most diabetes prevention interventions aim to improve insulin sensitivity in some way in order to prevent pancreatic β cell damage and dysfunction [8]. Most current interventions target the lifestyle factors of weight status, diet quality, and physical activity/exercise due to their known contributions to T2DM risk and based on current weight management position statements and recommendations

by the U.S. Preventive Services Task Force, The Obesity Society, the American Heart Association, the American College of Cardiology, and the Academy of Nutrition and Dietetics [8, 10, 15-20]. Pharmacological interventions, provided either alone or in combination with lifestyle intervention, are sometimes utilized as well in more severe cases of prediabetic dysglycemia and insulin resistance [21]. In some cases of severe obesity, surgical interventions such as bariatric surgery are recommended to prevent either the development of T2DM or the progression of T2DM and other obesity-related comorbidities [22]. In lifestyle interventions or pharmacological interventions with a lifestyle component, improved diet quality and increased physical activity/exercise are primary targets to promote weight loss, improved insulin sensitivity and glucose regulation, and overall health [8, 10]. While some lifestyle interventions may target diet or physical activity/exercise alone, research has repeatedly shown that interventions that target both diet and physical activity/exercise have more significant positive health outcomes than interventions that target diet or physical activity/exercise alone [15].

Physical activity

Physical activity guidelines for adults

Physical activity is an essential piece of lifestyle interventions for reducing obesity and T2DM risk, but benefits extend beyond T2DM to prevention of cardiovascular disease, some cancers, all-cause mortality and physical function [23]. Physical activity (PA) can lower the age-related increase in risk for several chronic diseases, with strong evidence showing an inverse association between regular aerobic PA and all-cause mortality [24]. Furthermore, the 2018 Physical Activity Guidelines Advisory Committee concluded that strong evidence exists supporting the benefit of PA for reducing age-related risk of physical function decline in the general older adult population [24].

In light of the evidence showing the benefits of PA for health, *Physical Activity Guidelines for Americans* were first published in 2008, with a revised version published in 2018 [23, 24]. These guidelines are developed by the Physical Activity Guidelines Advisory Committee, a panel of experts in the field that systematically reviews the current research literature on physical activity and health and synthesize the findings to develop guidelines for healthy populations across the lifespan [23]. Key PA recommendations for adults, including middle-age adults, are to 1) engage in 150 to 300 minutes of moderate-intensity aerobic PA, or 75 to 150 minutes of vigorous-intensity aerobic PA, per week, with activity preferably being spread over at least 3 days during the week; 2) 2 days of moderate-intensity muscle strengthening activities that work all major muscle groups (legs, hips, back, chest, abdomen, shoulders, arms), with at least 1 set of 8 to 12 repetitions [23]. Activities to maintain flexibility are also recommended, though no guidelines for frequency or duration of flexibility activities are provided [23]. Key PA recommendations for older adults (≥65 years old) include the same aerobic and muscle-strengthening activity recommendations as for other adults, as well as recommendations to engage in balance activities, as moderate evidence indicates a positive association between balance training and maintaining physical function for independence in older adulthood. Current clinical guidelines for the prevention of prediabetes and T2DM reference the PA guidelines for Americans as appropriate and effective for preventing and managing prediabetes and T2DM [25].

Unfortunately, less than 25% of U.S. adults meet these PA recommendations for both aerobic and muscle-strengthening activity, with middle-age and older adults having the lowest adherence to the PA guidelines [26, 27]. Thus, there is a need for dissemination of evidence-based

interventions that decrease barriers to PA and increase adherence to PA guidelines among the middle-older adult population, particularly those with prediabetes or T2DM

Physical activity assessment

While a variety of PA assessment methods are available, with objective methods like accelerometers providing the most valid and reliable data, several self-reported measures are available for use in settings where objective assessment is not feasible. The International Physical Activity Questionnaire-Short form (IPAQ-Short) has been validated in its use of categorizing adults based on activity level [28]. Metabolic equivalent (MET)-minutes of walking, moderative, and vigorous PA can be calculated from participant responses, followed by categorization of participants as 1) inactive, 2) minimally active, or 3) HEPA (health-enhancing physical activity)-active, according to IPAQ-Short data processing guidelines [29].

Diet quality

Association of diet quality with weight loss and weight loss maintenance

Diet quality has been defined by some as the extent that a dietary pattern reduces the risk for non-communicable diseases, commonly referred to as chronic diseases, such as T2DM, cardiovascular diseases, and certain types of cancer [30]. Indeed, research has shown associations between diet quality and weight status, weight loss, weight loss maintenance, and T2DM among other chronic diseases. In 2011, Raynor et al. compared the dietary energy density and food group intakes of weight loss maintainers (n=105; BMI < 25 kg/m^2) who had maintained at least 10% weight loss for at least 5 years to the diets of normal weight (n=85; BMI < 25 kg/m^2) and overweight/obese (n=97; BMI = 27-45 kg/m^2) individuals [31]. This study revealed that weight loss maintainers had significantly lower self-reported dietary energy density (calculated as energy [Calories] consumed divided by grams of food consumed) and energy intake from fat compared

to the normal weight or overweight/obese groups [31]. Furthermore, weight loss maintainers had significantly higher self-reported intakes of vegetable servings, whole grain servings, and fiber per day compared to both groups [31]. Another study (n=1,032) investigating the association between food group and nutrient intakes and weight loss and weight maintenance revealed significant associations between vegetable, fruit, low-fat dairy, protein, and carbohydrate intakes and weight loss and weight loss maintenance [32]. Higher intake of fruits and vegetables, as assessed by the Block Food Frequency Questionnaire (FFQ), was significantly associated with weight loss over 6 months, weight loss maintenance over 30 months, and even small amounts of additional weight loss over 30 months [32]. Higher low-fat dairy intake was also significantly associated with weight maintenance and even small, continued weight loss over 30 months [32]. Furthermore, greater substitution of protein or carbohydrate for fat and substitution of protein for carbohydrate were significantly associated with greater weight loss and maintenance [32].

Another study conducted among weight loss maintainers and regainers part of the MedWeight Greece weight loss registry identified a dietary pattern characteristic of the weight loss maintainers compared to the weight loss regainers [33]. This dietary pattern was composed primarily of vegetables, fruits, unprocessed cereals, low-fat dairy products, and olive oil [33]. Male weight loss maintainers were 4.6 times more likely to follow this dietary pattern, whereas male weight loss regainers followed a dietary pattern that frequently included regular sodas, alcohol, and salty snack foods [33]. Furthermore, weight loss maintainers had significantly higher protein intake per kilogram body weight compared to the regainers [33]. Taken together, these results indicate that higher diet quality reflecting a diet high in fruits, vegetables, whole grains, and low-fat dairy is associated with weight loss and weight loss maintenance.

Association of diet quality with T2DM risk

As mentioned in the previous section, diet quality is also associated with T2DM, among other chronic diseases. A large prospective cohort study including participants from three cohorts, the Nurses' Health Study (NHS), NHS II, and Health Professionals Follow-up Study, revealed associations between diet quality scores, as measured by the Alternative Healthy Eating Index (AHEI), and T2DM risk [34]. In this study, participants who did not have diabetes at baseline were followed for a total of 8 years [34]. The AHEI was administered every 4 years and diabetes incidence was monitored [35]. At the end of the study, it was shown that a greater than 10% *increase* in AHEI score was associated with lower T2DM risk (pooled hazard ratio [HR] = 0.84 [95% CI 0.75-0.90]), and that a greater than 10% *decrease* in AHEI score was associated with a higher T2DM risk (pooled HR = 1.34 [95% CI 1.23-1.46]) [34]. These associations were only partly (32%) explained by changes in body weight, indicating that diet quality improvements have benefits on T2DM risk independent of weight loss [34]. A longer prospective cohort study that followed only women in the Nurses' Health Study from 1984-2002 found a similar negative association between diet quality and T2DM risk in women [11]. Participants with a high AHEI score (mean 53.5) had a significantly lower risk (relative risk [RR] = 0.64 [95% CI 0.58-0.71], P_{trend} <0.001) for developing T2DM compared to participants with a low AHEI score (mean 24.2) [11]. Another 10-year prospective cohort study conducted among middle-age and older adults (≥49 years old) in Australia explored the association of diet quality, as assessed by a modified version of the Healthy Eating Index (HEI) with possible scores ranging from 0 to 20, with incident impaired fasting glucose [36]. Researchers found that male participants with total diet quality scores in the highest tertile (≥10.36) had 75% lower risk (multivariable-adjusted odds ratio [OR] = 0.25 [95% CI 0.08-0.73]) of incident impaired fasting blood glucose compared to male participants with total diet quality scores in the lowest tertile (≤8.35) [36]. These results

included adjustments for age, body mass index, hypertension, current smoking, and serum triglycerides [36]. Furthermore, researchers found that there was a 52% reduction in 10-year incident impaired fasting blood glucose in men for every 2-point increase in total diet quality score [36]. In a randomized controlled trial investigating the effects of an online diabetes prevention program on diet, physical activity, weight, and glycemia, similar positive results of diet quality changes on glycemia were observed [37]. The intervention group exhibited significantly greater increases in frequency of vegetable and fruit intake (3.71 [95% CI 2.73-4.70] additional times per week, effect size 0.62) and significantly greater decreases in frequency of refined carbohydrate intake (3.77 [95% CI 3.10-4.44] fewer times per week, effect size 0.34) and sweets (2.26 [95% CI 1.82-2.69] fewer times per week, effect size 0.40) compared to the control group [37]. These results paralleled significant decreases in fasting blood glucose and HbA1c levels [37]. In summary, positive changes in diet quality are associated with decreased T2DM risk beyond the effects of diet quality-associated weight changes on T2DM risk.

Indices of diet quality

A variety of indices are used to assess diet quality in research and practice. Informal measures of diet quality include amount consumed of each food group, calculated from dietary assessment tools such as a 24-hour recall or 3-day diet record, described below. While these are often used in practice because of their feasibility, research on diet quality changes related to an intervention or measures associated with diet quality often utilize more comprehensive indices. In the U.S., the Healthy Eating Index (HEI) and Alternative Healthy Eating Index (AHEI) are commonly used because they assess adherence to the U.S. Dietary Guidelines for Americans (DGAs), the national dietary recommendations for the general, healthy U.S. population [30]. Because the DGAs are updated every 5 years, the HEI is also revised every 5 years to reflect the

most current dietary recommendations in the DGAs [38]. Recent work by Reedy et al. has demonstrated construct validity, criterion validity, and reliability of the HEI-2015 corresponding to the most recent version of the DGAs released in 2015 [39]. Other diet quality indices seen in the literature include the Dietary Guidelines for Americans Index (DGAI), Dietary Guideline Index (DGI), Diet Quality Index (DQI), Diet Quality Score (DQS), Recommended Food Score (RFS), Not Recommended Food Score (NRFS), Food Variety Score (FVS), Dietary Diversity Score (DDS), Dietary Diversity Score with Portions (DDSP), and others [30].

Dietary assessment tools

Collection of dietary intake data is valuable for describing the diet quality of an individual, a group, or a population and for describing how diet quality changes due to an intervention or in association with another variable [40]. A variety of assessment tools and methods to calculate diet quality measures are available, each with advantages and disadvantages. Objective assessment of dietary intake through direct observation or measurement of nutritional biomarkers is desirable over subjective, self-reported measures [41]. As with any type of self-reported data, there is the risk of social desirability bias that can result in inaccurate data [42]. In the context of dietary assessment, there is risk of underreporting and overreporting, especially underreporting of energy intake [41, 42]. While objective assessment is preferred over subjective, self-report measures, objective assessment is often costly and not always feasible in research or practice, especially for interventions conducted in real-world settings [41, 42]. Characteristics of the specific research or practice setting, including time constraints, can further limit the feasibility of some dietary collection tools/methods [43]. Research conducted in real-world communities, in particular, faces numerous constraints that affect the feasibility of certain dietary assessment tools/methods. Still, diet quality is an important outcome to be assessed as part of community

nutrition and health research and practice. Furthermore, self-report data, when applied and interpreted correctly, still provides valuable information to inform nutrition research and practice [42].

The most common self-report dietary assessment tools include 24-hour dietary recalls, 3-day (or more) food records, food frequency questionnaires (FFQs), food screeners, and diet history questionnaires (DHQs). Some smaller assessment tools have also been developed and validated for use by specific organizations, such as the Expanded Food and Nutrition Education Program (EFNEP) Food and Physical Activity Behaviors Questionnaire [44]. These dietary assessment tools can be used alone to assess diet quality by intake of food groups and/or specific nutrients, or they can be used to calculate indices of diet quality such as those described above [30].

In order to allow for more feasible collection of dietary intake data, assessment tools with shorter time and other logistical requirements have been created and validated for use in community and other settings. These tools are often referred to as dietary screeners, as mentioned above; and several dietary screeners have been created and validated by the Risk Factor Assessment Branch of the National Cancer Institute's (NCI's) Epidemiology and Genomics Research Program [43, 45]. While these tools do not allow for assessment of the total diet or of portion sizes consumed, they do allow for assessment of median intakes of a population or the relationship between diet and other variables [43].

One of these screeners is the NCI's Dietary Screener Questionnaire (DSQ) [43]. This screener was used to assess dietary intake in the 2009-2010 National Health and Nutrition Examination Survey (NHANES) and the 2010 National Health Interview Survey (NHIS) Cancer Control Supplement (CCS) [43]. The DSQ contains twenty-six items, with nine items validated (dried beans, fruit, fruit juice, fried potatoes, other potatoes, other vegetables, salad, salsa, tomato

sauce), seven items indirectly validated (cheese, cookies/cake/pie, doughnuts, fruit drinks, ice cream, milk [two questions], soda), and validation of the other nine items not yet performed (candy, cereal, cereal type, pizza, popcorn, processed meat, red meat, sugar/honey in coffee/tea, whole grain bread) [43]. Another NCI validated screener is that used in the 2015 NHIS CCS, which differs from the DSQ by one additional question on intake of sports and energy drinks and "fruitades" [46]. These two screeners are the most comprehensive validated screeners, including questions on fruits and vegetables, whole grains/fiber, red and processed meats, dairy, calcium, and added sugars [43, 46]. Other NCI screeners include those used in the 2009 California Health Interview Survey, the Eating at America's Table Study (which assessed portion sizes of fruits and vegetables), the Percentage Energy from Fat Screener, and the multifactor screener used in the Observing Protein and Energy Nutrition study [46]. Again, the DSQ assesses most dietary components compared to these other NCI screeners, offering a shortened tool that still assesses most dietary components.

A systematic review investigating the association of diet quality indices with obesity revealed that FFQs and 24-hour recalls (either one, two, or more 24-hour recalls) were most frequently used to calculate various indices of diet quality, including the HEI [30]. Use of one or both of these methods is acceptable in dietary assessment research for assessing diet quality [41, 42].

ASA-24

The Automated Self-administered 24-hour recall (ASA-24) is a unique dietary assessment method that incorporates the Automated Multiple-pass Method (AMPM) used in interviewer-administered 24-hour recalls in a format that participants can complete on their own. In a validation study in which intakes reported via the ASA-24 were compared with intakes reported via the traditional interviewer-administered AMPM 24-hour recall and objectively

measured intakes, the ASA-24 was determined to be a valid (as well as cost-effective) measure [47]. In fact, the ASA-24, along with 4-day food records, were found to perform better than FFQs in a recent study in the *American Journal of Clinical Nutrition* [48]. A benefit of the ASA-24 compared to AMPM 24-hour recalls is that participants can complete them on their own time, decreasing participant and researcher burden. A benefit of the ASA-24 compared to food records is that because the ASA-24 incorporates AMPM principles, participants are prompted with questions needed for researchers to more accurately estimate nutrient intake. No prior participant training is required to report intake via the ASA-24, allowing for researchers to use this dietary assessment method to collect baseline dietary intake data before participants receive any nutrition education or counseling that could alter their intake from their true baseline.

Health-related quality of life

The concept of health-related quality of life (HRQoL) has become more prominent with advances in medical treatments that have increased average life expectancy by prolonging physiological functioning and delaying morbidity and mortality [49]. Individuals with prediabetes, specifically those with impaired glucose tolerance, have reported lower HRQoL in regard to mobility and psychological distress (using the HRQoL-15D measure) [50]. Furthermore, HRQoL is significantly lower in individuals with diabetes compared to those with normal glucose tolerance or impaired fasting glucose seen in prediabetes, highlighting the importance of diabetes prevention [50]. Recent literature has attempted to distinguish the concept of HRQoL from health or from quality of life in order to more accurately measure each of these concepts in research and practice [49]. The World Health Organization (WHO) defines health as more than just the absence of disease but physical, mental, and social well-being [49]. While there are differing definitions for quality of life, most agree that assessment of quality of life involves perception of the value of

aspects of one's life [49]. In light of these definitions, most HRQoL are not actual quality of life measures as they do not include questions asking individuals to place a value on aspects of their health [49]. In reality, most HRQoL questionnaires actually measure self-perceived health status by asking questions on physical functioning and well-being [49]. While it is generally accepted to still to refer to such questionnaires as HRQoL measures, knowledge of this distinction is valuable [49].

Two common, validated HRQoL measures used in research are the 36-item Short Form Health Survey (SF-36) and the EQ-5D. The SF-36 includes eight subscales: physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role, and mental health [51]. These different subscales comprise two overarching domains: a Physical Component Summary and a Mental Component Summary [52]. The SF-36 was used to measure HRQoL in the original Diabetes Prevention Program (DPP) implemented in clinical settings throughout the U.S. [53]. Results showed significant improvements in the physical functioning, general health, and vitality subscales in the lifestyle intervention group immediately after the DPP intervention [53]. These improvements were also greater than those seen in the metformin or placebo groups [53]. Participants were followed for 3 years after the program, and all scores declined over this follow-up period [53]. However, the decline in the lifestyle intervention group was significantly less for the subscales physical functioning, general health, vitality, and body pain than that in the placebo group, even after controlling for demographic factors, baseline weight, baseline physical activity, and any comorbidities [53]. SF-36 has been used to measure HRQoL in other primary care lifestyle change programs similar to the DPP as well [54]. Individuals in the lifestyle intervention group reported greater HRQoL related to physical functioning and emotional role on the SF-36 than the control [54]. In addition, changes in SF-36 scores were correlated with changes in anthropometrics, blood pressure, and blood glucose [54]. Research on HRQoL changes in a community-based DPP

is limited, however. Changes in the physical component summary of the SF-36 (PCS-36) have also been analyzed in relation to weight loss as a result of the DPP, and a significant association between weight loss and improvements in physical function as measured by the PCS-36 was found [55].

The EQ-5D has also been used in conjunction with the SF-36 or alone to assess HRQoL in lifestyle change interventions similar to the DPP. The EQ-5D assesses five dimensions of HRQoL: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression [56]. The EQ-5D includes an EQ-Visual Analogue Scale (VAS) and the five domains with either three (EQ-5D-3L) or five (EQ-5D-5L) severity levels [56]. The EQ-5D has been used to assess HRQoL in primary care lifestyle interventions similar to the DPP but targeted at individuals at high risk for cardiovascular disease [57]. Findings from this study showed improvements in HRQoL as assessed by the EQ-VAS and the SF-36 physical component summary but not the EQ-5D or SF-36 mental component summary [57]. EQ-5D has also been used to assess HRQoL changes in a community-based translation of the DPP [58]. This study found significant improvements in EQ-VAS scores at 6 and 12 months [58]. Significant improvements were also found in EQ-5D-3L scores at 6 and 12 months after adjusting for age, baseline score, and achievement of intervention goals [58].

The CDC has also developed its own HRQoL measures, the HRQoL-14 measure composed of three subsets or "modules": the Healthy Days Core module, the Healthy Days Symptoms module, and the Activity Limitations module [59]. This measure has been found to be a shorter but validated HRQoL measure, with acceptable criterion validity with the SF-36 [60]. Unhealthy BMI and cardiovascular health have all been associated with HRQoL as measured by the CDC's HRQoL14 measure [61, 62]. Impaired glucose tolerance among individuals with prediabetes has also been associated with certain measures of HRQoL, highlighting the

importance of this outcome measure [50]. To our knowledge, this measure has not been used to evaluate HRQoL among DPP participants, including DPP programs implemented in community settings such as Cooperative Extension. The Healthy Days Core module is incorporated into the Behavioral Risk Factor Surveillance System, highlighting the value of using this measure for comparison to national-level data [63].

Household food security

In 2017, 11.8% (15 million) of the U.S. population was considered food insecure, with 7.3% (9.3 million) having low food security and 4.5% (5.8 million) having very low food security (USDA ERS, 2018). Individuals living in food insecure households experience a high burden of chronic diseases, including diabetes [64]. A secondary analysis of cross-sectional data from the 2011-2012 National Health Interview Survey found that non-Hispanic white women living in a food insecure household had a 53% higher odds of being prediabetic than non-Hispanic white women living in a food secure household [65]. Even more astonishing, non-Hispanic black women living in a food insecure household had a 200% higher odds of being prediabetic than non-Hispanic black women living in a food secure household [65]. In addition, Hispanic individuals with very low food security have been shown to be 3.3 times more likely to develop type 2 diabetes, even after controlling for lifestyle characteristics, waist circumference, employment status, and acculturation [66]. These results highlight the importance of identifying food insecurity among lifestyle change intervention participants in order to more effectively prevent chronic diseases such as type 2 diabetes.

The U.S. Department of Agriculture Economic Research Service (USDA ERS) has developed several measures of food security: the Household Food Security survey module, the Adult Food Security survey module, and the Six-item Short Form of the Food Security survey

module [67]. The Household Food Security survey module is the most comprehensive of the three measures, containing eighteen items that ask questions on both adult and child food security in the entire household [67]. The Adult Food Security survey module contains only ten items, decreasing response burden on participants while still providing reliable data [67]. The shortest form available is the Six-item Short Form of the Food Security survey module that allows for estimation of low and very low food security with reasonable reliability and minimal response burden on participants [67]. While the 18-item Household Food Security survey module provides the most reliable data, the length of the measure is often not feasible for use in certain contexts [67]. In such contexts, the shorter forms are acceptable for use. The 6-item form has been shown to correctly classify 97.7% of households based on food security status, underestimating prevalence of food security and hunger by 0.3 percentage points [68].

Little research on food security status of DPP participants and its relationship to DPP outcomes has been conducted. Studies have found that among those with diabetes and food insecurity, a food assistance program resulted in significantly decreased diabetes distress and significantly greater diabetes self-management, suggesting that food security status may have an effect on prediabetes outcomes as well [69]. Cheyne et al. found that in a food bank-based DPP, food insecure participants had improvements in food security status and significant improvements in DPP outcomes, including PA and diet quality [70]. A systematic review on the benefits of providing material support to intervention participants for diabetes prevention supports the co-delivery of the DPP with other support programs for food insecure participants, such as the Supplemental Nutrition Assistance Program-Education component (SNAP-Ed) and the Expanded Food and Nutrition Education Program (EFNEP) [71].

Social support for behavior change

Social support measures

The importance of social support in personal behavior change to improve health outcomes has long been recognized. In individuals who have already developed type 2 diabetes, associations between certain aspects of social support and blood glucose control have been shown [72]. While there is variability among results of studies investigating associations between social support and glycemic control (as measured by hemoglobin A1c), a review investigating this association found that greater family support was most consistently associated with improved glycemic control among cross-sectional studies, using the Family Support Scale (FSS) and the Diabetes Family Behavior Checklist-II (DFBC-II) [72]. For research targeted at individuals who have not yet developed diabetes but have prediabetes, the DFBC-II measure is not applicable. Furthermore, the FSS is not a scale that measures familial support for health behavior change but rather familial support in raising children [73]. While this aspect of social support may influence health behavior change in individuals with children, its applicability is limited to families with children, making this social support measure less than ideal, especially for middle-age and older populations without young children at home.

In light of this and the other results of this review, inconsistencies among associations between familial and other aspects of social support and glycemic control may be due to differences in the specific social support measures used [72]. This review found that more complex measures of social support that measured the multiple components of social support were more predictive of health outcomes, consistent with other research [72]. Such multicomponent measures included the Chronic Illness Resource Survey (CIRS), the Personal Resource Questionnaire-II, and the Diabetes Care Profile (DCP) [72]. Again, the applicability of the DCP is limited to

individuals with diabetes. The CIRS, however, is a validated, comprehensive, multicomponent measure of social support [74]. The CIRS includes seven constructs of social support in relation to chronic illnesses: personal, family, friends, physician, health care team, neighborhood/community, and worksite [74]. Full (64 items) and brief (29 items) versions of the CIRS exist, both exhibiting acceptable internal consistency, test-retest reliability, and construct and criterion validity [74].

Other shorter, multicomponent measures of social support used in health literature include the Multidimensional Scale of Perceived Social Support (MSPSS) and the Medical Outcomes Study Social Support Survey (MOS-SS). The MSPSS is a 12-item scale that assesses social support from family, friends, and a significant other [75]. It has been tested among individuals with chronic diseases and shown to be a valid and reliable measure of social support among this population [75]. The MOS-SS is another validated measure of functional (distinct from structural) social support first used among participants with chronic health conditions in the Medical Outcomes Study [76]. It includes 19 items that assess four domains of functional social support: emotional/informational support, tangible support, positive social interaction, and affection [77]. A shorter form of the MOS-SS, the modified MOS-SS (mMOS-SS) has also been developed to reduce participant burden [77]. The mMOS-SS includes 8 items and two of the original four domains (emotional and tangible support), and it has shown to be comparable to the original MOS-SS [77].

Social support measures specific to healthy eating and physical activity are the Social Support and Eating Habits Survey and the Social Support and Exercise Survey, 10-item surveys that assesses social support from family and friends [78]. In the Social Support and Eating Habits Survey, each subscale (family and friends) includes 10 questions, 5 that reflect encouragement

and 5 that reflect discouragement, with responses reported on a 5-point Likert scale, with 1=none and 5=very often. Higher scores on the encouragement subscale reflect higher levels of encouragement, and higher scores on the discouragement subscale reflect higher levels of discouragement. In the Social Support and Exercise Survey, questions reflect family and friend participation in exercise and family rewards and punishment for exercise, again reported on a 5-point Likert scale, with 1=none and 5=very often.

Measurement of social support among DPP participants is limited. A worksite translation of the DPP conducted by Wilson et al. used a researcher-developed questionnaire to assess social support received by family, friends, and coworkers and support received for healthy eating, exercise, and weight management [79]. Although there were significant improvements in perceived social support within the intervention group, these improvements were not significantly different from perceived social support among the control group [79]. An Australian diabetes prevention program similar to the DPP assessed factors that contributed to sustained behavior change for diabetes prevention and found that greater family and community support promoted motivation for sustained health behavior change [80]. A study among women with a history of gestational diabetes is also investigating the effects of an intensive lifestyle intervention on type 2 diabetes prevention and the mediating effects of social support on the intervention's effects [81].

Interestingly, participation in a weight loss and diabetes prevention program similar to the DPP has been shown to result in positive influence on those within the social influence sphere of program participants [82]. Program participants' perceived effect on their social support system as a result of participation in the program was assessed through mixed methods data involving both quantitative data from a researcher-developed questionnaire and qualitative data gathered through participant interviews [82]. Program participants had a higher perceived positive

effect on the eating and exercise habits of the individuals in their social support system than non-participants [82]. Amount of weight loss during the program was associated with participants' perceived effect on the eating habits of their social support system [82]. These results suggest that one's social support system can not only influence a participant's behavior change during the program but can be influenced by a person's participation in a program [82].

Social support interventions

As mentioned above, the importance of social support in personal behavior change to improve health outcomes has long been recognized. In individuals who have already developed type 2 diabetes, associations between certain aspects of social support and blood glucose control have been shown [72]. While many interventions are designed to provide participants with social support, including the DPP, the prevalence of numerous social networks such as Facebook provide additional opportunities to enhance social support and, potentially, health outcomes among participants [83]. For example, Facebook groups are used by individuals who already have diabetes as a source of support and information [84]. Significant positive associations between perceived social support of web-health users, improved diet quality (lower fat and higher fruit, vegetable, and fiber intake), and increased physical activity have been shown [85]. In addition, perceived social support of web-health users has been shown to be a predictor of self-regulatory behavior including goal setting and self-monitoring [85].

A variety of health interventions have shown the use of Facebook social support groups to be effective in improving intervention outcomes. An 8-week walking intervention randomized college-aged women to either a Facebook social support group or no social support group [83]. Researchers posted educational information in the Facebook group weekly and encouraged members of the group to provide ideas, support, and encouragement to each other in meeting

physical activity goals (specified in steps/day) [83]. Interestingly, by the end of the intervention, participants in the Facebook group were getting an average 12,472 steps/day, compared to the control group getting an average 10,136 steps/day ($p<0.001$) [83]. This difference equates to about 1.3 miles, or about 26 minutes, more of walking by the Facebook group compared to the control group [83]. Results of this study indicate the powerful potential of a Facebook social support group to increase physical activity [83]. Another study investigating the association of engagement with a Twitter health intervention group and weight loss over the 6-month health intervention found that Twitter posts significantly predicted percent weight loss, with every additional 10 Twitter posts corresponding to -0.5% weight loss [86]. Another study investigated whether participation in a closed Facebook group was associated with weight loss during a 4-month maintenance phase of an intervention [87]. This intervention consisted of weekly sessions held for 8 weeks followed by monthly sessions held for 4 months [87]. During this 4-month maintenance period, participants were offered the option to join a closed Facebook group to provide social support during the lower frequency phase of the intervention [87]. Five posts of various types were uploaded by the researchers each week (on each weekday), including posts designed to solicit participant discussion and suggestions, posts in which a recipe was shared, posts in which nutrition-related news was shared, or polls on some nutrition or physical activity-related topic [87]. Researchers found that participant engagement (measured by total number of post views, likes, comments, poll votes, participant posts, and comments on participant posts) was significantly associated with weight loss during the 4-month maintenance phase, even after adjusting for number of monthly maintenance sessions attended [87]. Interestingly, similar to the findings from the previous study, for every 10 posts or likes in the Facebook group, an average additional 0.43 kg (0.95 lb) was lost [87]. In addition, poll posts solicited the greatest engagement among participants, followed

by posts soliciting weight-related discussion and suggestions/tips from participants [87]. Taken together, these studies suggest that online social media platforms such as Facebook can serve to increase social support and promote weight loss, improved diet quality, and increased physical activity.

The Diabetes Prevention Program

DPP clinical trial

A variety of diabetes prevention lifestyle interventions exist, most having the basic goals of weight loss, improved diet, and increased physical activity. One of the primary evidence-based diabetes prevention lifestyle interventions is the Centers for Disease Control and Prevention's (CDC's) National Diabetes Prevention Program (NDPP) lifestyle change program, based on the DPP clinical trial [2, 88]. The DPP clinical trial was conducted in 1996-2001 and resulted in an average weight loss of 6.9% initial body weight and 50% of participants achieving 7% weight loss at 3 months of the program [2, 89]. Furthermore, participants had 58% decreased risk of developing T2DM approximately 3 years after the program [90]. The DPP clinical trial was funded by the NIH/NIDDK and involved one-on-one counseling between participants and registered dietitians to promote weight loss, increases in physical activity, and improvements in diet quality [2, 3]. Due to the high costs associated with this intensive, one-on-one format with highly trained healthcare professionals, research on the effectiveness of more translatable, cost-saving forms of the DPP, using group-based settings and lay leaders, began [91]. A meta-analysis of these studies revealed that delivery of the DPP curriculum in these settings with lay leaders still leads to clinically meaningful weight loss [91]. Based on the positive results of the clinical trial, the ongoing follow-up study (the Diabetes Prevention Program Outcomes Study [DPPOS]), and the results of Ali et al.'s meta-analysis, the CDC was funded to begin the National DPP

effort in 2012 [2, 3]. The National DPP is a public-private partnership effort to address diabetes through increased screening and interventions [4]. A primary component of the National DPP is the lifestyle change program, referred to as the Diabetes Prevention Program (DPP), that addresses weight status, diet quality, and physical activity [4]. The Diabetes Prevention Recognition Program (DPRP) was created in 2011 as part of the National DPP effort to oversee dissemination and implementation of the DPP [4]. Even with standards set by the DPRP, leaders in the field of DPP research highlight the need for continued research as the DPP is translated into new settings, describing the DPP as a program that continues to "evolve and expand" [4].

The DPP is a 1-year, two-phase program [92, 93]. The first phase includes a minimum of 16 sessions, focused on a variety of lifestyle change topics including physical activity, diet, and self-monitoring, that are completed over the course of 6 months [92, 93]. The second phase includes a minimum of 6 sessions that are completed over the course of 6 months and continue to cover similar lifestyle change topics of diet and physical activity [92, 93]. There are currently two CDC-recognized DPP curriculums, the 2012 DPP curriculum, which was closely based on the clinical trial conducted from 1996-2002 and used in Ali et al.'s meta-analysis showing effective DPP translations, and the Prevent T2 curriculum, an updated version of the 2012 curriculum released in 2017 [91, 94]. The DPRP oversees use of these curriculums and sets standards for implementation of the DPP (focusing on program length and session frequency [as these were observed to be essential program components by Ali et al.] and participant-level outcomes [attendance, weight loss, physical activity]) [4, 91, 95]. These standards are used to recognize organizations that have demonstrated effective delivery of the DPP, with the original standards set in 2011 with the creation of the DPRP and revisions following in 2018 and 2021 to reflect the realities and emerging research of real-world DPP translations [4, 95, 96].

Still, it is important to note differences between the clinical trial and the lifestyle change program part of the National DPP effort. Again, the clinical trial involved one-on-one counseling with a registered dietitian, while the DPP is delivered in group settings by lifestyle coaches coming from a variety of educational and experience backgrounds [4]. In addition, the most recent Prevent T2 curriculum includes minimal detail on nutrition and physical activity compared to what a participant would receive in one-on-one counseling with a healthcare professional or in the original clinical trial, and little research is published on translations using this Prevent T2 curriculum [97]. In light of these differences and published literature [91], one would expect diminished outcomes of translations of the DPP part of this National DPP effort compared to the outcomes achieved in the clinical trial and the DPPOS. Still, research has demonstrated that for the cost, the DPP lifestyle intervention as delivered under the DPRP is reasonably effective for improving lifestyle and reducing T2DM risk.

Translation into community contexts

In recent years, community translations of the DPP have increased. However, due to the differences between clinical and community contexts for program implementation, further adaptations to the DPP have been made in community translations, compromising program fidelity and the rigor of DPP translational research [89, 98, 99]. The CDC has determined that meaningful changes can still be achieved with adaptations, as described above. Some adaptations are recognized as acceptable by the CDC, specifically, intervention personnel characteristics. Again, in the original DPP clinical trial, the lifestyle change intervention was delivered mostly by registered dietitians [2, 89]. However, with the desire to increase dissemination of the DPP to expand the reach of this diabetes prevention effort and based on the effectiveness of DPPs delivered by lay leaders, the DPP now allows individuals with any educational and experience

background to be trained by recognized master trainers to become DPP lifestyle coaches [94, 100]. With the revised approach of the Prevent T2 curriculum, focusing less on specific Calorie and fat goals and more on self-monitoring and realistic steps for lifestyle change, nutrition (or other health-related) expertise is not as imperative to delivering the program [94]. Still, adherence to certain program characteristics, particularly program length and session frequency, is imperative based on the clinical trial evidence base of the program as well as the Ali et al. meta-analysis [91, 101]. Program fidelity in terms of program length and session frequency are the areas in which DPP community translational research lacks rigor. For example, many community DPP translations reduce the program length to only 12, 8, or even 6 weeks, compared to the specified 1-year length [99]. A review published by Neamah et al. in 2016 revealed that of 28 DPP translation studies reviewed, 13 (46.4%) reduced the total program length and/or frequency of sessions held [101]. Notably, a majority of those programs that reduced program length and/or session frequency were translated to a non-clinical setting, such as a community organization, church, or worksite [101]. Furthermore, due to the implementation challenges shown to be inherent in many community settings, rigorous translational research investigating implementation and feasibility of the DPP when implemented as intended needs to be further explored [89].

Diet quality changes in the DPP

The two primary goals of the program, regardless of whether one is using the original 2012 curriculum or the Prevent T2 curriculum, are for participants to achieve and maintain 5-7% weight loss and at least 150 minutes of moderate physical activity per week [94]. Still, based on the association of diet quality with weight loss, weight loss maintenance, and T2DM risk, improved diet quality is an integral outcome to be improved as well. A randomized controlled trial was conducted in 2016 to investigate the diet quality changes that occurred during the first 16 weeks

(the first phase) of the DPP [102]. In this study, the DPP, using the 2012 curriculum, was delivered to the intervention group in a group setting to university employees, while the control group received a booklet on lifestyle change for diabetes prevention with no other contact with the intervention staff [102]. At 16 weeks, the intervention group had significantly lower intakes of nuts, legumes, and red and processed meats compared to the control group as assessed by the AHEI [102]. At 3 months after the end of the 16-week intervention, the intervention group had significantly higher intakes of fruit compared to the control group as assessed by the AHEI [102]. Furthermore, within the intervention group from baseline to post-intervention, there was a significant increase in fruit intake; significant decreases in red and process meat intake, trans fat intake, and sodium intake; and a significant increase in total AHEI score [102]. Based on the DPP program description in the previous section, these outcomes are consistent with one of the focuses of the original 2012 DPP curriculum, to decrease dietary fat intake to less than 25% of total Calories [94]. In this original curriculum, participants were provided a daily goal for fat intake (in grams of fat per day) [94]. On the contrary, the updated curriculum, Prevent T2, does not prescribe participants a specific fat or even Calorie goal [94]. Instead, a greater focus is placed on self-monitoring and adequate intake of food groups using the American Diabetes Association's Create Your Plate method [94]. With these changes, it is largely unknown the effects of the PreventT2 curriculum on diet quality. At present, a search of the literature revealed no published studies that reported on diet quality and specifically stated using the Prevent T2 curriculum with the DPP implemented according to DPRP standards.

A recent secondary analysis was also published evaluating diet quality of DPP clinical trial participants [5]. This study utilized the Alternative Healthy Eating Index (AHEI), which measures diet quality on a scale of 0-110 (compared to the HEI's scale of 0-100) [5]. This

secondary analysis found a significant increase in AHEI scores of DPP participants, from an average score of 44.4 at baseline to 48.6 at post-intervention [5].

Implementation science in the DPP

Implementation science is the study of the process of implementation, implementation outcomes and their predictors, and strategies to promote effective implementation of evidence-based interventions [103]. Implementation science is a key component of translational research, which investigates the ability to put an intervention shown to have efficacy and effectiveness in laboratory or clinical research settings into practice in real-world contexts [89, 104-107]. Similar to the fact that the effects of an intervention in one population are not necessarily applicable to other populations, the effectiveness of an intervention in one context is not necessarily applicable to other contexts. Differences in contextual and systems factors affect the feasibility and effectiveness of an intervention when conducted in a community compared to a clinical setting, for example [103]. Thus, in order to best translate interventions shown to be effective in clinical contexts and expand on what is known in community contexts with adaptations [91, 101], the effect of contextual factors on the feasibility, implementation, and effectiveness of the intervention when implemented according to the CDC DPRP standards should be studied [103, 104, 107]. Furthermore, understanding the predictors of implementation outcomes in a new context can allow program implementers to identify implementation barriers to address and facilitators to capitalize on to improve implementation outcomes [103, 108]. While implementation science studies have investigated the implementation context, strategies, and outcomes of DPPs implemented in clinical contexts and various community contexts, to our knowledge, no studies have rigorously evaluated these three aspects of implementation within the community context of Cooperative Extension [89, 109-115]. Understanding how the DPP functions in a variety of contexts is valuable to

the CDC's DPP dissemination goals of reducing T2DM burden through cost-effective interventions.

The field of implementation science is relatively new, particularly within nutrition education and behavior [103]. However, a variety of theories, models, and frameworks exist to guide researchers in investigating the three primary aspects of implementation: implementation context (where the intervention is implemented), implementation strategies (actions taken organizations or systems to improve implementation outcomes), and implementation outcomes (reach, feasibility, sustainability, cost, and other characteristics of the program itself) [103]. Determinant frameworks, such as the Consolidated Framework of Implementation Research (CFIR), guide the study of implementation contexts, allowing for identification of barriers to and facilitators of implementation affecting implementation outcomes [103]. Evaluation frameworks, such as the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) framework, guide the study of implementation outcomes along with the intended health outcomes of the intervention [103]. Implementation strategies encompass a wide variety of approaches targeted at different stakeholders within program implementation, from the consumer of the program to the implementer of the program [103, 116, 117]. Feasibility, utility, and comparative effectiveness of different implementation strategies are often tested as part of implementation research [103, 104, 116].

CFIR

The CFIR, developed by Damschroder et al. in 2009, is one of the most common determinant frameworks used to identify predictors of implementation outcomes [103, 108, 113, 114]. In fact, the CFIR has been used by the creator of the framework to study implementation of the DPP within the context of Veterans Affairs (VA) hospitals [113, 114]. The CFIR includes five

domains with thirty-nine constructs to identify as many contextual factors as possible that may influence implementation outcomes [108, 118]. The framework, with all domains, constructs, and their definitions, is provided in Appendix B. The CFIR is used as a guide to thematic qualitative analysis of interviews with key program stakeholders.

RE-AIM

RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) is an evaluation framework used to determine implementation outcomes, including the intended outcomes of the program (such as the DPP's intended health outcomes of weight loss, improved diet quality, and increased physical activity) and other outcomes relevant to health programming impact [103, 119-122]. Reach (R) is defined as the number, percentage, and/or proportion of eligible participants who participated in the intervention [121]. Effectiveness (E) is defined as positive changes in the intended health outcomes of the program [121]. Adoption (A) is defined as the number and proportion of potential practitioners who decide to actually implement the program [121]. In the current study, adoption will be used to measure the number and proportion of eligible University of Georgia Family and Consumer Sciences Extension agents who chose to implement the DPP in their county. Implementation (I) is defined as fidelity to important program components (for example, program and session duration, frequency and number of sessions, completion of required session components), as assessed by on-site observations or through interviews with program implementers [108, 113, 114, 121, 123-127]. Utilization of determinant frameworks such as the CFIR can inform this aspect of implementation outcomes [113]. Maintenance indicates the feasibility for continued implementation of the program by the organization [121]. Due to the limited 1-year duration of this study, maintenance (M) will be assessed in future studies [107, 128].

Effectiveness-implementation hybrid study designs

While most studies aim to investigate either effectiveness of a clinical intervention or implementation contexts, strategies, and outcomes, there are cases where a hybrid study design that investigates both of these outcomes simultaneously, referred to as an effectiveness-implementation hybrid study, can hasten the translation of an intervention into new contexts [103-105, 129]. There are three types of hybrid designs. Type 1 has a primary aim to investigate the effectiveness of a clinical intervention in the context of interest with a secondary aim to better characterize the implementation context [103, 104]. Type 2 has two co-primary aims: (1) to determine the effectiveness of a clinical intervention in the context of interest and (2) to determine the feasibility and utility of an implementation strategy to promote more effective implementation [103, 104]. Type 3 has a primary aim to compare two implementation strategies to determine the most effective strategy with a secondary aim of assessing clinical outcomes of the intervention in the context of interest [103, 104]. Type 2 and type 3 hybrid trials are particularly applicable for interventions with much documented effectiveness in the clinical context and with an aim to determine their effectiveness in new contexts while simultaneously determining factors related to implementation unique to the new context, as is the case for the DPP in Cooperative Extension [103, 104, 129].

Cooperative Extension

Cooperative Extension model

The Cooperative Extension Service was established in 1914 as a partnership between the USDA and land-grant universities to educate farmers on current agricultural research and assist them in applying that research in their farming practice [130]. The role of Extension has expanded into nutrition and health education and assistance with the changes in American agriculture, the

food environment, and nutrition- and health-related chronic disease prevalence [130]. Cooperative Extension is poised to reach a large and diverse population with nutrition and health programming, with offices in nearly every county throughout the states [130]. In Georgia, Cooperative Extension has personnel in all 159 counties [131]. University of Georgia Cooperative Extension provides its nutrition and health education and services through the Family and Consumer Sciences (FACS) sector of Extension [132]. While there are not FACS Extension agents located in every county throughout the state, there are numerous agents located in each region of Georgia, still allowing for extensive reach of a large and diverse population through Extension programs. This multi-site model of Cooperative Extension positions UGA Extension to serve as an avenue to increase potentially effective dissemination of diabetes prevention interventions such as the DPP [133].

Existing diabetes interventions

As discussed above, the community setting of Cooperative Extension offers a particularly powerful model for DPP implementation. Cooperative Extension has not only the capacity for multi-site implementation and but also nutrition and health specialist support available to Extension agents serving as lifestyle coaches who have various backgrounds in nutrition and health. While DPP has been implemented by Cooperative Extension Services throughout the country for several years, with the Cooperative Extension National Diabetes Prevention Program Interest Group (CE-NDPP) working to strengthen these efforts since 2017, research on its translational feasibility *as intended* by Extension is limited [89, 134]. Furthermore, while University of Georgia (UGA) Cooperative Extension specifically has diabetes *management* programming, such as the Right Bite Diabetes Cooking School, there is a need for evidence-based, diabetes

prevention efforts among UGA Cooperative Extension in light of the high prevalence of prediabetes and T2DM risk factors [1].

Summary and Conclusions

It is evident that there is a need for increased dissemination of effective, sustainable, evidence-based efforts to prevent T2DM among high-risk populations in the U.S. Lifestyle factors such as diet quality and physical activity affect T2DM risk and, thus, are important, modifiable targets for T2DM prevention interventions. By increasing dissemination of current evidence-based interventions such as the CDC's Diabetes Prevention Program in contexts with potential to reach large, diverse populations, such as the University of Georgia Cooperative Extension Service, T2DM may be prevented in some high-risk populations throughout Georgia. Furthermore, by studying implementation of the DPP in the context of Cooperative Extension and testing implementation strategies for this context, program implementation and fidelity may be improved to optimize implementation outcomes. In addition, identifying an effective social support intervention may offer a feasible method to enhance participant outcomes in a Cooperative Extension delivered DPP.

CHAPTER 2

HEALTH-RELATED OUTCOMES OF A SOCIAL SUPPORT-ENHANCED COOPERATIVE EXTENSION DIABETES PREVENTION PROGRAM[1]

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Abstract

Objective: The CDC's National Diabetes Prevention Program (DPP) evidence-based lifestyle change program aims to decrease type 2 diabetes (T2DM) risk through weight loss, diet, and physical activity. While the DPP has proven effective in a variety of settings, its effectiveness in the community setting of Cooperative Extension is largely unknown. Thus, the purpose of the present study was to evaluate 1) effectiveness of the DPP in improving participant health outcomes in Cooperative Extension, and 2) the association between engagement with a social media group and DPP health outcomes.

Design: The present study was part of a 12-month, multi-site, hybrid type 2 effectiveness-implementation trial of a translation of the DPP and is a one-group, repeated measures design.

Setting: The present study was set in the context of the Cooperative Extension Service (CES) in [STATE].

Participants: Participants were overweight or obese adults (18-75 years) with prediabetes or at high risk for prediabetes and without any major comorbidities or physical disabilities (N = 88, mean age 56.4 $\pm$ 13.2 years, 70.5% white, 26.1% black, 52.3% college educated).

Intervention: The 12-month DPP using the Prevent T2 curriculum was implemented according to CDC standards from approximately January 2020 to January 2021.

Main Outcome Measures: Weight change, physical activity, diet quality (Healthy Eating Index-2015, 26-item Dietary Screener Questionnaire), health-related quality of life, and association of engagement with the social media group with outcome measures

Analysis: Linear, ordinal, and binary logistic mixed effects regression models were performed to evaluate changes over time and explore relationships of demographics, attendance, and social media engagement with main outcome measures.

Results: Participants lost an average of 5.2% ± 5.0% of their initial body weight, with 46.7% of participants meeting the CDC intervention goal of 5% weight loss by the end of the intervention. 56.7% of participants reported meeting the 150 minutes per week of moderate physical activity goal (mean = 179.0 ± 122 minutes/wk). Participants also significantly increased their predicted intakes of fiber, fruits, and vegetables ($p < 0.05$) over the course of the intervention. Number of physically unhealthy days significantly decreased ($p = 0.042$) and days full of energy significantly increased ($p = 0.006$) over the course of the intervention. Engagement with the social media group had no influence on outcomes.

Conclusions and Implications: This study provides insight into outcomes of the DPP when translated into the community setting of a state CES. Participants lost a clinically meaningful amount of weight on average, significantly increased their physical activity, increased their predicted intake of fruits and vegetables, and experienced some improvements in health-related quality of life. Future research should evaluate outcomes in the post-pandemic era and other potential enhancements to the DPP curriculum to maximize participant outcomes of DPP translations.

Objective

The National Diabetes Prevention Program

With approximately one third of the U.S. population living with prediabetes and 5-10% of these individuals developing type 2 diabetes mellitus (T2DM) each year, the need for increased dissemination of diabetes prevention interventions is imperative [1]. The CDC's National Diabetes Prevention Program (NDPP) is a public-private partnership effort to address diabetes through increased screening and interventions. A primary component of the NDPP is the lifestyle change programs, referred to as the Diabetes Prevention Program (DPP), that address weight

status, diet quality, and physical activity. Although weight loss is the primary driver for risk reduction observed in lifestyle interventions for preventing type 2 diabetes, dietary quality is an important component of a healthy lifestyle and related to overall reduced risk for type 2 diabetes. Several studies have investigated this relationship and found significant associations between diet quality and T2DM risk that may even be independent of weight loss [11, 34, 36, 37]. Ley et al. observed a lower T2DM risk (pooled hazard ratio [HR] = 0.84 [95% CI 0.75-0.90]) with a greater than 10% increase in Alternative Healthy Eating Index scores in a large longitudinal study investigating diet quality and T2DM incidence, and these associations were only partly (32%) explained by changes in body weight [34].

The DPP is a community-based translation of the clinical trial shown to reduce rates of T2DM in samples of the prediabetes population by up to 58% [2]. The DPP is a 1-year program, including a core phase (months 1-6) of at least 16 weekly sessions and a core maintenance phase (months 7-12) of at least 6 monthly sessions. During these approximately 1-hour sessions, participants meet in groups with a trained lifestyle coach to discuss and problem-solve lifestyle behaviors related to nutrition and physical activity for weight loss and decreased T2DM risk, using the DPP curriculum as a discussion guide. The first DPP curriculum was released in 2012, and an updated version, referred to as the Prevent T2 curriculum, was recently released in 2017. The curriculum is significantly altered from the original 2012 curriculum and from the focus of the curriculum used in the original clinical trial [3]. While the Prevent T2 curriculum incorporates the Diabetes Plate Method suggested to be beneficial for individuals with prediabetes, the curriculum includes no specific dietary goals for participants, such as energy intake or food group goals [135]. Little has been published on the effectiveness of the DPP since the release and implementation of the Prevent T2 curriculum in 2017.

The DPP in Cooperative Extension

In 2012, the CDC began the National DPP effort to increase dissemination of the DPP lifestyle change program in not only clinical contexts but also community contexts, including Cooperative Extension Services (CES) [4]. CES has a history of delivering health education and interventions to improve the lives of citizens. In many states, CES county professionals deliver lifestyle interventions for chronic disease prevention and management [130]. With its presence in every county in almost every state, as well as an infrastructure that includes CES state-level specialists with content and administrative expertise in nutrition and health programming, CES is poised as an effective platform for dissemination and implementation of the DPP. In fact, many CES organizations are becoming DPP providers, with 31 CES organizations listed as CDC-recognized DPP providers [136]. However, there is limited evidence of the effects of the DPP when implemented as intended in community contexts such as CES [89, 99].

Social support and lifestyle change

The importance of social support in personal health behavior change has long been recognized [137]. Interventions similar to the DPP have found perceived social support to increase with the intervention and to be associated with immediate and sustained outcomes [80, 138]. In light of this important role of social support in success of programs similar to the DPP, social support enhancements have the potential to increase intervention effectiveness [103].

A variety of health interventions have shown the use of Facebook social support groups to be effective as a stand-alone intervention or an intervention enhancement. An 8-week Facebook intervention designed to promote walking among college-aged women found that participants in the Facebook group were getting an average 2,336 steps/day (equating to about 1.3 miles or 26 minutes) more than the control group ($p < 0.001$) [83]. Another study found that a

Facebook social support group enhancement to the 4-month maintenance phase of a weight loss intervention was significantly associated with weight loss, even after adjusting for number of monthly maintenance sessions attended (-0.43 kg [0.95 lb] for every 10 Facebook comments or likes by participants) [87]. Taken together, these and other studies suggest that online social media platforms such as Facebook may enhance intervention health outcomes [139-142].

Thus, the purpose of the present study was to evaluate 1) effectiveness of the DPP in improving weight status, physical activity, diet quality, and health-related quality of life when delivered as intended by Extension, and 2) the association between engagement with a social media group and DPP health outcomes.

Design

The present study was part of a 12-month, multi-site, hybrid type 2 effectiveness-implementation trial of the DPP in [STATE] CES [103, 104, 114]. The implementation evaluation is described elsewhere (see Chapter 4). The present study assesses effectiveness among participants using a repeated measures design where all participants received the intervention with no comparison or control group. All methods and procedures were approved by the University of Georgia Institutional Review Board of Human Subjects, and DPP participants provided written informed consent.

Setting

The present study was conducted in the Cooperative Extension Service (CES) in [STATE]. Lifestyle coaches administering the DPP were Family and Consumer Sciences (FACS) Extension county professionals in [STATE] trained as lifestyle coaches by the Diabetes Training and Technical Assistance Center (DTTAC) at Emory University. Twelve FACS CES professionals implemented the DPP in 13 sites across [STATE], 5 programs in the northeast

region, 5 programs in the northwest region, 2 programs in the southeast region, and 1 program in the southwest region. Of the 13 counties in which the program was implemented, 7 counties were metropolitan and 6 were nonmetropolitan [143]. One CES professional delivered programs in 2 counties.

Participants

Inclusion criteria

Participants were recruited for the Diabetes Prevention Program according to the CDC guidelines: BMI $\geq$ 25 kg/m^2 and a clinical prediabetes diagnosis or a score of $\geq$ 5 on the CDC/American Diabetes Association prediabetes risk test [95, 144]. The research study inclusion criteria were more restrictive and limited to those who met these guidelines, but also the additional inclusion and exclusion criteria below.

Because the DPP is designed for adults and to prevent potential confounding factors present in the adolescent life stage, only adults, both males and females, 18 to 75 years of age were included in the study and program. While the CDC does not place an upper age limit on DPP participation, the present study excluded participants over 75 years of age due to a physical function assessment completed as part of the larger study (not part of this dissertation nor completed at midpoint or post-intervention due to COVID-19 restrictions).

Exclusion criteria

Individuals who were pregnant or with self-reported current diagnoses of T2DM, chronic kidney disease, liver disease, cancer, Alzheimer's or other dementias, or severe physical or cognitive limitations were excluded from the analytical sample.

Note that because this was a translational study, the program was offered to all individuals in a setting, regardless of prediabetes or T2DM risk status. However, participants

without prediabetes, not at high risk for prediabetes or T2DM, or already with T2DM were not included in the analytical sample.

Recruitment

Participants were recruited for the DPP by CES professionals in their respective counties through physician referrals, new or existing community collaborations/relationships, local employers, flyers, newspaper ads, radio announcements, and social media advertisements. The CES professionals recruited participants for the research study at in-person informational sessions to join the DPP program or via email upon expressed interest in the program. All study participants provided informed consent to participate in the research.

A total of 124 individuals attended a DPP informational session or otherwise expressed interest in participating in the DPP. Of those, 119 were eligible for the program; and 89 were eligible for the research based on the inclusion and exclusion criteria above. Information needed to determine eligibility was collected via paper questionnaires based on CDC DPP eligibility criteria and the Physical Activity Readiness Questionnaire (PARQ) (Appendix D). A nutrition graduate student screened all potential participants for eligibility in the program and research. For those who were eligible for both the program and research but indicated a potential concern for engaging in PA in their response to questions on the PARQ, kinesiology graduate students contacted these participants to determine safety of participating in PA over the course of the program. Following screening, a total of 88 participants enrolled in the study at baseline.

Intervention

DPP intervention characteristics

The DPP was implemented according to the 2018 CDC Diabetes Prevention Recognition Program (DPRP) standards [95]. The most updated DPP curriculum, Prevent T2, was used in this

study. Following the DPRP standards, the schedule included weekly sessions for the first 16 weeks, followed by one session every two weeks for approximately 2 months, and monthly sessions for the last 6 months of the program (core maintenance). Program implementation began in person in January – March 2020 and continued through January – March 2021. Upon the onset of the COVID-19 pandemic, program implementation of all 13 DPPs was converted from in-person to distance learning formats following the CDC DPRP COVID-19 pandemic guidelines [145]. Twelve groups utilized Zoom and one group utilized FreeConferenceCall.com® to conduct sessions. All groups remained in the distance learning format for the remainder of the program [146, 147].

Social support enhancement

DPP participants were invited to join a social media group as a potential source of additional social support. This program enhancement utilized a private Facebook group to connect DPP participants throughout the state, provide a platform for communication and problem-solving outside weekly/monthly sessions, and allow for support from and communication with Extension DPP leadership outside weekly/monthly sessions. The research team (state-level Extension specialist and trained graduate students) posted prompts three times per week throughout the 12-month intervention to encourage discussion among the group or share evidence-based nutrition and physical activity information and resources [87, 148]. Prompts were tailored to the curriculum topic for that week or featured current events/news in nutrition and physical activity (Appendix H). For example, in week 1 of the intervention, participants were introduced to the tracking and goal-setting components of the DPP with the "Introduction to the Program" lesson. A link to an Extension newsletter that included an article on goal-setting was provided, along with the following caption:

> How many of you set a goal this first week of your Prevent T2 class? Goal setting is a key part of the Prevent T2 program. The two big goals of the Prevent T2 program are 1) 5-7% weight loss and 2) 150 minutes of moderate physical activity each week. Each week, you will make an "Action Plan" to meet your goal for the next week. Check out pages 4 and 5 of the [university] Extension newsletter linked below for tips on setting SMART goals each week!

Main outcome measures

With the exception of weight at baseline and 24-hour dietary recalls completed using ASA-24, all measures were self-reported by participants via Qualtrics online survey software [149]. Participants were sent an email with individualized links to Qualtrics surveys, their personalized ASA-24 username and password with the link to log into the ASA-24 website, and instructions on completing the surveys. Participants were given 2 weeks to complete all surveys at each timepoint. Baseline surveys were sent approximately 1 week prior to the first DPP session. Midpoint surveys were sent at the start of month 6 of the program, and post-intervention surveys were sent at the start of the final month of the DPP.

Demographic information

Demographic information of participants, including age (years), sex, race (American Indian or Alaska Native, Asian or Asian American, Black or African American, Native Hawaiian or Other Pacific Islander, White), ethnicity (Hispanic or Latino, Not Hispanic or Latino), and education level (some high school, graduated from high school or got a GED, some college or technical school, college graduate), was also collected according to CDC DPRP standards [95]. Demographic variables were treated as independent variables in all statistical analyses to determine any influences on outcomes or changes in outcomes over time. Race was reduced to Black, White, and Other based on small sample size in the following categories: Asian (n = 2), Multiracial (n = 1).

Weight loss

Anthropometrics were assessed at baseline, midpoint, and post-intervention. Height was measured at baseline by CES professionals with portable stadiometers (Seca model 213). Weight was measured at baseline and at each DPP session by CES professionals with research-grade digital scales (Seca model 876) with participants wearing clothes and no shoes until the switch to distance learning in March 2020. Participants were instructed to take note of the clothes they had on at baseline or take a picture of themselves so they could wear something similar at midpoint and post-intervention. Following the onset of the COVID-19 pandemic, participants self-reported weight using a home scale of their choice or digital scale provided by the research team (Etekcity Model EB4074C, EB9388H, EB9380H or EB4473C). Weight change and percent weight change were calculated from baseline to 6 and 12 months, and the percentage of participants achieving 2%, 5%, and 7% weight loss was calculated to examine clinically meaningful weight change (2%) and meeting intervention goals (5 to 7%) [19, 95]. BMI was also calculated (weight (kg)/height (m^2)) at baseline, midpoint, and post.

Diet quality

Diet quality was assessed with the Healthy Eating Index-2015 (HEI-2015), calculated from 24-hour dietary recalls, and the 26-item Dietary Screener Questionnaire [38, 40, 150]. The HEI-2015 includes 12 components (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars, saturated fats) [40]. Each component is scored individually, and the scores from each component are totaled to provide an overall HEI-2015 score. Component scores range from 0-5 or 0-10, depending on the component; and HEI total scores can range from 0 to 100. The HEI-

2015 was calculated at each time point (baseline, midpoint, and post) from at least one 24-hour recall [38, 40].

Dietary recalls were collected online from participants using the Automated Self-Administered 24-hour recall (ASA-24), 2018 version; and participants were instructed to complete two 24-hour recalls, one weekday and one weekend day, at each time point (baseline, midpoint, post) [47, 48]. Participants were emailed a link to the ASA-24 website, along with their individualized ASA-24 username and password. Each participant's username and password did not change throughout the course of the study. Participants simply entered their username and password (for example, username: DPPExt500; password: Food%500) into the ASA-24 website homepage linked in the email. The ASA-24 website then prompted participants to answer questions about everything they consumed (both food and beverages) over the last 24 hours. Participants were also asked about where they consumed their food/beverages, if they ate alone or with someone, if they were watching television or using a computer while eating/drinking, and if they took any supplements.

While determining feasibility of ASA-24 use in community settings was of interest to collect detailed dietary quality data and calculate HEI scores, the researchers anticipated a potentially poor response rate on the ASA-24 due to the extra participant burden of the detailed questions asked by the ASA-24 recall. Therefore, the 26-item Dietary Screener Questionnaire (DSQ) food frequency questionnaire was used as an additional measure of diet quality [150]. The DSQ asks participants to report usual intake of specific foods: fruits, vegetables, dairy/calcium, whole grains/fiber, and added sugars [150] to predict usual intake over a 30-day period. No total "score" is calculated from the DSQ like the HEI-2015 score. Rather, the DSQ provides estimated quantities of food groups consumed. The DSQ has demonstrated satisfactory agreement with the

24-hour recall, with mean intakes differing by less than 2%, and is useful in settings like a community-based study where the researchers are less able to support participants in completion of a 24-hour recall or participant comprehension or burden is a concern [150]. DSQs were administered online via Qualtrics survey software at baseline, midpoint, and post-intervention.

Physical activity

Physical activity (PA) was assessed with the International Physical Activity Questionnaire-Short form, collected online at baseline, midpoint, and post-intervention. The IPAQ-Short has been validated in its use of categorizing adults based on activity level [28]. Metabolic equivalent (MET)-minutes of walking, moderative, and vigorous PA were calculated from participant responses, and participants were categorized as 1) inactive, 2) minimally active, or 3) HEPA (health-enhancing physical activity)-active, according to IPAQ-Short data processing guidelines [29]. Participants also self-reported moderate PA minutes/week at each DPP session in accordance with CDC DPRP requirements. Moderate PA minutes reported at midpoint and post-intervention were also considered in assessment of PA and of whether participants met the program goal of 150 minutes of moderate PA/week at each time point. Baseline self-report of weekly PA was not included in the analysis, as PA reporting in the DPP does not begin until approximately week 4 of the program.

Health-related quality of life

Health-related quality of life (HRQoL) was assessed using the CDC's HRQoL-14 measure, collected online at baseline, midpoint, and post [60, 63]. The number of physical and mental "unhealthy days" over the past 30 days were assessed, as well as the number of days participants suffered from physical limitations, pain, depression/sadness, anxiety, and inadequate rest/sleep and perceived themselves to be full of energy. Unhealthy BMI and cardiovascular

health have all been associated with HRQoL as measured by the CDC's HRQoL14 measure [61, 62]. Impaired glucose tolerance among individuals with prediabetes has also been associated with certain measures of HRQoL, highlighting the importance of this outcome measure [50].

Engagement with Facebook group

Engagement with the Facebook group was quantified by summing the number of views, likes/other reactions, comments, poll votes, and original posts of participants throughout the duration of the intervention, modeled after methods by Hales et al. [87]. After exploratory analyses revealed limited power to detect differences between levels of Facebook engagement, participants were dichotomized as either Facebook users or non-users. Participants who engaged with at least one Facebook post were categorized as Facebook users. Participants who either did not join the Facebook group or joined but did not engage with any posts were categorized as Facebook non-users. Engagement with the Facebook group was treated as an independent, dichotomous variable in all statistical analyses to determine any influences on outcomes or changes in outcomes over time.

Intervention attendance and completion

Participant attendance and program completion were tracked throughout the study. Total number of sessions attended (range of maximum total possible sessions: 25-27) during the core phase, the core maintenance phase, and throughout the whole program were calculated for each participant. Participants who attended at least 9 sessions during the core phase, at least 3 sessions during the core maintenance phase, and their first and last sessions over a minimum of 9 months during the 1-year program, per CDC DPRP standards, were considered to have completed the intervention "per protocol" [95]. Total number of sessions attended and per protocol completion

were treated as independent variables in all statistical analyses to determine any influences on outcomes or changes in outcomes over time.

Analysis

Data cleaning

Established cut offs, based on the 5th and 95th percentiles of intakes reported in the National Health and Nutrition Examination Surveys (NHANES), were used to identify outliers in the ASA-24 and DSQ data [151]. Outliers in the ASA-24 data were removed if total kilocalories, protein, and/or total fat intakes reported were outside the 5th to 95th NHANES percentiles. While cut offs for vitamin C and beta-carotene intakes exist, food items consumed by individuals with reported intakes outside the 5th-95th percentiles were evaluated to determine reasonability of portion size of vitamin C- or beta-carotene-containing foods. Thus, not all recalls with vitamin C or beta-carotene intakes outside the cutoffs were removed if it was determined that portion sizes were reasonable based on established criteria [151]. Of the 120, 60, and 56 total recalls completed at baseline, midpoint, and post-intervention, 10, 4, and 5 outliers were removed, respectively, based on the above criteria.

Statistical analyses

All statistical analyses were performed using SPSS version 27 [152].

The study analytical sample includes all participants with data at baseline and who completed at least one session of the program. Missing data was not imputed or the last value carried forward with one exception: physical activity minutes per week. As part of the intervention, participants were self-reporting physical activity minutes on a weekly basis at the midpoint of the study. Thus, if a participant was missing a value at midpoint data collection, but had a value for the previous week, that value was carried forward. Missing data was not imputed

for post-intervention physical activity minutes per week, as participants were reporting PA on a monthly basis. Since the previous value was a minimum of three weeks prior to the post-intervention data collection, it could not be reasonably assumed that physical activity was similar to post-intervention quantity per week.

Descriptive statistics (numeric variables: mean, standard deviation, median, range; categorical variables: frequency and percentages) were used to describe participant demographics (age, sex, race, ethnicity, education level), participation by site (county), session attendance, participants meeting "per protocol" session attendance/program completion requirements, and engagement with the Facebook group. Descriptive statistics were also calculated for primary outcomes (weight, moderate PA minutes/week, PA category, HEI-2015 total score, DSQ predicted food group/nutrient intakes, and days experiencing some health-related quality of life factor [poor physical health, poor mental health, physical limitations, pain, sadness, worry, rest, energy]).

Regression models were used to explore changes in each outcome over time (repeated measures) and relationships of independent variables (demographics, attendance, social media engagement) with the primary outcomes (weight, physical activity, diet quality, and health-related quality of life). Most models were mixed effects models to account for the random variation within an individual and over time, and the random effect of intervention site. Most analyses used a repeated measures approach to evaluate outcomes at the three time points. Exceptions to this were models exploring the primary CDC intervention outcomes: meeting 5% weight loss goal and meeting 150-minute moderate PA goal which were each assessed at midpoint and post-intervention only.

For continuous outcomes (weight, PA minutes/week, HEI-2015 total score, some DSQ variables [fiber, fruits/vegetables/legumes/French fries, vegetables/legumes/French fries, vegetables/legumes, dairy, calcium]) that were normally distributed, linear mixed effects models were used to evaluate changes over time, and relationships between independent and dependent variables. Model residuals were tested for normality through histograms and visualizations. Variables (PA minutes/week, some DSQ variables [whole grains, fruits/vegetables/legumes, fruit, sugar]) were natural log transformed as needed to meet the distribution assumptions of the linear mixed effects model.

For binary outcomes (the primary CDC intervention goals: meeting 5% weight loss goal, meeting 150-minute moderate PA per week), HRQoL factors [days of poor physical health, poor mental health, physical limitations, pain, sadness, worry, rest, energy]), a binary logistic regression models with a logit link was used to evaluate relationships between independent variables and these outcomes of interest. In the models predicting meeting the 5% weight loss goal, baseline weight was explored for significance in predicting the outcome. It was not significant and removed from the models.

After review, the HRQL variables were not treated as numeric variables due to skewed distributions, but were treated as binomial variables instead. Each observation was treated as a collection of 30 binary trials, as the items asked about number of days out of the last 30 where a participant was affected. In order to account for the lack of independence within one observation, an additional random effect for time point within participant was added to the model.

For ordinal outcomes (PA category, one DSQ variable [sugar-sweetened beverages]), an ordinal logistic regression repeated measures model with a cumulative logit link was used to evaluate changes over time, and relationships between independent and dependent variables. The

DSQ sugar-sweetened beverage variable was changed from continuous to ordinal as a floor effect was observed, with no participants having values below 3.57. To allow for analysis, values were broken into three categories to get roughly equal distributions among the three categories.

A forward selection process was used in all models to test for significant independent variables. Type III F tests were conducted, with the level of significance for entry into and removal from the model set a priori at $p < 0.05$. Post-hoc analyses were conducted for significant independent variables in the models, which included calculation of estimated marginal means or proportions beta coefficients and pairwise comparisons using Bonferroni corrections where appropriate. For repeated measures, changes over time were included in the model first and remained even if not statistically significant, followed by demographics (age, sex, race, education), attendance (sessions), per protocol attendance, and engagement with Facebook group for significance in predicting the outcome of interest. All of these variables entered the model for forward selection purposes individually and in combination with their interaction with time. Note that ethnicity was not included in the demographic variables, as the study sample included little variability by ethnicity.

The final models presented include only the variables that were found to be statistically significant through this forward selection process in predicting the selected outcome of interest. Note that if a variable no longer met the threshold of significance following the inclusion of additional variables, it was removed.

To assess the relationship between engagement with the Facebook group and general social support (as measured by the Multidimensional Scale of Perceived Social Support [MSPSS]), Mann-Whitney tests were used to determine differences in general social support at each timepoint between Facebook engagers and non-engagers.

Post hoc pairwise comparisons involved exploring significant variables from regression models and estimating marginal means and probabilities. Bonferroni adjustment and other adjustments for multiple comparisons were used as appropriate to the data and model type when comparing across time or categories to adjust the level of significance so that there was an overall *p* value of 0.05 on any of the tests, rather than a *p* value of 0.05 of any one of the tests. To explore the effects of interaction terms, outcomes were modeled across a range of the independent variable as a function of time.

Results

Participant characteristics, including demographics, site, and baseline weight and BMI, are reported in Table 2.1. Participants (N = 88) were, on average, middle age (mean age 56.4 years), mostly females (85.2%), mostly white (70.5%), black/African American (26.1%), and not Hispanic or Latino (94.3%). Most participants were either college graduates (52.3%) or had some college or technical school (31.8%). Of the 88 participants that completed baseline measures, 60 were still active in the intervention and completed post-intervention measures for a retention rate of 68% in the study, although not all participants provided complete data at each time point.

Descriptive statistics for the primary outcomes at each time point (baseline, midpoint, post-intervention) are reported in Table 2.2. Notably, participants lost an average of 4.9 ± 4.9 kg (median = 3.8 kg [range: -5.7 kg, 20.9 kg]) and 5.2% ± 5.0% of their initial body weight (median = 3.8% [range: -3.4%, 19.4%]), with 46.7% of participants meeting the CDC intervention goal of 5% weight loss by the end of the intervention. Additionally, 75.4% of participants lost at least 2% of their initial body weight; and 31.1% lost at least 7% of their initial body weight. At post-intervention, 56.7% of participants reported meeting the 150 minutes per week of moderate

physical activity (mean = 179.0 ± 122 minutes per week; median = 152.5 [range: 30-822]). The following sections report on results of the regression modeling to explore relationships between independent demographic, attendance, and Facebook engagement variables and health outcomes. Results are presented as *b,* SE*,* mean difference (MD)*,* estimated marginal means or probabilities, Odds Ratios (OR), and 95% Confidence Intervals (CI).

Weight loss

Weight decreased over time (Table 2.3), with significant reductions between baseline and midpoint (MD = 4.4 kg [95% CI: 3.2-5.5], $p < 0.001$) and baseline and post-intervention (MD = 4.9 kg [95% CI: 3.7-6.1], $p < 0.001$), but no significant changes between midpoint and post-intervention. Age was a significant predictor in the model for weight change (Table 2.3). As age increased by 1 year, average weight decreased by 0.67 kg (b = -0.67, SE: 0.18, t (76.37) = -3.74, $p < 0.001$). There was no interaction of age with time, however. There was also a significant interaction between race and time (Table 2.3). Post hoc testing revealed that while all three race categories experienced significant decreases in weight throughout the intervention, the mean reduction in weight from pre- to post-intervention among individuals of "other race" was nearly two to three times greater than that of white and black individuals, respectively (Table 2.4, Figure 2.1A).

Binary logistic regression revealed that baseline weight was not a significant predictor of meeting the CDC intervention 5% weight loss goal. No other independent variables were significant predictors of meeting this goal.

Physical activity

PA category changed significantly over time (Table 2.3) such that compared to baseline, the odds of a participant being in a higher-ordered PA category were estimated to be 2.78 times

higher at midpoint and 3.99 times higher at post-intervention. Notably, no participants reported being in the "inactive" category at post-intervention (Table 2.2). No significant independent variables or interactions with time were found to predict PA category.

Minutes of moderate PA/week did not change significantly over time in the unadjusted model. However, after adjusting for attendance, time became significant (Table 2.3). There was a significant interaction between time and attendance (Table 2.3). Post hoc testing modeling attendance at 5, 15, and 25 sessions (low, moderate, high attendance) revealed that for those with low and moderate attendance, estimated moderate PA min/wk significantly increased from midpoint to post-intervention; but for those with higher attendance, there was no change from midpoint to post-intervention in PA min/wk (Table 2.4, Figure 2.1B – note that this outcome was natural log transformed to improve fit for the linear mixed effects model, so values in Table 2.4/Figure 2.1B are not on the original scale). Estimation of this interaction involved extrapolating the slope for number of sessions attended at the 5-session attendance level, as participants who only attended 5 sessions did not have data at midpoint or post-intervention. Thus, caution should be taken when interpreting the influence of number of sessions attended on changes in moderate PA minutes/week over the course of the intervention.

Participants meeting the CDC intervention goal of 150 minutes moderate PA/week was also assessed. At midpoint, 56.9% of participants met this intervention goal; and 56.7% met this goal at post-intervention. Neither time nor any other independent variables were related to change in meeting this PA goal or in meeting the goal by the end of the intervention.

Diet quality

Diet quality as assessed by the HEI-2015 total score did not change significantly over time, and there were no interactions of independent variables with time (Table 2.3). However,

age was a significant predictor of HEI-2015 total score (Table 2.3), such that as age increased, HEI-2015 total increased (b = 0.35, SE: 0.12, t (59.32) = -3.03, p = 0.004). No other independent variables were significant predictors of HEI-2015 total.

Several of the diet quality variables as assessed by the DSQ changed over time and/or were related to demographics or attendance. Regression analyses revealed that fiber and fruit and vegetable intake, as assessed by the DSQ, increased over time. Education and attendance were related to change in fiber intake, while race was related to change in combined vegetable and fruit intake and age and attendance were related to change in fruit intake alone over time. Detailed descriptions of DSQ results are provided below.

Fiber: Predicted fiber intake (grams/day) significantly increased over time (Table 2.3), with significant increases between baseline and midpoint (MD = -0.80 [95% CI: -1.52,-0.08], p = 0.023) and baseline and post-intervention (MD = -0.84 [95% CI: -1.54,-0.14], p = 0.013), but no significant changes between midpoint and post-intervention. Sex was a significant predictor of fiber intake (Table 2.3), with males having higher intakes than females. Education was also a significant predictor (Table 2.3). There were also significant interactions between time and education and between time and attendance (Table 2.3). Participants who were college graduates had significantly higher predicted fiber intakes at midpoint and at post-intervention compared to baseline, whereas there were no changes in fiber intake among those with high school or some college education (Table 2.4, Figure 2.1C). When exploring predicted fiber intakes at different levels of attendance (5, 15, and 25 sessions), predicted fiber intake increased significantly from baseline to midpoint at attendance of 5 and 15 sessions, and intake increased significantly from baseline to post-intervention at 25 sessions (Table 2.4, Figure 2.1D). Estimation of this interaction involved extrapolating the slope for number of sessions attended at the 5-session

attendance level, as participants who only attended 5 sessions did not have data at midpoint or post-intervention. Thus, caution should be taken when interpreting the influence of number of sessions attended on changes in fiber intake over the course of the intervention.

Fruits and vegetables (including legumes and French fries): Predicted intake of fruits/vegetables/legumes/French fries (cup equivalents/day) did not significantly change over time (Table 2.3). Sex and education were significant predictors of intake, with males having higher predicted intakes than females and college graduates than those with some college or technical school (Table 2.4). No other independent variables were significant predictors of intake, and there were no other interactions with time.

Fruits, vegetables, and legumes (excluding French fries): Predicted intake of fruits/vegetables/legumes (cup equivalents/day) increased significantly over time (Table 2.3). Sex and education were significant predictors of intake (Table 2.3), with males having higher predicted intakes than females and college graduates having higher predicted intakes than those with some college or technical school or those with some high school or high school or GED (Table 2.4).

Vegetables (including legumes and French fries): Predicted intake of vegetables/legumes/French fries (cup equivalents/day) did not significantly change over time in the unadjusted model; however, after controlling for independent variables, time became significant (Table 2.3). Sex and education were significant predictors of intake (Table 2.3), with males having higher predicted intakes than females and college graduates than those with some college or technical school (Table 2.4). These effects were unrelated to time/change over the course of the intervention. There was also a significant interaction between time and race (Table 2.3), with the "other" race category alone seeing significant increases between baseline and

midpoint and baseline and post-intervention (Table 2.4, Figure 2.1E). Upon removal of the "other" race category, the time*race interaction was no longer significant; and time was no longer significant in the adjusted model.

Vegetables and legumes (excluding French fries): Predicted intake of vegetables/legumes (cup equivalents/day) did not significantly change over time in the unadjusted model; however, after controlling for independent variables, time became significant (Table 2.3). Sex and education were significant predictors of intake (Table 2.3), with males having higher predicted intakes than females and college graduates having higher intakes than those with some college or technical school (Table 2.4). These effects were unrelated to time/change over the course of the intervention. A significant interaction between race and time was also found (Table 2.3), with the "other" race category alone seeing significant increases between baseline and midpoint and baseline and post-intervention (Table 2.4, Figure 2.1F). Upon removal of the "other" race category, the time*race interaction was no longer significant; and time was no longer significant in the adjusted model.

Fruit: Predicted fruit intake (cup equivalents/day) did not significantly change over time (Table 2.3). Education and attendance were significant predictors of fruit intake (Table 2.3), with college graduates having significantly higher intakes than those with some college or technical school (Table 2.4). There were also significant interactions between time and attendance and time and age (Table 2.3). To examine these interactions, fruit intake was explored at different levels of attendance. When predicting fruit intakes at different levels of attendance (5, 15, and 25 sessions), estimated mean fruit intake increased significantly from baseline to midpoint at attendance of 5 and 15 sessions; but fruit intake did not increase significantly from baseline to midpoint or post-intervention at 25 sessions (Table 2.4, Figure 2.1G). Estimation of this

interaction involved extrapolating the slope for number of sessions attended at the 5-session attendance level, as participants who only attended 5 sessions did not have data at midpoint or post-intervention. Thus, caution should be taken when interpreting the influence of number of sessions attended on changes in fruit intake over the course of the intervention. Similarly for the interaction between age and time, predicted fruit intakes were assessed at different age levels. At age 65 years, predicted mean fruit intake was significantly greater at midpoint and at post-intervention compared to baseline (no change from midpoint to post-intervention) (Table 2.4, Figure 2.1H). At age 80 years, predicted fruit intake increased significantly from baseline to post-intervention (Table 2.4, Figure 2.1H).

Dairy: Predicted dairy intake (cup equivalents/day) did not significantly change over time (Table 2.3). Sex was a significant predictor of dairy intake (Table 2.3), with males having higher predicted dairy intakes than females. No other independent variables were significant predictors of dairy intake, and there were no interactions with time.

Calcium: Predicted calcium intake (milligrams/day) did not significantly change over time (Table 2.3). Sex was a significant predictor of calcium intake (Table 2.3), with males having higher predicted calcium intakes than females. No other independent variables were significant predictors of calcium intake, and there were no interactions with time.

Whole grains: Predicted whole grain intake (ounce equivalents/day) did not significantly change over time, and there were no significant independent variables or interactions with time (Table 2.3).

Total added sugars: Predicted total added sugar intake (teaspoon equivalents/day) did not significantly change over time, and there were no significant independent variables or interactions with time (Table 2.3).

Sugar-sweetened beverages: Predicted added sugar intake (teaspoon equivalents/day) from sugar-sweetened beverages did not significantly change over time, and there were no significant independent variables or interactions with time (Table 2.3).

Health-related quality of life

Physically unhealthy days: The number of physically unhealthy days reported by participants changed over time (Table 2.3). Pairwise contrasts indicated that the difference was between baseline and midpoint, (Table 2.5). Moreover, the estimated marginal probability of reporting a day of poor physical health was lower at midpoint (*Pr(Physically Unhealthy)* = 0.007, 95% CI: 0.003, 0.019) compared to baseline (*Pr(Physically Unhealthy)* = 0.028, 95% CI: 0.013, 0.060). There was no difference between baseline and post intervention (*Pr(Physically Unhealthy)* = 0.028, 95% CI: 0.013, 0.060), and no difference between midpoint and post intervention. None of the independent variables were related to physically unhealthy days, and there were no interactions with time.

Mentally unhealthy days: The number of mentally unhealthy days reported by participants did not significantly change over time (Table 2.3). Age was a significant predictor of mentally unhealthy days reported (Table 2.3), with the odds of having a mentally unhealthy day decreased for every additional one year of age (OR= 0.93; 95% CI: 0.90, 0.97; b = -0.07, t (129) = -3.42; $p < 0.001$).

Interference of physical or mental health with daily life: The number of days in which poor physical or mental health interfered with daily life did not change over time (Table 2.3). Age was a significant predictor of this outcome (Table 2.3), with the odds of having a day interfered by poor health decreased by about 6% for every additional one year of age (OR= 0.94; 95% CI: 0.90, 0.99; *b(SE)* = -0.06 (0.03); t = -2.41; $p = 0.017$). There was also a significant

interaction between time and education (Table 2.3). However, following the Bonferroni adjustment for post-hoc tests, none of the individual comparisons were statistically significant. For participants with some college or technical school, the probability of a day being interfered by poor health was higher at post-intervention compared to baseline, although this difference did not meet statistical significance (Table 2.3, Figure 2.2A). For college graduates, the probability was lower at midpoint compared to baseline, although this difference did not reach statistical significance (Table 2.5, Figure 2.2A).

Pain: The number of days in which pain interfered with daily life did not change over time in the unadjusted model; however, after controlling for independent variables, time became significant (Table 2.3). No other independent variables were significant predictors, but there was a time*age interaction (Table 2.3). Days interfered by pain were assessed at different age levels. At lower ages (20, 35, 50), there were no statistically significant differences in the probability of having a day where pain interfered with activities (Table 2.5, Figure 2.2B). At ages 65 and 80 years, the estimated probability of having days interfered by pain was significantly lower at midpoint compared to baseline or post-intervention (Table 2.5, Figure 2.2B). Moreover, at age 65, the probability of a day interfered by pain was significantly higher at baseline (*Pr(Pain)* = 0.020, 95% CI: 0.007, 0.058) and post intervention (*Pr(Pain)* = 0.015, 95% CI: 0.007, 0.058) compared to midpoint (*Pr(Pain)* = 0.001, 95% CI: 0.000, 0.009). The same relationship was found for those 80 years of age: the probability of a day interfered by pain was significantly higher at baseline (*Pr(Pain)* = 0.032, 95% CI: 0.005, 0.191) and post intervention (*Pr(Pain)* = 0.020, 95% CI: 0.003, 0.137) compared to midpoint (*Pr(Pain)* = 0.0002, 95% CI: 0.000, 0.005).

Sadness: Days experiencing sadness did not change over time (Table 2.3). Age was a significant predictor of this outcome (Table 2.3), with the odds of having a day experiencing

sadness decreased for every additional one year of age (OR= 0.93; 95% CI: 0.89, 0.97; t = -3.14; $p = 0.002$). No other independent variables were significant predictors, and there were no interactions with time.

Worry: Days experiencing worry did not change over time (Table 2.3). Age was a significant predictor of this outcome (Table 2.3), with the odds of having a day experiencing worry decreased for every additional one year of age (OR= 0.94; 95% CI: 0.89, 0.99; $b = -0.07$; t (58) = -2.45; $p = 0.014$). No other independent variables were significant predictors, and there were no interactions with time.

Rest: Days experiencing inadequate rest did not change over time (Table 2.3), and there were no significant predictors or interactions with time.

Energy: Days experiencing energy did not change over time in the unadjusted model; however, after forward selection, there was a significant effect of race and an interaction between age and time (Table 2.3). The probability of having more days full of energy was higher for black/African American participants than for white participants (Table 2.5, *Pr(Energy)*, 95% CI, Black: *Pr(Energy)* = 0.91, 95% CI 0.70, 0.98, White: *Pr(Energy)* = 0.52, 95% CI: 0.28, 0.75). Days full of energy were assessed at different age levels. At ages 20, 35 and 50 years, the estimated marginal probability of having a day full of energy was higher at post-intervention compared to baseline or midpoint (Table 2.5, Figure 2.2C). No changes in probability seen at ages 65 and 80 years appears to be due to higher estimated marginal probabilities at baseline and midpoint for these age groups compared to younger age groups (Figure 2.2C).

<u>Engagement with Facebook group</u>

Engagement with the Facebook group was entered as an independent variable in all models and was not found to be a significant predictor for any outcome. Facebook engagement

was also treated as an independent variable to predict changes in general social support assessed via the MSPSS questionnaire (using Mann-Whitney tests to account for non-normal distribution of general social support as an outcome). Facebook engagers versus non-engagers did not have significant differences in perceived general social support at any timepoint over the course of the intervention.

See Chapter 3 for detailed analyses of other social support measures.

Discussion

This study provides insight into outcomes of the Diabetes Prevention Program when translated into the community setting of a state Cooperative Extension Service. Statistically significant and clinically meaningful weight loss occurred over the course of the program. While the average weight loss achieved by participants in the present study (mean = 4.9 kg, 5.2% initial body weight; median = 3.8%) did not reach the level observed in the DPP clinical trial (6.5 kg, 6.9% initial body weight), average percent weight loss of participants in the present study (5.2%) exceeded average weight loss reported in a recent analysis of 14,747 participants in the National DPP effort (4.2%; median = 3.1%) [3, 89, 138]. Percentage of participants in the present study meeting the minimum 5% weight loss goal of the DPP (46.7%) also exceeded that found by Ely et al. (35.5%) [138]. Notably, the evaluation by Ely et al. included DPPs implemented in a variety of settings, including clinical and community settings.

Several systematic reviews evaluating outcomes of community translations of the DPP have revealed similar weight loss outcomes to the present study. However, most of these community translations made adaptations to program length and session frequency that did not meet CDC DPRP implementation standards. While these translations are not directly comparable to the present study, Whittemore et al. found that average weight loss among DPP community

translations ranged from 1.5 kg to 6.1 kg, with 11-56% of participants achieving at least 5% weight loss [89]. Aziz et al. reported 0.45-7 kg average weight loss among DPP translations evaluated, with 20-64% of participants achieving the 5% weight loss goal [98]. Again, many of these translations involved significant adaptations to the DPP, including decreased program length and session frequency, likely contributing to the large range of weight loss outcomes [89, 98].

The present study provides insight into DPP outcomes when translated into the community setting of CES and delivered as intended according to CDC standards. It is expected that, even though the present study involved delivering the DPP as intended, the weight loss outcomes would be less than those of the DPP clinical trial. The lifestyle change intervention in the DPP clinical trial was delivered mostly by registered dietitians (RDs) in one-on-one settings with participants, while the National DPP effort allows individuals who are not RDs and come from a variety of educational and experience backgrounds to deliver the DPP in group settings [94, 100]. Furthermore, the revised DPP curriculum used in the present study, the Prevent T2 curriculum, focuses less on specific energy intake goals and more on encouraging self-monitoring and goal-setting for lifestyle change to allow for greater dissemination by a variety of individuals [94]. In light of these changes, the weight loss outcomes of the present translational study are not surprising.

Participants in the present study reported an average of 179 minutes of moderate PA/week at the end of the program, with 56.7% of participants meeting the CDC intervention goal of 150 minutes moderate PA/week. Again, these outcomes are similar to those reported by Ely et al., with participants in this large DPP evaluation reporting an average of 152 minutes of moderate PA/week and 41.8% meeting the CDC 150-minute moderate PA goal [138]. An interaction between time and attendance was also found in the present study to predict self-

reported moderate PA minutes/week. Interestingly, at higher levels of attendance (25 sessions), there were non-significant changes in PA from midpoint to post-intervention, while there were significant changes from midpoint to post-intervention at lower levels of attendance (5 and 15 sessions). A variety of factors could have contributed to this observation. Those with higher attendance may have increased their PA primarily during the first half of the intervention and maintained that level of PA from midpoint to post-intervention. Those with more sporadic attendance may have increased their PA more during the second half of the program, due to a lower "dose received" in the first half than those with greater and more consistent attendance.

Few studies of the DPP have explored the impact of the intervention on dietary quality. Although weight loss is the primary driver for risk reduction observed in lifestyle interventions for preventing type 2 diabetes, dietary quality is an important component of a healthy lifestyle and related to overall reduced risk for type 2 diabetes. Participants in the present study did not significantly increase their reported adherence to the Dietary Guidelines for Americans (HEI-2015 total score) over the course of the study. Older participants had higher diet quality (as measured by HEI-2015 total score), a finding consistent with previous research and national data on average HEI across the lifespan [153].

While changes in several diet quality outcomes as measured by the DSQ occurred in the present study, these changes were often limited to individuals with certain characteristics in the sample. While predicted fiber intake increased significantly over the course of the intervention, further exploration revealed that only college graduates significantly increased their predicted intake. Multiple factors could have contributed to this finding, including greater resources among the college graduate population to purchase fiber-rich foods like whole grains, vegetables, and fruits. This finding could also be due to the curriculum potentially being more appropriate for

individuals with higher levels of education. Vegetable and legume intake, both including and excluding French fries, significantly increased over time, but these increases were limited to individuals in the "other" race category. Little can be concluded about these relationships given the small sample size. When participants in the "other" race category were removed from the sample, the change in vegetable and legume intake, both including and excluding French fries, over time was no longer significant. Similarly, fruit intake significantly increased over time; but further exploration revealed that these significant changes were related to attendance and age. Interestingly, predicted fruit intake increased among those with lower attendance and did not change among those with higher attendance. This observation is similar to that seen with changes in self-reported moderate PA minutes/week. Again, a variety of factors could have contributed to this observation; but it is possible that those with lower attendance overestimated their fruit intakes compared to those participants who attended more sessions and had greater exposure to food tracking and accurate portion size estimations. Older individuals (65 and 80 years of age) were also the only age categories that had significant increases in fruit intake. As discussed above, older individuals have higher diet quality on average compared to younger individuals [153]. It is possible that older individuals were more receptive to making adjustments in their dietary intake, perhaps due to higher risk susceptibilities, or they had more time and/or resources to improve their dietary intake.

Importantly, fruit/vegetable/legume intake significantly increased over the course of the intervention, and this increase was not limited to certain subgroups of the study sample. However, predicted intake of whole grains, added sugars, and added sugars from sugar-sweetened beverages did not change over the course of the intervention. One would expect that predicted intake of carbohydrate sources like these would change over the course of the program,

as the curriculum teaches the Diabetes Plate Method with half of the plate for non-starchy vegetables and only one-quarter of the plate for grains/starches [97]. The 2012 DPP lifestyle change program curriculum first used as part of the National DPP effort utilized the standard USDA MyPlate plate method and focused heavily on total fat intake, along with energy intake [4, 97]. The newer Prevent T2 curriculum utilized in the present study was created as part of the National DPP effort to reflect new research in the nutrition and physical activity arenas, including research around the effectiveness of the Diabetes Plate Method for blood sugar control [135].

Neither the DPP clinical trial nor the DPP outcomes study report diet quality changes of participants. However, a recent secondary analysis was published evaluating diet quality of DPP clinical trial participants [5]. This study utilized the Alternative Healthy Eating Index (AHEI), which measures diet quality on a scale of 0-110 (compared to the HEI's scale of 0-100) [5]. This secondary analysis found a significant increase in AHEI scores of DPP participants, from an average score of 44.4 at baseline to 48.6 at post-intervention [5]. A few translations of the DPP have also explored dietary changes, focusing on vegetable and fruit intake as well as total fat intake, as that was a major component of the original 2012 DPP curriculum [79, 89, 154-156]. Two studies reported significant increases in vegetable and fruit intake and significant decreases in total fat intake, while the others observed no significant changes in these indicators of diet quality [79, 89, 154-156]. However, few of these published studies that report dietary changes utilized the new Prevent T2 curriculum, a relevant distinction in light of the different amount and focus of nutrition information in the Prevent T2 curriculum and the original 2012 curriculum, as discussed previously [97].

Again, it is not surprising that the participants in the DPP clinical trial increased adherence to the Dietary Guidelines for Americans, while participants in the present study and other DPP translations have not improved diet quality. The clinical trial involved one-on-one nutrition counseling with an RD, while the National DPP effort involves group delivery by lifestyle coaches from a variety of backgrounds. Furthermore, the new Prevent T2 curriculum provides participants with relatively little direction on making dietary changes compared to the 2012 curriculum. While the 2012 curriculum required revisions because of its focus on total fat intake, tangible goals for participants, like Calorie need goals, were also removed in the development of the Prevent T2 curriculum [97]. The combination of no one-on-one counseling with an RD and the diluted nutrition information in the new Prevent T2 curriculum likely contributes to the stagnant dietary quality seen in the present study and comparable studies.

Although not measured in the present study, nutrition literacy, defined as an individual's ability to retrieve, understand, and use nutrition information for making healthful nutrition decisions [157], may contribute to the minimal diet quality changes observed in the present study with the Prevent T2 curriculum. Preliminary data suggest that nutrition literacy, as measured by validated tools such as the Nutrition Literacy Assessment Instrument (NLit), is associated with diet quality [157]. A positive and significant relationship between NLit and diet quality as assessed by the Healthy Eating Index-2010 have been observed [157]. In this study, nutrition literacy contributed most to HEI-2010 scores when compared to other significant contributors, including education level, age, BMI, and diabetes diagnosis [157]. These data suggest that nutrition literacy plays an important role in diet quality. Our study found some relationships between education and dietary quality, suggesting that a particular education level may be needed to elicit changes in diet quality when the Prevent T2 curriculum is used for the DPP. However, this was not a

consistent relationship. Future research should evaluate changes in nutrition literacy with the Prevent T2 curriculum and association of those changes with participants' diet quality over the course of the program.

While the present study aimed to enhance the nutrition and physical activity information provided in the curriculum through a social media social support group among participants, the participation in the social media group was not related to any of the outcomes explored. Overall, participation in the social media intervention was less than anticipated. Of the 88 participants that enrolled in the study, only 24 joined and engaged with the Facebook group. Of those who did join/engage, average engagement (number of views, likes/other reactions, comments, poll votes, or original posts) was 129 (range: 10-369). Focus groups were conducted with participants that explored program satisfaction including the social media enhancement. Initial exploration of focus groups suggest that Facebook may not be an appropriate enhancement for the DPP population, as many participants stated they did not have Facebook and/or did not have a desire for any support outside their DPP group. The focus group data will be explored in future studies. Lastly, some CES professionals provided their DPP group with additional information similar to that found in the Facebook group, either in response to questions or requests or simply as additional handouts or resources provided outside of class time. Thus, individuals not part of the Facebook group may have still had access to content similar to that in the Facebook group, potentially confounding any influence of the Facebook group.

Some positive changes in measures of health-related quality of life were also observed in the present study. The number of physically unhealthy days reported was lower at midpoint of the program compared to baseline. The average number of physically and mentally unhealthy days reported by participants in the present study is similar though slightly higher than that

reported elsewhere [158, 159]. Interestingly, the number of days that pain was experienced significantly decreased for older adults (65 and 80 years of age). This finding is consistent with literature supporting the benefits of weight loss for pain reduction and improved physical function in obese older adults with functional impairments or medical complications [159-161]. Older participants with knee osteoarthritis reported lower perceived knee pain intensity and had improved physical function following even moderate amounts of weight loss, with even greater benefits at higher weight loss levels [159, 160]. In younger adults, the number of days participants reported being full of energy significantly increased (20, 35, and 50 years of age).

The DPP clinical trial also reported significant improvements in health-related quality of life, as measured by the 36-Item Short-Form (SF-36) [53]. However, interpretation of these health-related quality of life measures is very limited in light of the context of the present study. A majority of this study was conducted during the COVID-19 pandemic, which emerging research is showing to have had significant effects on mental and physical health. A survey conducted among U.S. adults at the end of June 2020 revealed that 30.9% of U.S. adults reported symptoms of anxiety and depression, a 3-4 times increase compared to 2019 [162]. Participants reported increases in these symptoms were related to concerns around the disease itself, the changes to daily life brought on by social distancing and shelter-in-place orders, and other pandemic-related challenges [162]. Therefore, while these DPP participants experienced some changes in health-related quality of life, any changes in these measures is highly confounded by the COVID-19 pandemic. These findings are likely not a true representation of the influence of DPP participation on health-related quality of life. Future research in the post-pandemic era should continue to investigate this outcome of DPP translations.

Similar to its effect on health-related quality of life measures, the COVID-19 pandemic no doubt influenced participants' nutrition and physical activity behaviors and, thus weight loss. Further discussion of the influence of the pandemic on participants' health behaviors is reported elsewhere (Wilson et al., forthcoming). Still, it is important to remember the context of the present study and take caution when interpreting and applying its outcomes to future iterations of the DPP in Extension.

As discussed, a major limitation of the present study is that its outcomes are highly specific to the context of the COVID-19 pandemic. It is impossible to parcel out outcomes influenced and uninfluenced by the pandemic, as the unprecedented and scoping nature of the circumstances affected nearly every area of life for most individuals. While this research encompassed participants in a variety of counties and settings, offering promising external validity, the generalizability of these findings outside the context of the COVID-19 pandemic is likely limited. In addition, this study included no control group, highly limiting its internal validity. While advanced statistical methods were used to account for as much variability as possible, it is still possible that the outcomes observed could be due to factors outside the DPP intervention. Lastly, weight was completely self-reported at midpoint and post-intervention due to the pandemic; and physical activity minutes, both collected as part of the program and collected via the IPAQ-Short, were also self-reported. While participants were encouraged to wear similar clothing to that worn at baseline measurement, it is highly possible that these instructions were not followed and that participants may have misreported weight due to social desirability bias. Furthermore, although CES professionals repeatedly explained to participants what counts as moderate PA, some individual participants consistently over-reported moderate PA, limiting the validity of this data.

Conclusions and implications for research and practice

Still, the present study provides valuable insight into outcomes of the DPP when implemented as intended in the community setting of Cooperative Extension. Participants experienced significant reductions in weight, increases in physical activity, and improvements in some measures of diet quality and health-related quality of life. Many of these outcomes were greater than what has been observed in other translations of the DPP, even in the context of the COVID-19 pandemic when much of society gained weight and experienced extreme disturbances in health [163]. These positive outcomes are perhaps due to the DPP's implementation as intended in the present study as well as the benefits of the Cooperative Extension Service for optimizing implementation and providing content expertise for DPP implementers. Still, the lack of dietary changes observed in the present and comparable studies highlights the need for potential revisions to the DPP lifestyle change program to have meaningful effects on diet quality, as we know improvements in diet quality would reduce the risk for not only diabetes but the other diet-related chronic disease that plague this country. Future research should evaluate these outcomes in the post-pandemic era and potential enhancements to the DPP curriculum, besides the social media enhancement evaluated in the present study, to maximize participant outcomes of DPP translations.

Tables

Table 2.1 Baseline participant characteristics		
Variable	**N**	**Mean ± SD, Median [Range] or %**
Age (years)	88	56.4 ± 13.2, 58 [18-75]
Sex	88	
Male	13	14.8%
Female	75	85.2%
Race	88	
White	62	70.5%
Black or African American	23	26.1%
Other	3	3.4%
Ethnicity	88	
Hispanic or Latino	5	5.7%
Not Hispanic or Latino	83	94.3%
Weight (kg)	88	96.7 ± 22.0, 89.6 [64.5-170.9]
BMI (kg/m^2)	88	35.8 ± 7.0, 34.6 [26.3-57.3]
Overweight (25 ≤ BMI < 30)	20	22.7%
Obese (BMI ≥ 30.0)	68	77.3%
Education	88	
Some high school	1	1.1%
High school graduate/GED	13	14.8%
Some college or technical school	28	31.8%
College graduate	46	52.3%
County	88	
A[1]	7	8.0%
B[1]	11	12.5%
C[1]	7	8.0%
D[1]	3	3.4%
E[1]	3	3.4%
F[1]	10	11.4%
G[1]	6	6.8%
H[2]	13	14.8%
I[2]	10	11.4%
J[2]	7	8.0%
K[2]	2	2.3%
L[2]	1	1.1%
M[2]	8	9.1%

[1]Metro county (USDA ERS rural-urban continuum code = 1-3) [143]
[2]Non-metro county (USDA ERS rural-urban continuum code = 4-9) [143]

Table 2.2 DPP participant health outcomes over time

	Baseline		Midpoint		Post-intervention	
Variable	**N**	**Mean ± SD, Median [Range] or %**	**N**	**Mean ± SD, Median [Range] or %**	**N**	**Mean ± SD, Median [Range] or %**
Weight (kg)	88	96.5 ± 21.9, 89.5 [64.4-170.6]	68	92.7 ± 22.6, 84.8 [61.2-167.4]	60	89.2 ± 20.4, 83.0 [56.7-172.4]
PA Category						
Inactive[1]	27	39.1%	6	14.3%	0	0.0%
Minimally Active[2]	21	30.4%	19	45.2%	20	58.8%
HEPA Active[3]	21	30.4%	17	40.5%	14	41.2%
PA min/wk	-	-	65	189.2 ± 128.3, 150 [30-691]	60	179.0 ± 122.0, 152.5 [30-822]
Met PA goal	-	-	37	56.9%	34	56.7%
HEI Total	59	56.7 ± 13.2, 55.5 [26.0-80.6]	36	58.8 ± 14.5, 62.7 [27.6-79.9]	35	56.9 ± 14.3, 58.4 [27.4-88.5]
DSQ						
Fiber (g/d)	50	14.2 ± 2.3, 14.1 [10.5-20.8]	42	15.2 ± 2.2, 14.8 [10.9-20.1]	48	15.1 ± 2.3, 14.9 [11.2-21.5]
Whole Grains (oz eq/d)	51	0.53 ± 0.18, 0.50 [0.35-1.18]	43	0.56 ± 0.16, 0.52 [0.35-0.95]	48	0.54 ± 0.17, 0.50 [0.35-1.15]
Added Sugars (tsp eq/d)	50	13.0 ± 3.5, 11.9 [10.0-26.4]	42	12.2 ± 2.8, 11.0 [10.0-24.5]	48	12.4 ± 2.7, 11.5 [10.1-21.5]
Sugar-Sweetened Drinks (tsp eq/d)	56	5.7 ± 4.5, 3.9 [3.6-28.9]	43	4.8 ± 2.6, 3.8 [3.6-18.5]	48	4.5 ± 1.7, 3.8 [3.6-11.5]
Fruits/Vegetables (c eq/d)						
Fr/Veg/Leg/FF	56	2.4 ± 0.6, 2.3 [1.6-4.5]	43	2.6 ± 0.5, 2.6 [1.8-4.4]	48	2.5 ± 0.5, 2.4 [1.6-3.5]
Veg/Leg/FF	56	1.5 ± 0.3, 1.5 [1.1-2.3]	43	1.6 ± 0.3, 1.6 [1.2-2.7]	48	1.6 ± 0.3, 1.6 [1.1-2.5]
Fr/Veg/Leg	56	2.2 ± 0.6, 2.2 [1.4-4.4]	43	2.5 ± 0.6, 2.4 [1.6-4.4]	48	2.4 ± 0.5, 2.3 [1.6-3.4]
Veg/Leg	56	1.4 ± 0.3, 1.4 [1.0-2.2]	43	1.5 ± 0.3, 1.5 [1.1-2.7]	48	1.5 ± 0.4, 1.5 [1.0-2.5]
Fr	56	0.8 ± 0.3, 0.7 [0.5-1.9]	43	0.9 ± 0.3, 0.9 [0.5-1.7]	48	0.8 ± 0.3, 0.7 [0.5-1.8]
Dairy (c eq/d)	56	1.3 ± 0.4, 1.2 [0.9-2.7]	43	1.3 ± 0.3, 1.2 [0.9-2.4]	48	1.3 ± 0.4, 1.2 [0.9-3.0]
Calcium (mg/d)	50	837.9 ± 127.2, 810.3 [645.4-1249.4]	42	842.2 ± 120.5, 811.6 [628.0-1298.0]	48	845.6 ± 117.5, 812.1 [676.6-1213.4]
HRQoL (days)						
Physical Health	53	6.4 ± 8.9, 3 [0-30]	42	0.8 ± 2.0, 0 [0-10]	45	3.0 ± 6.9, 0 [0-30]
Mental Health	49	4.1 ± 7.3, 0 [0-30]	39	4.4 ± 8.2, 0 [0-30]	45	3.2 ± 6.1, 0 [0-25]
Days Interfered	53	2.9 ± 6.8, 0 [0-30]	40	1.9 ± 5.3, 0 [0-30]	44	2.7 ± 5.8, 0 [0-26]
Pain	53	6.4 ± 8.9, 3 [0-30]	43	1.0 ± 3.2, 0 [0-15]	46	2.5 ± 6.8, 0 [0-30]
Sadness	51	2.7 ± 5.6, 0 [0-26]	43	3.6 ± 7.7, 0 [0-30]	43	3.2 ± 5.4, 0 [0-20]
Worry	53	6.4 ± 8.9, 3 [0-30]	41	5.2 ± 8.8, 2 [0-30]	43	4.9 ± 8.7, 1 [0-30]
Rest	53	6.4 ± 8.9, 3 [0-30]	40	6.0 ± 8.6, 3 [0-30]	45	5.8 ± 8.4, 2 [0-30]

Energy	46	16.2 ± 10.8, 17.5 [0-30]	39	18.3 ± 11.0, 25 [0-30]	39	19.4 ± 11.5, 25 [0-30]

[1]Inactive: participants who do not meet the criteria for "Minimally Active" or "HEPA Active" below

[2]Minimally Active: ≥3 days of vigorous PA 20 min/d OR ≥5 days of moderate PA or ≥30 min walking/d OR ≥5 days of any combination of walking, moderate or vigorous PA achieving ≥600 MET-min/wk

[3]HEPA (Health-Enhancing Physical Activity) Active: ≥3 days of vigorous PA achieving ≥1500 MET-min/wk OR ≥7 days of any combination of walking, moderate, or vigorous PA achieving ≥3000 MET-min/wk

Table 2.3 Mixed effects regression models for weight, physical activity, diet quality, and health-related quality of life[a]				
Outcome variable **Significant predictor variables**	**Numerator df**	**Denominator df**	**F statistic**	***p* value**
Weight[b] (N = 60)				
Time	2	122.15	31.92	< 0.001
Age	1	76.37	13.99	< 0.001
Race	2	46.13	0.73	0.486
Time*Race	4	122.25	3.07	0.019
Met 5% Weight Loss Goal[c] (N = 60)				
Baseline weight	1	58	0.03	0.856
PA Min/Wk[b] (N = 60)				
Time	1	77.25	4.79	0.032
Attendance	1	79.65	0.17	0.683
Time*Attendance	1	75.65	4.89	0.030
150-Min PA Goal[c] (N = 34)				
Time	1	123	0.03	0.871
PA Category[d] (N = 40)				
Time	2	141	5.92	0.003
HEI-Total[b] (N = 35)				
Time	2	82.14	0.28	0.755
Age	1	59.32	9.15	0.004
DSQ Fiber[b] (N = 42)				
Time	2	103.57	4.59	0.012
Sex	1	62.09	19.05	< 0.001
Education	2	60.84	4.10	0.021
Time*Education	4	77.28	3.17	0.018
Attendance	1	122.41	3.68	0.057
Time*Attendance	2	103.12	3.34	0.039
DSQ Whole Grains[b] (N = 43)				
Time	2	84.52	0.93	0.398
DSQ Added Sugars[b] (N = 43)				
Time	2	83.53	0.88	0.419
DSQ Sugar-Sweetened Drinks[d] (N = 43)				
Time	2	112	0.57	0.570
DSQ Fr/Veg/Leg/FF[b] (N = 43)				
Time	2	95.54	2.74	0.069
Sex	1	58.16	10.74	0.002
Education	2	56.85	6.97	0.002
DSQ Veg/Leg/FF[b] (N = 43)				
Time	2	76.31	7.67	0.001

Sex	1	54.82	11.28	0.001
Education	2	54.93	3.96	0.025
Race	2	46.15	1.41	0.256
Time*Race	4	80.95	3.45	0.012
DSQ Fr/Veg/Leg[b] (N = 43)				
Time	2	90.22	3.69	0.029
Sex	1	57.03	6.98	0.011
Education	2	55.78	8.3	0.001
DSQ Veg/Leg (N = 43)				
Time	2	77.27	7.71	0.001
Sex	1	55.20	5.42	0.024
Education	2	55.32	4.16	0.021
Race	2	44.53	1.65	0.204
Time*Race	4	82.00	3.41	0.012
DSQ Fruit[b] (N = 43)				
Time	2	112.16	2.35	0.100
Education	2	62.18	4.64	0.013
Age	1	57.32	0.002	0.960
Time*Age	2	97.91	3.34	0.040
Attendance	1	131.59	4.28	0.041
Time*Attendance	2	119.95	5.57	0.005
DSQ Dairy[b] (N = 43)				
Time	2	77.82	0.22	0.806
Sex	1	56.26	13.11	0.001
DSQ Calcium[b] (N = 42)				
Time	2	76.28	0.80	0.452
Sex	1	63.46	51.04	< 0.001
Physical Health[c] (N = 42)				
Time	2	93	3.27	0.042
Mental Health[c] (N = 39)				
Time	2	129	0.17	0.848
Age	1	129	11.85	0.001
Days Interfered[c] (N = 40)				
Time	2	127	1.73	0.182
Age	1	127	5.81	0.017
Education	2	127	0.69	0.504
Education*Time	4	127	3.11	0.018
Pain[c] (N = 43)				
Time	2	138	3.13	0.047
Age	1	138	0.40	0.526

Age*Time	2	138	4.14	0.018
Sadness[c] (N = 43)				
Time	2	133	0.56	0.570
Age	1	133	9.88	0.002
Worry[c] (N = 41)				
Time	2	76	0.57	0.568
Age	1	58	6.39	0.014
Rest[c] (N = 40)				
Time	2	71	0.66	0.519
Energy[c] (N = 39)				
Time	2	78	5.43	0.006
Race	2	37	4.20	0.023
Age	1	54	7.16	0.010
Age*Time	2	77	4.29	0.017

[a]Independent variables assessed in mixed effects models: time, sex, age, race, education, attendance, Facebook engagement and interactions with time; final model includes only variables with significant relationship ($p<0.05$) with the dependent variable (weight, physical activity, diet quality, health related quality of life) after the forward selection process

[b] Linear mixed effects regression models

[c]Binary logistic regression models

[d]Ordinal logistic regression models

Table 2.4 Pairwise comparisons of weight, physical activity, and diet quality as a function of demographics, attendance, social media, and/or time

Variable	Comparison	Mean difference	Standard error	*p* value	95% CI
Weight (N = 60)					
Race					
White	Time 1 – Time 2	4.93	0.58	< 0.001	3.53,6.33
	Time 2 – Time 3	0.31	0.59	1.000	-1.13,1.74
	Time 1 – Time 3	3.29	0.97	< 0.001	3.80,6.67
Black/African American	Time 1 – Time 2	2.37	0.86	0.021	0.28,4.47
	Time 2 – Time 3	0.91	0.97	1.000	-1.43,3.26
	Time 1 – Time 3	3.29	0.97	0.003	0.95,5.63
Other	Time 1 – Time 2	8.77	2.23	< 0.001	3.36,14.18
	Time 2 – Time 3	0.76	2.23	1.000	-4.66,6.17
	Time 1 – Time 3	9.53	2.23	< 0.001	4.11,14.94
PA Min/Wk[a] (N = 60)					
Attendance					
5 sessions	Time 2 – Time 3	-1.30	0.60	0.032	-2.48,-0.11
15 sessions	Time 2 – Time 3	-0.60	0.29	0.041	-1.18,-0.02
25 sessions	Time 2 – Time 3	0.09	0.11	0.418	-0.13,0.30
DSQ Fiber (N = 42)					
Education					
High school	Time 1 – Time 2	-1.03	0.70	0.435	-2.73,0.68
or less	Time 2 – Time 3	-0.97	0.83	0.734	-3.01,1.06
	Time 1 – Time 3	-2.00	0.85	0.063	-4.07,0.08
Some college	Time 1 – Time 2	0.06	0.06	1.000	-1.27,1.09
	Time 2 – Time 3	0.21	0.53	1.000	-1.10,1.51
	Time 1 – Time 3	0.11	0.49	1.000	-1.08,1.3
College graduate	Time 1 – Time 2	-1.66	0.39	0.000	-2.61,-0.72
	Time 2 – Time 3	0.12	0.39	1.000	-0.84,1.09
	Time 1 – Time 3	-1.54	0.40	0.001	-2.52,-0.56
Attendance					
5 sessions	Time 1 – Time 2	-4.76	1.54	0.008	-8.51,-1.01
	Time 2 – Time 3	1.71	2.61	1.000	-4.65,8.07
	Time 1 – Time 3	-3.05	2.47	0.660	-9.06,2.96
15 sessions	Time 1 – Time 2	-2.60	0.74	0.002	-4.40,-0.81
	Time 2 – Time 3	0.63	1.30	1.000	-2.54,3.79
	Time 1 – Time 3	-1.97	1.23	0.335	-4.97,1.02
25 sessions	Time 1 – Time 2	-0.44	0.35	0.635	-1.29,0.41
	Time 2 – Time 3	-0.46	0.34	0.536	-1.29,0.37
	Time 1 – Time 3	-0.90	0.35	0.036	-1.75,-0.04

DSQ Fr/Veg/Leg/FF (N = 43)					
Education	High school or less v. Some college	0.04	0.14	1.000	-0.30,0.38
	High school or less v. College graduate	-0.32	0.13	0.052	-0.64,0.002
	Some college v. College graduate	-0.35	0.10	0.003	-0.61,-0.10
DSQ Veg/Leg/FF (N = 43)					
Education	High school or less v. Some college	0.02	0.08	1.000	-0.19,0.22
	High school or less v. College graduate	-0.15	0.08	0.208	-0.34,0.05
	Some college v. College graduate	-0.16	0.06	0.036	-0.32,-0.01
Race					
White	Time 1 – Time 2	-0.02	0.06	1.000	-0.16,0.12
	Time 2 – Time 3	-0.07	0.06	0.714	-0.20,0.07
	Time 1 – Time 3	-0.09	0.05	0.298	-0.21,0.04
Black/African American	Time 1 – Time 2	-0.07	0.08	1.000	-0.27,0.13
	Time 2 – Time 3	0.07	0.09	1.000	-0.16,0.29
	Time 1 – Time 3	-0.01	0.09	1.000	-0.23,0.22
Other	Time 1 – Time 2	-0.76	0.21	0.002	-1.28,-0.24
	Time 2 – Time 3	0.11	0.21	1.000	-0.41,0.63
	Time 1 – Time 3	-0.65	0.21	0.010	-1.17,-0.13
DSQ Fr/Veg/Leg[a] (N = 43)					
Education	High school or less v. Some college	0.01	0.06	1.000	-0.14,0.16
	High school or less v. College graduate	-0.156	0.06	0.020	-0.30,-0.02
	Some college v. College graduate	-0.17	0.05	0.002	-0.28,-0.05
DSQ Veg/Leg (N = 43)					
Education	High school or less v. Some college	0.02	0.09	1.000	-0.21,0.25
	High school or less v. College graduate	-0.17	0.09	0.192	-0.38,0.05
	Some college v. College graduate	-0.18	0.07	0.030	-0.36,-0.01
Race					
White	Time 1 – Time 2	-0.02	0.06	1.000	-0.18,0.13

	Time 2 – Time 3	-0.07	0.06	0.812	-0.22,0.08
	Time 1 – Time 3	-0.09	0.06	0.354	-0.24,0.05
Black/African American	Time 1 – Time 2	-0.08	0.09	1.000	-0.31,0.15
	Time 2 – Time 3	0.07	0.10	1.000	-0.18,0.33
	Time 1 – Time 3	-0.01	0.10	1.000	-0.26,0.24
Other	Time 1 – Time 2	-0.85	0.24	0.002	-1.44,-0.26
	Time 2 – Time 3	0.12	0.24	1.000	-0.47,0.71
	Time 1 – Time 3	-0.73	0.24	0.009	-1.32,-0.15
DSQ Fruit[a] (N = 43)					
Education	High school or less v. Some college	0.04	0.1	1.000	-0.21,0.29
	High school or less v. College graduate	-0.16	0.09	0.255	-0.38,0.07
	Some college v. College graduate	-0.20	0.07	0.019	-0.37,-0.03
Attendance					
5 sessions	Time 1 – Time 2	-0.82	0.27	0.007	-1.46,-0.18
	Time 2 – Time 3	-0.20	0.47	1.000	-1.35,0.96
	Time 1 – Time 3	-1.02	0.43	0.062	-2.07,0.04
15 sessions	Time 1 – Time 2	-0.43	0.13	0.004	-0.74,-0.12
	Time 2 – Time 3	-0.08	0.23	1.000	-0.65,0.49
	Time 1 – Time 3	-0.51	0.21	0.058	-1.02,0.01
25 sessions	Time 1 – Time 2	-0.03	0.06	1.000	-0.17,0.10
	Time 2 – Time 3	0.04	0.05	1.000	-0.10,0.17
	Time 1 – Time 3	0.01	0.05	1.000	-0.12,0.13
Age					
65 years	Time 1 – Time 2	-0.16	0.06	0.027	-0.31,-0.01
	Time 2 – Time 3	-0.02	0.07	1.000	-0.19,0.15
	Time 1 – Time 3	-0.18	0.07	0.018	-0.34,-0.03
80 years	Time 1 – Time 2	-0.24	0.11	0.082	-0.50,0.02
	Time 2 – Time 3	-0.09	0.11	1.000	-0.36,-0.18
	Time 1 – Time 3	-0.33	0.10	0.005	-0.58,-0.08

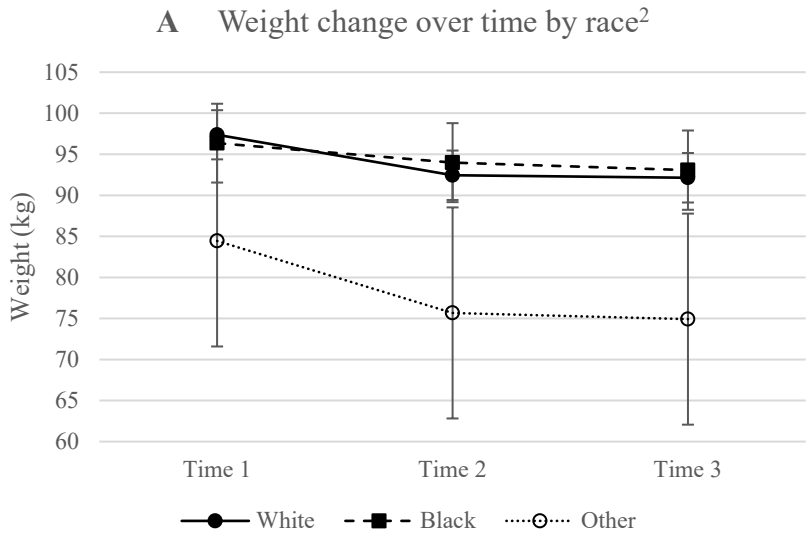
[a]Values natural log transformed – not on original scales

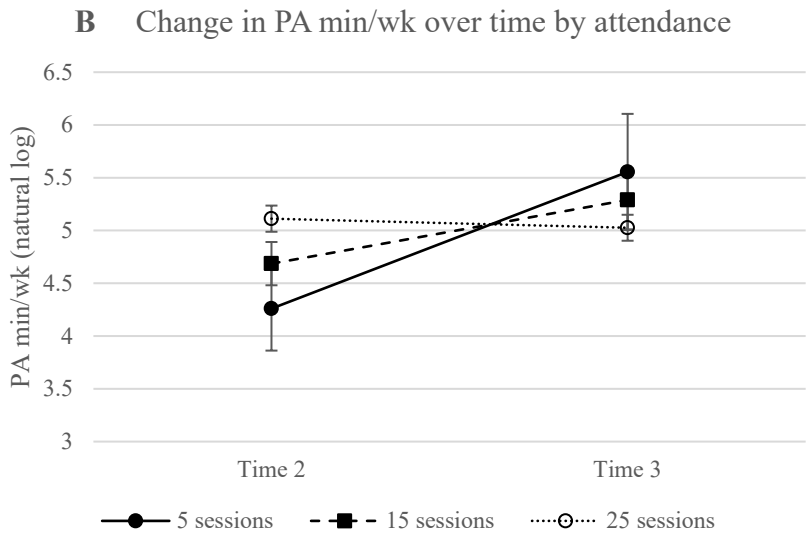
Table 2.5 Pairwise comparisons of HRQoL as a function of demographics, attendance, social media, and/or time						
Variable	**Contrast**	**Contrast estimate**	**Standard error**	**t**	***p* value**	**95% CI**
Physical Health (N = 42)						
	Time 1 – Time 2	1.42	0.56	2.52	0.04	0.05,2.79
	Time 2 – Time 3	-1.18	0.59	-2.02	0.093	-2.52,0.15
	Time 1 – Time 3	0.24	0.50	0.47	0.637	-0.76,1.23
Days Interfered						
Education						
Some high school	Time 1 – Time 2	-2.07	1.59	-1.30	0.389	-5.67,1.53
	Time 2 – Time 3	-1.13	1.68	-0.67	0.502	-4.45,2.19
	Time 1 – Time 3	-3.20	1.94	-1.65	0.306	-7.91,1.51
Some college	Time 1 – Time 2	-0.82	1.00	-0.81	0.472	-2.86,1.22
	Time 2 – Time 3	-1.17	0.98	-1.19	0.472	-3.40,1.06
	Time 1 – Time 3	-2.00	0.88	-2.25	0.079	-4.13,0.16
College graduate	Time 1 – Time 2	1.19	0.58	2.05	0.126	-0.22,2.60
	Time 2 – Time 3	-0.10	0.61	-0.16	0.876	-1.31,1.12
	Time 1 – Time 3	1.10	0.57	1.92	0.126	-0.22,2.42
Pain (N = 43)						
Age						
65 years	Time 1 – Time 2	2.76	0.99	2.79	0.018	0.37,5.15
	Time 2 – Time 3	-2.47	1.02	-2.42	0.034	-4.78,-0.15
	Time 1 – Time 3	0.29	0.68	0.43	0.671	-1.06,1.64
80 years	Time 1 – Time 2	4.94	1.64	3.01	0.009	0.96,8.92
	Time 2 – Time 3	-4.47	1.67	-2.67	0.017	-8.27,-0.68
	Time 1 – Time 3	0.47	1.19	0.39	0.695	-1.89,2.82
Energy (N = 39)						
Race	Black/African American v. White	2.30	0.76	3.05	0.013	0.41,4.19
	Black/African American v. Other	1.12	1.79	0.62	0.973	-3.01,5.24
	White v. Other	-1.19	1.69	-0.70	0.973	-5.14,2.76
Age						
20 years	Time 1 – Time 3	-4.69	1.47	-3.19	0.006	-8.28,-1.10
	Time 2 – Time 3	-4.35	1.51	-2.88	0.010	-7.81,-0.9
	Time 1 – Time 3	-4.69	1.47	-3.19	0.006	-8.28,-1.10
35 years	Time 1 – Time 3	-3.22	0.96	-3.36	0.004	-5.56,-0.88
	Time 2 – Time 3	-2.92	0.98	-2.98	0.008	-5.16,-0.68
	Time 1 – Time 3	-3.22	0.96	-3.36	0.004	-5.56,-0.88
50 years	Time 1 – Time 3	-1.74	0.54	-3.25	0.005	-3.05,-0.43
	Time 2 – Time 3	-1.49	0.55	-2.73	0.016	-2.74,-0.24

	Time 1 – Time 3	-1.74	0.54	-3.25	0.005	-3.05,-0.43

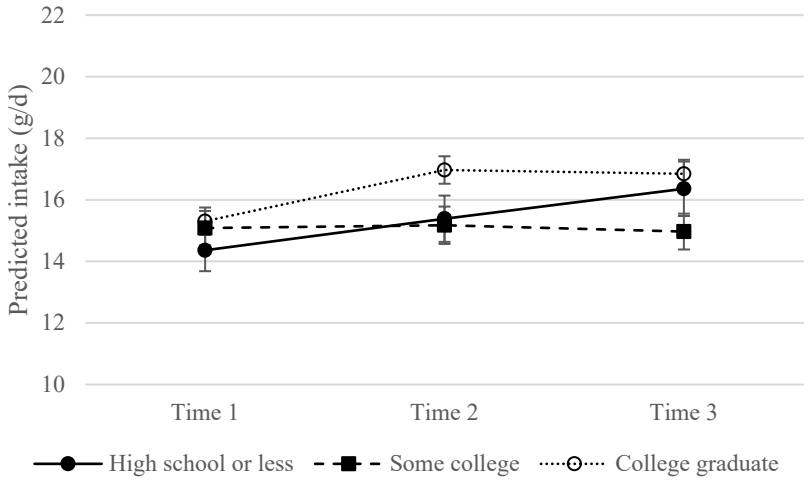
Figures

Figure 2.1 Selected interaction effects of time and independent variables on weight, physical activity, and diet quality[1]

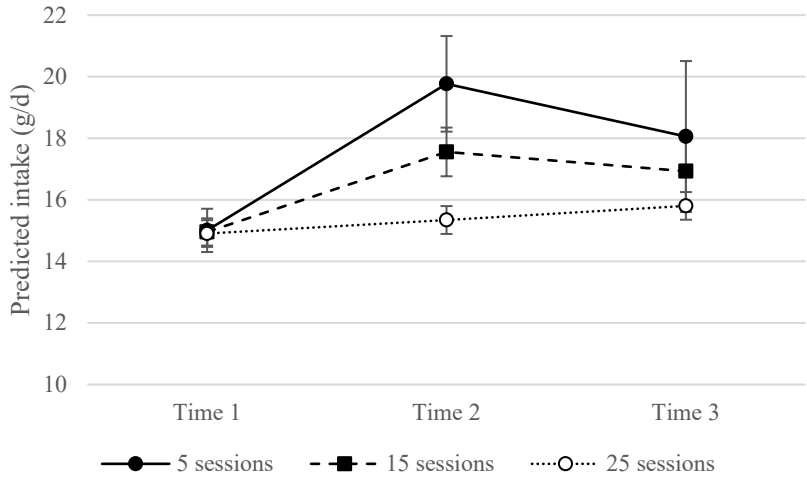




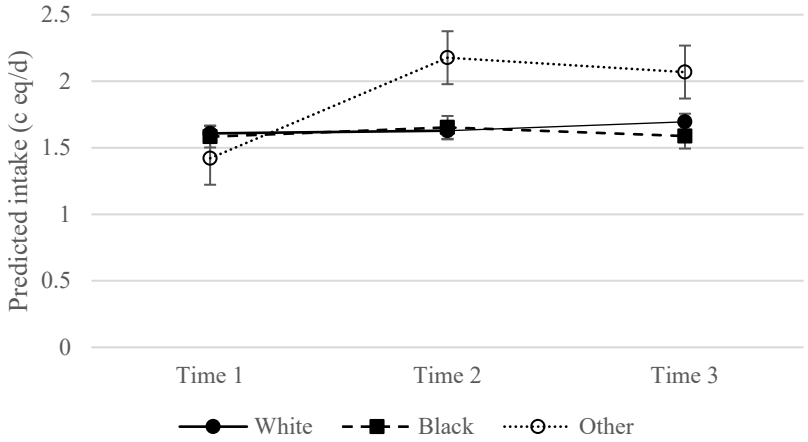
C Predicted fiber intake over time by education[3]



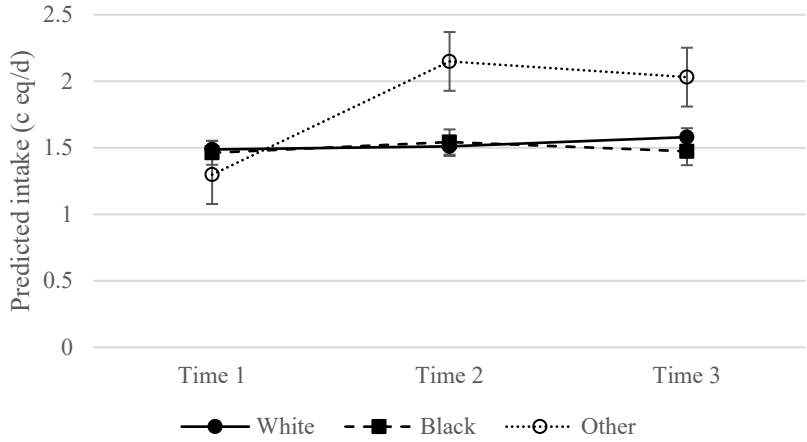
D Predicted fiber intake over time by attendance[4]



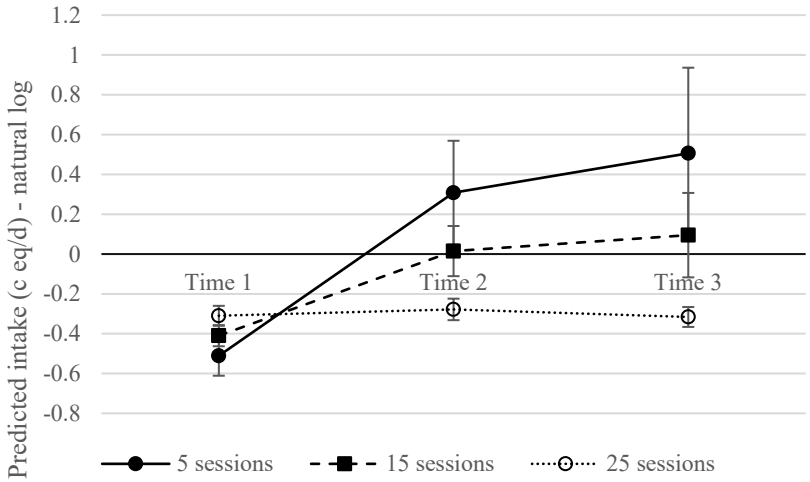
E Predicted vegetable/legume/french fry intake over time by race



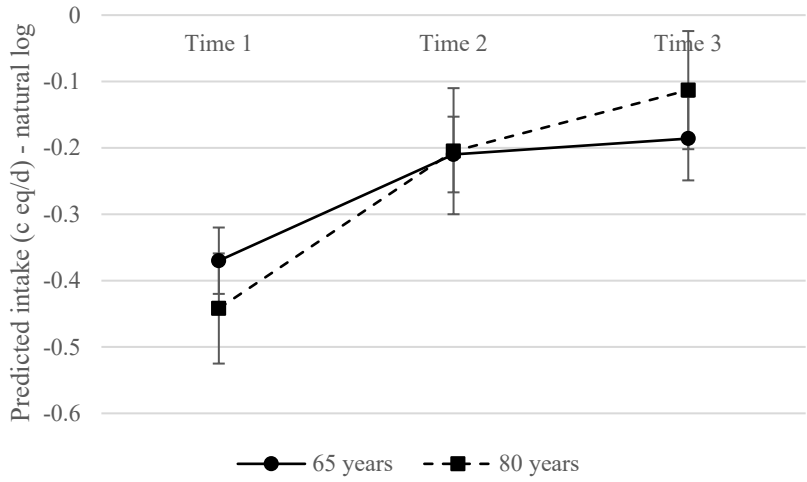
F Predicted vegetable/legume intake over time by race



G Predicted fruit intake over time by attendance[5]

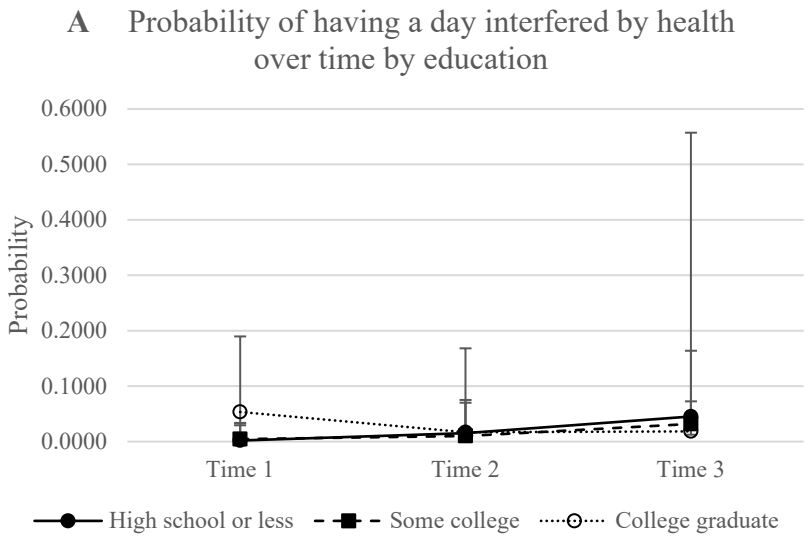


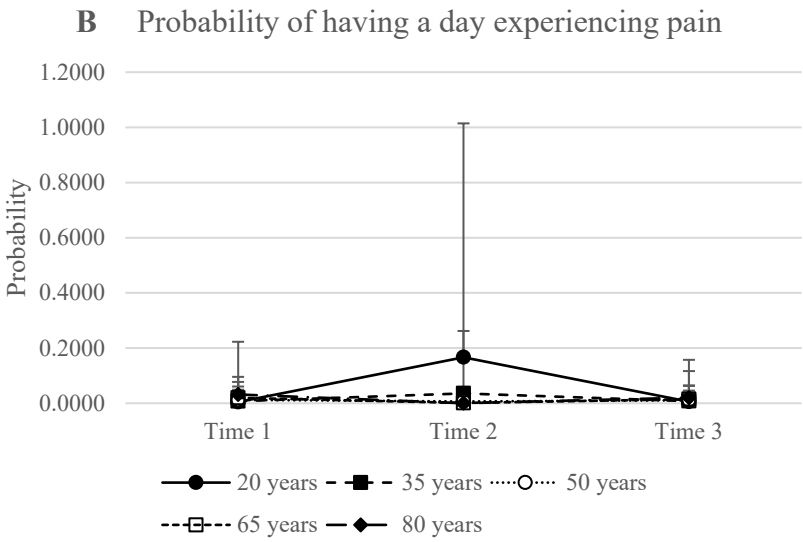
H Predicted fruit intake over time by age[6]

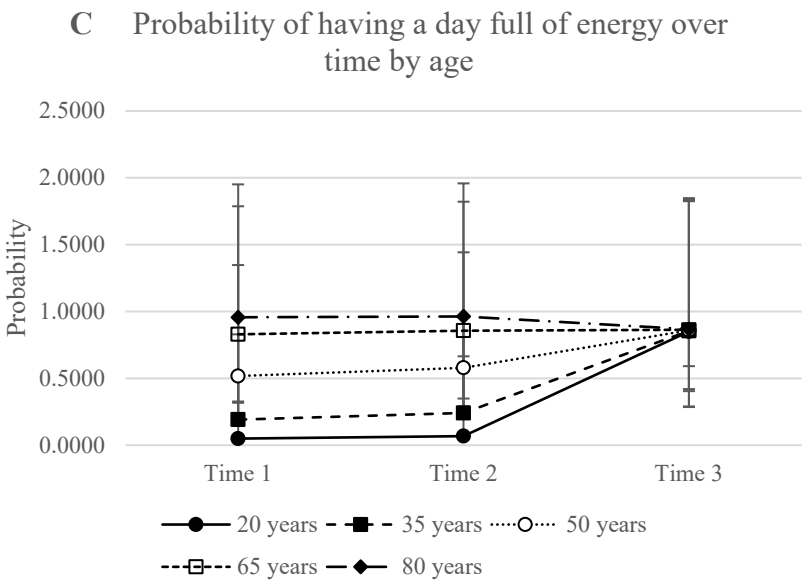


[1]Values are estimated marginal means (± SE) predicted from the regression models over time or modeled at various levels of an independent variable (e.g., attendance) and adjusted to average levels of other significant predictors in the model
[2]Adjusted for age
[3]Adjusted for attendance
[4]Adjusted for education
[5]Adjusted for age
[6]Adjusted for attendance

Figure 2.2 Probability of selected health-related quality of life outcomes over time by education and age[1]







[1]Values are estimated marginal probabilities (± SE) predicted from the regression models over time or modeled at various levels of an independent variable (e.g., education) and adjusted to average levels of other significant predictors in the model
[2]Adjusted for age

CHAPTER 3

ASSOCIATION OF SOCIAL SUPPORT AND FOOD SECURITY WITH HEALTH-RELATED OUTCOMES OF A COOPERATIVE EXTENSION DIABETES PREVENTION PROGRAM[1]

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Abstract

Objective: The CDC's National Diabetes Prevention Program (DPP) evidence-based lifestyle change program aims to decrease type 2 diabetes (T2DM) risk through weight loss, diet, and physical activity. While the DPP has proven effective in a variety of settings, understanding when and for whom it is most effective may help to decrease health disparities. The purpose of the present study was to investigate the association of social support and food security with DPP participant health outcomes.

Design: The present study was part of a 12-month, multi-site, hybrid type 2 effectiveness-implementation trial of a translation of the DPP and is a one-group, repeated measures design.

Setting: The present study was set in the context of the Cooperative Extension Service (CES) in [STATE].

Participants: Participants were overweight or obese adults (18-75 years) with prediabetes or at high risk for prediabetes and without any major comorbidities or physical disabilities.

Intervention: The most recent DPP curriculum, Prevent T2, was used to implement 12 DPPs from approximately January 2020 to January 2021 according to CDC implementation standards.

Main Outcome Measures: Weight change, physical activity, diet quality (Healthy Eating Index-2015, 26-item Dietary Screener Questionnaire), health-related quality of life, and association of general and healthy eating social support and food security status with these outcome measures

Analysis: Linear, ordinal, and binary logistic regression models were used to evaluate relationships of social support and food security status with intervention outcomes.

Results: Social support for healthy eating from friends or family was a significant predictor of fruit and vegetable (b = 0.03, SE: 0.01, t (31.70) = 2.96, p = 0.006) and added sugar intake (b = -0.012, SE: 0.004, t (34.79) = -2.72, p = 0.010), as well as physically and mentally unhealthy days

and days full of energy. Social support also influenced change in weight and fiber intake over time. Food security status was a significant predictor of dairy and calcium intake, as well as days interfered by poor health.

Conclusions and Implications: This study provides insight into the relationships of social support and food security status with outcomes of DPP participants in the context of CES and the COVID-19 pandemic. Future research should further investigate these relationships post-pandemic and strategies to promote social support and address food security among DPP participants to decrease health disparities and overall T2DM risk.

Objective

The National Diabetes Prevention Program

Lifestyle change programs like the Centers for Disease Control and Prevention's (CDC's) National Diabetes Prevention Program (DPP) lifestyle change program have significantly reduced rates of type 2 diabetes mellitus (T2DM) among individuals with prediabetes. The National DPP is a public-private partnership effort to address diabetes through increased screening and interventions. The DPP is a community-based translation of the clinical trial shown to reduce rates of T2DM in samples of the prediabetes population by up to 58% [2]. With approximately one third of the U.S. population living with prediabetes and 5-10% of these individuals developing T2DM each year, dissemination of the DPP in a variety of settings to diverse populations may reduce T2DM burden [1].

The DPP is a year-long program that focuses on weight loss through diet and physical activity [4]. The goal of the DPP is for participants to lose at least 5-7% of their body weight and to engage in at least 150 minutes of moderate-intensity physical activity each week [4]. Participants meet in groups with a trained lifestyle coach for approximately 1-hour sessions throughout the

year to discuss and problem-solve lifestyle behaviors for weight loss and decreased T2DM risk, using the DPP curriculum as a discussion guide.

As part of the National DPP effort, the CDC has overseen dissemination of the DPP in not only clinical contexts but also community contexts, including Cooperative Extension Services (CES) [4]. With its presence in almost every county in every state, as well as an infrastructure that provides connections to other programming related to food security and relationships, CES is poised as an effective platform for dissemination and implementation of the DPP [133].

While there is limited evidence of the effects of the DPP when implemented with fidelity in community contexts such as CES, recent research suggests that the DPP is effective in helping participants achieve the weight loss and physical activity goals of the DPP (see Chapter 2).

Food security status

Knowing that an intervention is effective is important, but knowing when and for whom an intervention is most effective may help address health disparities [64-66, 69, 103, 122]. Individuals living in food insecure households experience a high burden of chronic diseases, including T2DM [64]. Research has shown that non-Hispanic white and black women living in a food insecure household had 53% and 200% higher odds of being prediabetic than non-Hispanic white and black women living in a food secure household, respectively [65]. These results highlight the importance of identifying food insecurity among DPP participants in order to more effectively prevent T2DM.

Understanding food security of DPP participants may be of even great importance in light of the COVID-19 pandemic. Estimates of food insecurity in the U.S. during March and April of 2020 were as high as 38% of the U.S. population, more than triple the national average prior to

the pandemic [164]. The effects of the COVID-19 pandemic on food insecurity throughout the U.S. will be long-lasting, and understanding its influence on participants' outcomes of programs like the DPP is imperative to prevent worsening health disparities among this population.

A review of currently available literature suggests food security status of DPP participants and its relationship to DPP outcomes has not been assessed. However, Cheyne et al. found that in a food bank-based DPP, food insecure participants had improvements in food security status and significant improvements in DPP outcomes, including PA and diet quality [70]. Cooperative Extension provides financial literacy and capability education and addresses food security and nutrition through a variety of interventions, such as the Supplemental Nutrition Assistance Education Program (SNAP-ED) and the Expanded Food and Nutrition Education Program (EFNEP). Thus, Extension is well poised to foster education and resources to support these clientele to address food security and potentially improve their DPP outcomes.

Social support and lifestyle change

The importance of social support in personal health behavior change has long been recognized. Interventions similar to the DPP have found perceived social support to increase with the intervention and to be associated with immediate and sustained outcomes [79, 80]. An Australian diabetes prevention program similar to the DPP assessed factors that contributed to sustained behavior change for diabetes prevention and found that greater family and community support promoted motivation for sustained health behavior change [80].

The role of social support in lifestyle change in the DPP may be of even greater importance in the context of the COVID-19 pandemic.COVID-19's impact on mental health factors and sources of social support has been substantial, stemming from concerns around the disease itself to the effect of social distancing and shelter-in-place orders [162]. A survey conducted

among U.S. adults at the end of June 2020 revealed that 30.9% of U.S. adults reported symptoms of anxiety and depression, a 3-4 times increase compared to 2019 [162].

Thus, the purpose of the present study was to investigate the association of social support and food security with participant health outcomes of a Cooperative Extension-delivered Diabetes Prevention Program.

Design

The present study was part of a 12-month, multi-site, hybrid type 2 effectiveness-implementation trial of the DPP in a state CES [103, 104, 114]. The primary effectiveness and implementation evaluations are described elsewhere (see Chapters 2 and 4, respectively). In Chapter 2, demographics, intervention attendance and completion, and engagement with the social media group were explored for relationships with the main outcome measures (weight, physical activity, diet quality, health-related quality of life). The present study explored the relationship of general social support, social support for eating, and food security on the outcomes of interest after accounting for significant effects found in the first exploration as reported in Chapter 2. All methods and procedures were approved by the University of Georgia Institutional Review Board of Human Subjects, and DPP participants provided written informed consent.

Setting

The present study was set in the context of the Cooperative Extension Service (CES) in [STATE]. Lifestyle coaches administering the DPP were Family and Consumer Sciences (FACS) Extension county professionals in [STATE] trained as lifestyle coaches by the Diabetes Training and Technical Assistance Center (DTTAC) at Emory University. Twelve FACS Extension professionals delivered 13 DPPs across all four regions of [STATE], 5 programs in the

northeast region, 5 programs in the northwest region, 2 programs in the southeast region, and 1 program in the southwest region. Of the 13 counties in which the program was implemented, 7 counties were metropolitan and 6 were nonmetropolitan.

Participants

Inclusion criteria

Participants were recruited for the Diabetes Prevention Program according to the CDC guidelines: BMI $\geq$ 25 kg/m^2 and a clinical prediabetes diagnosis or a score of $\geq$ 5 on the CDC/American Diabetes Association prediabetes risk test [95, 144]. The research study inclusion criteria were more restrictive and limited to those who met these guidelines, but also the additional inclusion and exclusion criteria below.

Because the DPP is designed for adults and to prevent potential confounding factors present in the adolescent life stage, only adults, both males and females, 18 to 75 years of age were included in the study and program. While the CDC does not place an upper age limit on DPP participation, the present study excluded participants over 75 years of age due to a physical function assessment completed as part of the larger study (not part of this dissertation nor completed at midpoint or post-intervention due to COVID-19 restrictions).

Exclusion criteria

Individuals who were pregnant or with self-reported current diagnoses of T2DM, chronic kidney disease, liver disease, cancer, Alzheimer's or other dementias, or severe physical or cognitive limitations were excluded from the analytical sample.

Note that because this was a translational study, the program was offered to all individuals in a setting, regardless of prediabetes or T2DM risk status. However, participants

without prediabetes, not at high risk for prediabetes or T2DM, or already with T2DM were not included in the analytical sample.

Recruitment

Participants were recruited for the DPP by CES professionals in their respective counties through physician referrals, new or existing community collaborations/relationships, local employers, flyers, newspaper ads, radio announcements, and social media advertisements. The CES professionals recruited participants for the research study at in-person informational sessions to join the DPP program or via email upon expressed interest in the program. All study participants provided informed consent to participate in the research.

A total of 124 individuals attended a DPP informational session or otherwise expressed interest in participating in the DPP. Of those, 119 were eligible for the program; and 89 were eligible for the research based on the inclusion and exclusion criteria above. Information needed to determine eligibility was collected via paper questionnaires based on CDC DPP eligibility criteria and the Physical Activity Readiness Questionnaire (PARQ) (Appendix D). A nutrition graduate student screened all potential participants for eligibility in the program and research. For those who were eligible for both the program and research but indicated a potential concern for engaging in PA in their response to questions on the PARQ, kinesiology graduate students contacted these participants to determine safety of participating in PA over the course of the program. Following screening, a total of 88 participants enrolled in the study at baseline.

Intervention

DPP intervention characteristics

The DPP was implemented according to the 2018 CDC Diabetes Prevention Recognition Program (DPRP) standards [95]. The most updated DPP curriculum, Prevent T2, was used in this

study. Following the DPRP standards, the schedule included weekly sessions for the first 16 weeks, followed by one session every two weeks for approximately 2 months, and monthly sessions for the last 6 months of the program (core maintenance). Program implementation began in person in January – March 2020 and continued through January – March 2021. Upon the onset of the COVID-19 pandemic, program implementation of all 13 DPPs was converted from in-person to distance learning formats following the CDC DPRP COVID-19 pandemic guidelines [145]. Twelve groups utilized Zoom and one group utilized FreeConferenceCall.com® to conduct sessions. All groups remained in the distance learning format for the remainder of the program [146, 147].

Participants also had the option to join a private social media (Facebook) group open only to participants of [STATE] CES DPPs. Informative and supportive content was posted 3 times per week over the duration of the 1-year program.

Main outcomes and measures

With the exception of weight at baseline and 24-hour dietary recalls completed using ASA-24, all measures were self-reported by participants via Qualtrics online survey software [149]. Participants were sent an email with individualized links to Qualtrics surveys, their personalized ASA-24 username and password with the link to log into the ASA-24 website, and instructions on completing the surveys. Participants were given 2 weeks to complete all surveys at each timepoint. Baseline surveys were sent approximately 1 week prior to the first DPP session. Midpoint surveys were sent at the start of month 6 of the program, and post-intervention surveys were sent at the start of the final month of the DPP.

Demographics and other predictor variables

Demographics were self-reported and included age (years), sex, race (American Indian or Alaska Native, Asian or Asian American, Black or African American, Native Hawaiian or Other Pacific Islander, White), ethnicity (Hispanic or Latino, Not Hispanic or Latino), and education level (some high school, graduated from high school or got a GED, some college or technical school, college graduate). Attendance was collected to account for potential impact of dose of the intervention on outcomes. Demographic variables were treated as independent variables in all statistical analyses to determine any influences on outcomes or changes in outcomes over time. Race was reduced to Black, White, and Other based on small sample size in the following categories: Asian (n = 2), Multiracial (n = 1). Engagement in the social media enhancement was assessed and dichotomized as Facebook user (any level of engagement with the Facebook group) or Facebook non-user (Chapter 2).

Weight loss

Anthropometrics were assessed at baseline, midpoint, and post-intervention. Height was measured at baseline by CES professionals with portable stadiometers (Seca model 213). Weight was measured at baseline and at each DPP session by CES professionals with research-grade digital scales (Seca model 876) with participants wearing clothes and no shoes until the switch to distance learning in March 2020. Participants were instructed to take note of the clothes they had on at baseline or take a picture of themselves so they could wear something similar at midpoint and post-intervention. Following the onset of the COVID-19 pandemic, participants self-reported weight using a home scale of their choice or digital scale provided by the research team (Etekcity Model EB4074C, EB9388H, EB9380H or EB4473C). Weight change and percent weight change were calculated from baseline to 6 and 12 months, and the percentage of participants achieving

2%, 5%, and 7% weight loss was calculated to examine clinically meaningful weight change (2%) and meeting intervention goals (5 to 7%) [19, 95]. BMI was also calculated (weight (kg)/height (m^2)) at baseline, midpoint, and post.

Diet quality

Diet quality was assessed with the Healthy Eating Index-2015 (HEI-2015), calculated from 24-hour dietary recalls, and the 26-item Dietary Screener Questionnaire [38, 40, 150]. The HEI-2015 includes 12 components (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars, saturated fats) [40]. Each component is scored individually, and the scores from each component are totaled to provide an overall HEI-2015 score. Component scores range from 0-5 or 0-10, depending on the component; and HEI total scores can range from 0 to 100. The HEI-2015 was calculated at each time point (baseline, midpoint, and post) from at least one 24-hour recall [38, 40].

Dietary recalls were collected online from participants using the Automated Self-Administered 24-hour recall (ASA-24), 2018 version; and participants were instructed to complete two 24-hour recalls, one weekday and one weekend day, at each time point (baseline, midpoint, post) [47, 48]. Participants were emailed a link to the ASA-24 website, along with their individualized ASA-24 username and password. Each participant's username and password did not change throughout the course of the study. Participants simply entered their username and password (for example, username: DPPExt500; password: Food%500) into the ASA-24 website homepage linked in the email. The ASA-24 website then prompted participants to answer questions about everything they consumed (both food and beverages) over the last 24 hours. Participants were also asked about where they consumed their food/beverages, if they ate alone

or with someone, if they were watching television or using a computer while eating/drinking, and if they took any supplements.

While determining feasibility of ASA-24 use in community settings was of interest to collect detailed dietary quality data and calculate HEI scores, the researchers anticipated a potentially poor response rate on the ASA-24 due to the extra participant burden of the detailed questions asked by the ASA-24 recall. Therefore, the 26-item Dietary Screener Questionnaire (DSQ) food frequency questionnaire was used as an additional measure of diet quality [150]. The DSQ asks participants to report usual intake of specific foods: fruits, vegetables, dairy/calcium, whole grains/fiber, and added sugars [150] to predict usual intake over a 30-day period. No total "score" is calculated from the DSQ like the HEI-2015 score. Rather, the DSQ provides estimated quantities of food groups consumed. The DSQ has demonstrated satisfactory agreement with the 24-hour recall, with mean intakes differing by less than 2%, and is useful in settings like a community-based study where the researchers are less able to support participants in completion of a 24-hour recall or participant comprehension or burden is a concern [150]. DSQs were administered online via Qualtrics survey software at baseline, midpoint, and post-intervention.

Physical activity

Physical activity (PA) was assessed with the International Physical Activity Questionnaire-Short form, collected online at baseline, midpoint, and post-intervention. The IPAQ-Short has been validated in its use of categorizing adults based on activity level [28]. Metabolic equivalent (MET)-minutes of walking, moderative, and vigorous PA were calculated from participant responses, and participants were categorized as 1) inactive, 2) minimally active, or 3) HEPA (health-enhancing physical activity)-active, according to IPAQ-Short data processing guidelines [29]. Participants also self-reported moderate PA minutes/week at each DPP

session in accordance with CDC DPRP requirements. Moderate PA minutes reported at midpoint and post-intervention were also considered in assessment of PA and of whether participants met the program goal of 150 minutes of moderate PA/week at each time point. Baseline self-report of weekly PA was not included in the analysis, as PA reporting in the DPP does not begin until approximately week 4 of the program.

Health-related quality of life

Health-related quality of life (HRQoL) was assessed using the CDC's HRQoL-14 measure, collected online at baseline, midpoint, and post [60, 63]. The number of physical and mental "unhealthy days" over the past 30 days were assessed, as well as the number of days participants suffered from physical limitations, pain, depression/sadness, anxiety, and inadequate rest/sleep and perceived themselves to be full of energy. Unhealthy BMI and cardiovascular health have all been associated with HRQoL as measured by the CDC's HRQoL14 measure [61, 62]. Impaired glucose tolerance among individuals with prediabetes has also been associated with certain measures of HRQoL, highlighting the importance of this outcome measure [50].

Household food security

Household food security was assessed at baseline, midpoint, and post-intervention with the Six-item Short Form of the Food Security survey module developed by the USDA Economic Research Service [68]. This form allowed for estimation of food security status with reasonable reliability and minimal participant response burden [67].

To calculate the composite food security score, the number of affirmative responses (responses of "often" or "sometimes" on questions asking how frequently participants ran out of food and did not have money to buy more food or money to buy balanced meals, and "yes" on questions asking if participants ever restricted their intake because they did not have enough

money, are coded as affirmative; responses of "almost every month" and "some months but not every month" on the question asking about frequency of food restriction due to financial limitations are coded as affirmative) was summed. A scores of 0 is considered food secure; a score of 1 was considered marginal food security; scores of 2-4 were considered low food security; and scores of 5-6 were considered very low food security [165]. Upon exploration of the data, the study sample was largely food secure (mean score 0.48 ± 1.44, 85.7% = 0, food secure, Table 3.1). Thus, to allow for power to detect any potential influences on DPP outcomes, participants were categorized as either food secure (score of 0) or at least marginally food insecure (score of 1 or higher).

Social Support

Social support was assessed at baseline, midpoint, and post-intervention with multiple measures. The Multidimensional Scale of Perceived Social Support (MSPSS), a 12-item scale that assesses social support from family, friends, and a significant other, was collected online to assess general social support [75]. Each of the three subscales (family, friends, significant other) includes four questions to assess perceived social support in that area. Responses are reported on a 7-point Likert scale, with 1=very strongly disagree and 7=very strongly agree. The mean overall score was calculated to assess general social support across all subscales [75]. Higher scores indicate higher levels of social support.

Social support for specifically nutrition behaviors was also assessed using the Social Support and Eating Habits Survey, a 10-item survey that assesses social support from family and friends. Each subscale (family and friends) includes 10 questions, 5 that reflect encouragement and 5 that reflect discouragement, with responses reported on a 5-point Likert scale, with 1=none and 5=very often. Higher scores on the encouragement subscale reflect higher levels of

encouragement, and higher scores on the discouragement subscale reflect higher levels of discouragement.

Analysis

In Chapter 2, demographics, intervention attendance and completion, and Facebook engagement were explored for relationships with the main outcome measures (weight, physical activity, diet quality, health-related quality of life). The present study explored the relationship of general social support, social support for eating, and food security with the outcomes of interest after accounting for significant effects found in the first exploration as reported in Chapter 2.

Statistical Analyses

Food security status of participants throughout the intervention was explored, revealing little variability in food security status among the study sample. At baseline, 85.7% of the study sample was completely food secure (food security score = 0), with 3.6% scoring 1, 3.6% scoring 2, 1.8% scoring 3, and 5.4% scoring 6 on the food security assessment, making the distribution right skewed. To be able to explore food security as a nominal variable, the 6 insecure categories (considering a score of 1 to be marginal food security) were collapsed to create 1 category of food insecurity to compare to complete food security (score of 0). Out of 13 people who experienced food insecurity at some point, only 4 of those were food secure at other time points. Therefore, only baseline values were used to explore relationships with outcomes of interest.

Social support variables (general social support, family encouragement/discouragement for healthy eating, and friend encouragement/discouragement for healthy eating) were explored for change over time using linear mixed effects models. No variables changed significantly throughout the intervention. In addition, due to the potential impact of the COVID-19 pandemic on these psycho-social variables, a variety of factors could have influenced changes in these

outcomes over time. Thus, the research team chose to limit analyses of social support with dependent variables to the impact of baseline social support values on intervention outcomes.

The type of regression model used to evaluate the relationships of food security status and social support with intervention outcomes were chosen based on the type of outcome variable (continuous, binary, or ordinal) and are described in detail in Chapter 2 (continuous: weight, PA minutes per week, diet quality [HEI total; DSQ variables]; binary: meeting the CDC weight loss and physical activity goals, HRQoL measures; ordinal: PA category, DSQ sugar-sweetened beverages). Regression models included any significant predictors (demographics, attendance, Facebook engagement) and/or interactions with time described in Chapter 2.

A forward selection process was then used in all models to test for significance of food security and social support for predicting outcomes of interest. Type III F tests were conducted, with the level of significance for entry into and removal from the model set a priori at $p < 0.05$. However, significant predictors/interactions from Chapter 2 were retained in all models, even if they became non-significant following the addition of food security or social support predictors. Post-hoc analyses were conducted for significant independent variables in the models, which included calculation of estimated marginal means or beta coefficients and pairwise comparisons using Bonferroni adjustment where appropriate. Bonferroni adjustment and other adjustments for multiple comparisons were used as appropriate to the data and model type when comparing across categories to adjust the level of significance so that there was an overall p value of 0.05 on any of the tests, rather than a p value of 0.05 of any one of the tests.

Results

Participant characteristics are described in detail in Chapter 2, Table 2.1. Percentage of participants in each food security category and social support responses are presented in Table

3.1. Overall, the majority of the sample was food secure (85.7% at baseline), and this did not change throughout the course of the intervention. General social support was an average of 5.74 ± 1.40 out of 7 at baseline, and this did not change over the course of the intervention. Mean family and friend encouragement for healthy eating was13.76 ± 5.25 and 9.76 ± 4.91 out of 25, respectively. Mean family and friend discouragement for healthy eating was 10.63 ± 4.98 and 8.55 ± 4.21 out of 25, respectively. Results are presented as *b,* SE*,* mean difference (MD)*,* estimated marginal means or probabilities, Odds Ratios (OR), and 95% Confidence Intervals (CI).

Weight loss

Weight significantly decreased over the course of the intervention, with age being a significant predictor and time and race having a significant interaction (Chapter 2, Table 2.3). Food security and general social support were not related to change in weight. There was a significant interaction of healthy eating discouragement from friends with time on weight change (Table 3.2). To explore this relationship, weight was assessed at each timepoint at different levels of friend discouragement (assessed at scores 5, 15, and 25). For low and moderate values of friend discouragement (i.e., less discouragement from friends for healthy eating), predicted weight decreased significantly from baseline to midpoint and from baseline to post-intervention (Table 3.3, Figure 3.1A). However, for high levels of friend discouragement, there was no statistically significant change in weight over time. Of note, the original time*race interaction became non-significant ($p < 0.05$) with the addition of social support but was retained in the model.

Neither food security nor any social support variables were found to be significant predictors of meeting the CDC intervention 5% weight loss goal.

Physical activity

PA category changed significantly over time, such that more participants reported being in a higher activity category at post-intervention, and was unrelated to demographics, attendance, or Facebook engagement (Chapter 2, Table 2.3). There was a significant interaction between time and attendance for moderate PA minutes/week, such that PA minutes/week increased more between midpoint and post-intervention at lower levels of attendance (Chapter 2, Tables 2.3 and 2.4). 56.9% and 56.7% of the sample met the CDC PA goal of 150 min per week at midpoint and post-intervention, respectively (Chapter 2, Table 2.2); and none of the demographic variables, attendance, or Facebook engagement were related to meeting the CDC intervention goal of 150 minutes moderate PA/week or meeting the goal by the end of the intervention (Chapter 2, Table 2.3). When added to the models, neither food security nor any social support variables were found to be significant predictors of PA category, PA minutes/wk, or meeting the PA threshold of 150 minutes per week at midpoint or post-intervention; and there were no interactions with time.

Diet quality

Diet quality assessed by the total HEI-2015 total score did not change significantly over time (Chapter 2, Table 2.3), but age was a significant predictor of HEI-2015 total score (Chapter 2, Table 2.3). Neither food security nor any social support variables were found to be significant predictors of HEI-2015 total score, and there were no interactions with time.

Several of the diet quality variables as assessed by the DSQ were related to demographics, attendance, and/or Facebook engagement as reported in Chapter 2. After accounting for these factors, regression analyses revealed baseline food security was related to dairy and calcium intake, while various measures of social support were related to several of the

diet quality outcomes as assessed by the DSQ, including fiber, total added sugar, and added sugar from sugar sweetened beverages, and are reported as follows. Significant predictors and interactions from Chapter 2 were retained and reported in the final models including any significant food security and social support variables after forward selection (Table 3.3).

Fiber: There was a significant interaction between time and healthy eating encouragement from friends with fiber intake (Table 3.2). To explore this relationship, predicted fiber intake was assessed at each timepoint at different levels of friend encouragement (assessed at scores 5, 15, and 25). For the lowest value of friend encouragement (i.e., less encouragement from friends for healthy eating), predicted fiber intake was significantly higher at midpoint and post-intervention than at baseline (Table 3.3, Figure 3.1B). Food security was not related to fiber intake.

Total added sugar: Healthy eating encouragement from friends was a significant predictor of added sugar intake (Table 3.2), with lower added sugar intake at higher levels of friend encouragement (b = -0.012, SE: 0.004, t (34.79) = -2.72, p = 0.010). There was a significant interaction between time and general social support (Table 3.2). For lower levels of social support (scores 1 and 4), predicted total added sugar intake was significantly higher at post-intervention compared to baseline and midpoint (Table 3.3, Figure 3.1C). For higher levels of social support (score 7), added sugar was higher at post-intervention compared to midpoint (Table 3.3, Figure 3.1C).

Sugar-sweetened beverages: Friend encouragement for healthy eating was a significant predictor of added sugar intake from sugar-sweetened beverages (Table 3.2). As friend encouragement for healthy eating increased by one point, the odds of being in a higher category of sugar-sweetened beverage intake (i.e., higher predicted intakes of added sugar from sugar-

sweetened beverages) decreased (OR: 0.83; 95% CI: 0.70, 1.00; b = -0.18; t (33) = -2.08; $p <$ 0.045).

Fruits and vegetables (including legumes and French fries): Healthy eating encouragement from friends was a significant predictor of intake (Table 3.2), with higher intake of fruits/vegetables/legumes/French fries at higher levels of friend encouragement (b = 0.03, SE: 0.01, t (31.70) = 2.96, p = 0.006).

Fruits, vegetables, and legumes (excluding French fries): Healthy eating encouragement from friends was a significant predictor of intake of fruits, vegetables, and legumes (excluding French fries) (Table 3.2), with higher intakes at higher levels of friend encouragement (b = 0.012, SE: 0.004, t (30.37) = 2.83, p = 0.008).

Vegetables (including legumes and French fries): Healthy eating encouragement from friends was a significant predictor of vegetable intake (Table 3.2), with higher intakes at higher levels of friend encouragement (b = 0.02, SE: 0.01, t (24.83) = 3.28, p = 0.003). There was a significant interaction between time and healthy eating discouragement from family (Table 3.2). Intake was assessed at each timepoint at different levels of family discouragement (assessed at scores 5, 15, and 25). At high levels of family discouragement (score = 25), vegetable intake (including legumes and French fries) increased from baseline to post-intervention (Table 3.3, Figure 3.1D). Note that education was no longer a significant predictor when social support variables were added but was kept in the model. Also note that social support and food security variables were added to the model from Chapter 2 that excluded the "other" race category driving changes in this outcome.

Vegetables and legumes (excluding French fries): Healthy eating encouragement from friends was a significant predictor of intake (Table 3.2), with higher vegetable and legume

intakes at higher levels of friend encouragement (b = 0.02, SE: 0.01, t (26.21) = 3.42, p = 0.002). A significant interaction between time and family discouragement of healthy eating was also found (Table 3.2). Intake was assessed at each timepoint at different levels of family discouragement (assessed at scores 5,15, and 25). At high levels of family discouragement (score = 25), vegetable and legume intake increased from baseline to post-intervention (Table 3.3, Figure 3.1E). Note that education was no longer a significant predictor when social support variables were added but was kept in the model. Also note that social support and food security variables were added to the model from Chapter 2 that excluded the "other" race category driving changes in this outcome.

Dairy: There was a significant interaction between time and baseline food security (Table 3.2). For food insecure participants, predicted dairy intake significantly increased from baseline and to post-intervention and from midpoint to post-intervention, while predicted diary intake over time did not change for those who were food secure (Table 3.3, Figure 3.1F).

Calcium: There was a significant interaction between baseline food security with time on calcium intake (Table 3.2). For food insecure participants, predicted calcium intake significantly increased from baseline to post-intervention, while food secure participants did not have any significant changes in calcium intake over time (Table 3.3, Figure 3.1G).

Fruit: There was no relationship between food security or any of the social support measures and fruit intake.

Whole Grains: There was no relationship between food security or any of the social support measures and whole grain intake.

Health-related Quality of Life

Several of the measures of health-related quality of life were related to demographics and time, but not attendance or Facebook engagement, as reported in Chapter 2. When added to the models, food security and social support emerged as predictors of some HRQoL outcomes as follows.

Physically unhealthy days: The number of physically unhealthy days reported by participants significantly decreased over time, but was unrelated to demographics, attendance, and/or Facebook engagement as reported in Chapter 2 (Table 2.3). After accounting for these factors, regression analyses revealed family discouragement for healthy eating was a significant predictor of physically unhealthy days, and time became no longer significant (Table 3.2). As family discouragement increased, the odds of reporting a physically unhealthy day were increased (OR= 1.17; 95% CI: 1.00, 1.36; $b = 0.16$; t (104) = 2.04; $p = 0.044$). Food security was not related to frequency of physically unhealthy days.

Mentally unhealthy days: The number of mentally unhealthy days reported by participants did not significantly change over time, but increasing age was associated with fewer mentally unhealthy days (Chapter 2, Table 2.3). Friend encouragement for healthy eating was a significant predictor of this outcome (Table 3.2), with odds of reporting a mentally unhealth day being decreased as friend encouragement increased (OR= 0.83; 95% CI: 0.73, 0.94; $b = -0.18$; t (39) = -3.12; $p = 0.003$). Food security was not related to frequency of mentally unhealthy days.

Interference of physical or mental health with daily life: Initial regression analyses indicated age and the interaction of time with education were significant predictors of the number of days in which poor physical or mental health interfered with daily life (Chapter 2, Table 2.3). When food security was added to the model, the interaction of time and education

remained significant predictors of this outcome, but age was no longer significant (Table 3.2). Food security was related to the number of days in which poor physical or mental health interfered with daily life (Table 3.2). For individuals who were food insecure, the odds of reporting a day interfered by poor health were more than ten times that of those who were food secure (OR= 10.62; 95% CI: 1.16, 97.11; b = 2.36; t (110) = 2.12; p = 0.037). Still, the estimated marginal probability of reporting a day interfered by poor health were low for both groups (estimated marginal probabilities, food secure: 0.01 [95% CI: 0.00, 0.03]; food insecure: 0.09 [95% CI 0.01, 0.45]). None of the measures of social support were related to the number of days in which poor physical or mental health interfered with daily life.

Pain: Age and time significantly interacted to predict days pain interfered with daily life (Chapter 2, Table 2.3). Neither food security nor any social support variables were significant predictors of this outcome, and there were no interactions with time.

Sadness: Age was a significant predictor of days experiencing sadness, with older adults reporting fewer days of sadness (Chapter 2, Tables 2.3 and 2.4). Family encouragement for healthy eating was a significant predictor of this outcome (Table 3.2), such that for each additional point on the family encouragement scale, the odds of having a sad day decreased (OR= 0.87; 95% CI: 0.77, 1.00; b = -0.14; t (39) = -2.11; p = 0.042). Food security was not related to reported sadness.

Worry: Days experiencing worry did not change over time, but increasing age was associated with decreased worry (Chapter 2, Tables 2.3 and 2.4). Neither food security nor any social support variables were found to be significant predictors of this outcome, and there were no interactions with time.

Rest: Days experiencing inadequate rest did not change over time, and there were no significant demographic, attendance or Facebook engagement predictors (Chapter 2, Table 2.3). Neither food security nor any social support variables were found to be significant predictors of this outcome, and there were no interactions with time.

Energy: Time and age interacted to predict days full of energy, and race was a significant predictor of this outcome (Chapter 2, Table 2.3). When food security and social support were added to the models, family discouragement for healthy eating was also a significant predictor of this outcome (Table 3.2). As family discouragement increased by one point on the family discouragement scale, the odds of having a day full of energy decreased (OR= 0.86; 95% CI: 0.75, 1.00; b= -0.15; t (42) = -2.04; p = 0.047).

Discussion

This study provides insight into the potential influences of social support and food security status on outcomes of participants of a Diabetes Prevention Program implemented in Cooperative Extension. A primary difference between the DPP clinical trial and the lifestyle change program part of the National DPP effort is the one-on-one setting versus group settings, respectively, in which the programs were/are delivered [4]. Naturally, one of the perceived benefits of the group setting of the DPP is the social support provided by fellow group members [166]. Thus, understanding the role of this social support in participant outcomes is of value.

Social support, including general social support and family and friend encouragement and discouragement for healthy eating, did not change over the course of the intervention. However, participants' social support at the beginning of the intervention was associated with some outcomes. Friend discouragement for healthy eating was associated with weight over time, with less discouragement from friends being associated with a lower weight at midpoint and post-

intervention. This finding is similar to that in the existing literature, as Wang et al. found family discouragement for healthy eating to be associated with weight gain over 2 years [167]. Seguin et al. also found social support for healthy eating to be associated with BMI maintenance or additional weight loss 3 years following the 12-week Strong Women, Healthy Hearts program [168]. These consistent findings highlight the importance of positive support for achieving and maintaining weight loss over time.

Social support from friends for healthy eating was associated with certain measures of diet quality. Interestingly, a lower level of friend encouragement for healthy eating at baseline was associated with higher predicted fiber intakes at midpoint and post-intervention. A potential explanation of this finding could be that those participants that began the DPP with lower levels of social support from friends benefited more from the group setting of the DPP for improving their fiber intake over the course of the intervention. Friend encouragement for healthy eating was a significant predictor of total added sugar intake and intake of added sugar from sugar-sweetened beverages: the greater the encouragement from friends for healthy eating, the lower the added sugar (total and from beverages) intake. General social support was also associated with predicted total added sugar intake over time, with lower levels of general social support associated with higher predicted added sugar intakes over the course of the intervention. Capitalizing on friend encouragement may be important for helping DPP participants reduce their added sugar intake. Friend encouragement was also a predictor of intake of fruits/vegetables/legumes/French fries, vegetables/legumes/French fries, vegetables/legumes, and fruits/vegetables/legumes, with intake being higher at higher levels of friend encouragement. These findings are consistent with existing literature, identifying social support as a predictor of intention to consume and consumption of fruits and vegetables [169-173]. In light of these results,

consideration should be given to the level of social support that DPP participants have when they enter the program. Assessment of participant social support at the beginning of the program, such as with the social support measures used in the present study, may be a valuable step in the DPP enrollment process to provide DPP implementers a better understanding of participants' support needs and ensure that those support needs are met throughout the program to optimize outcomes.

While the DPP theoretically provides friend encouragement, as participants gain "friends" through their fellow group members, additional opportunities may be needed to foster stronger relationships between participants to be impactful for positive behavior change. Addition of more hands-on activities, such as group walking opportunities, may be valuable for increasing friend social support and encouragement among DPP group members [174]. Additionally, the perceived support of participants may be different based on DPP delivery method [175]. While the popularity of distance learning is increasing, especially due to the COVID-19 pandemic, distance learning may not provide the same social support as in-person sessions for some participants [175, 176]. The present study is unique in that although it was delivered primarily through distance learning, the program was not fully distance learning with the short in-person component prior to the COVID-19 pandemic's onset. In participant focus groups, participants overwhelmingly preferred the in-person sessions over distance learning. Many also spoke to the importance of the initial in-person component of the program in creating the "bond" they had as a group. These additional qualitative outcomes will be explored in future studies. While consideration should be given to each group's preference for delivery method, fully in-person sessions may be valuable for maximizing social support and friend encouragement among participants to promote outcomes.

Social support from family for healthy eating was also associated with a few measures of diet quality as well. Interestingly, at high levels of family discouragement, predicted intake of vegetables and legumes, both including and excluding French fries, increased from baseline to post-intervention. These findings are unique compared to similar studies and the results of friend encouragement discussed above. Yoshikawa et al. found social support for healthy eating to be a mediator of change in fruit and vegetable intake, such that fruit and vegetable intake increased in the intervention group, and this increase was mediated by increases in positive social support for healthy eating [172]. However, similar to the findings regarding friend encouragement and fiber intake, those participants that began the DPP with high levels of family discouragement may have benefited more from the social support derived in the DPP group setting for encouraging them to improve their vegetable intake over the course of the intervention. This explanation would be consistent with the findings by Yoshikawa et al. [172]. However, no changes were observed in any of the social support measures used in the present study. While no quantitative changes were observed, positive social support did emerge as a major theme in focus groups conducted with participants and will be explored further in future studies.

General social support was not related to the health-related quality of life measures. However, social support from friends and family for healthy eating was associated with a few health-related quality of life measures. In general, more encouragement from friends and family for healthy eating was associated with fewer mentally unhealthy and fewer sad days, respectively. Conversely, greater family discouragement for healthy eating was associated with more physically unhealthy days. It is interesting that these healthy eating-specific measures of social support were associated with these health-related quality of life outcomes, while general social support was not. It could be possible that these variable associations are mediated by

health behaviors and outcomes, which may better explain these associations. In addition, the type of social support assessed in the Social Support for Healthy Eating survey is, in general, more health-focused than the support assessed in the MSPSS survey. Participants may have answered MSPSS questions from less of a health perspective than they answered the Social Support for Healthy Eating questions, contributing to the association observed between this survey and some health-related quality of life measures. However, the sample size of the present study was too small to complete any mediation analyses.

Food security was associated with a limited number of outcomes. For food insecure participants, predicted dairy and calcium intake significantly increased from baseline to post-intervention, while food secure participants did not significantly increase their intake. While there is no clear explanation for this observation, food insecure participants may have increased their dairy intake as a relatively inexpensive, nutrient-dense food item, as choosing nutrient dense foods like low-fat dairy is discussed in the Prevent T2 curriculum. It is again important to remember that the present study was conducted during the COVID-19 pandemic, a period of rapid increases in food insecurity rates [164]. Estimates of food insecurity in the U.S. during March and April of 2020 were as high as 38% of the U.S. population, more than triple the national average prior to the pandemic [164]. Research consistently supports an inverse association between food insecurity and diet quality, with lower levels of diet quality at higher levels of food insecurity [177]. However, the study sample was primarily food secure, providing little power to detect influences of food insecurity on participant outcomes.

Food security status was also associated with one health-related quality of life measure. Food insecure participants had significantly higher probabilities of having a day interfered by poor health than participants who were food secure. Current research literature supports the

associations between food insecurity and poorer health, including poorer health-related quality of life factors [178]. Again, because this study occurred during the COVID-19 pandemic, this observation could be due to a variety of reasons, including the physical effects of extreme financial stress of food insecure participants during the COVID-19 pandemic. Moreover, it is possible that those participants who were food insecure were more likely to contract COVID-19 and, thus, have a day of illness. While it is unknown at this time if food insecurity was related to COVID-19 infection, it is known that COVID-19 infection rates were higher among those of lower socioeconomic status and who are more likely to be food insecure [179]. Future research should continue to investigate the effects of the pandemic on food insecure participants, as well as the potential influence of food insecurity on DPP outcomes, to prevent worsening health disparities among this population [164]. If future research finds that food insecure DPP participants have poorer outcomes, additional support for these participants, such as through the SNAP-Ed program, may help reduce these disparities.

Again, the results of this study are highly specific to the COVID-19 pandemic. It is unknown if and to what degree the pandemic influenced the present study's outcomes, as emerging research suggests social support and food security to be highly affected during these unprecedented times [163, 164, 179-181]. While this study offers external validity with the real-world setting in which it was implemented, the generalizability of these findings beyond the COVID-19 pandemic is likely limited. In addition, internal validity is limited with no control group included. Advanced statistical methods were used to account for as much variability as possible, but relationships observed could still be influenced by other factors. Lastly, the study sample was primarily food secure, limiting the power able to detect the relationship of food insecurity with outcomes. Lastly, weight was completely self-reported at midpoint and post-intervention due to

the pandemic, as well as physical activity minutes at all three time points. Participants were encouraged to wear similar clothing to that worn at baseline measurement, but it is highly possible that these instructions were not followed and that participants may have misreported weight due to social desirability bias. In addition, participants were regularly reminded what is considered moderate PA. Still, some individual participants consistently over-reported moderate PA, limiting the validity of this data.

Conclusions and implications for research and practice

While the results of the present study are highly confounded by the context of the COVID-19 pandemic, still, the role of social support in health outcomes is evident. While no changes in the chosen measures of social support were observed over the course of the intervention, social support was related to positive health outcomes. Furthermore, in focus groups conducted with participants that will be explored in future studies, participants repeatedly discussed the value of the support provided through the DPP in their health behavior change, both specific and not specific to the COVID-19 pandemic. One participant stated the following in regard to the value of participating in the DPP during the pandemic: "Zoom...that I get to look forward to once a week has been great. It's been an uplift for me. I live for Thursday morning…eight o'clock." These focus group findings indicate the need for further exploration into these qualitative indicators of social support and participants' health outcomes. Still, the health improvements observed among participants in the present study during the isolating period of the COVID-19 pandemic, when the average adult experienced weight gain and other health-related challenges, suggests value of the program and the support provided for health behavior change [163, 181]. In light of the influence of low and high levels of social support observed on participant outcomes, future iterations of the DPP in CES should consider

emphasizing social support-focused lessons in the curriculum and including resources, activities, or other strategies, without compromising program fidelity, to address low levels of social support or high levels of discouragement that participants may receive from family and/or friends. Future research should continue to investigate the role of social support in DPP participant outcomes, as well as strategies to further promote support among DPP group members.

In addition, the few findings of the influence of food insecurity on participant outcomes warrants future research on the potential benefit of offering food insecure participants additional resources, perhaps through SNAP-Ed, EFNEP, financial literacy education, or other general resources, to improve outcomes in this population.

Tables

Table 3.1 Food security and social support of DPP participants over time						
	Baseline		Midpoint		Post-intervention	
Variable	**N**	**Mean ± SD, Median [Range] or %**	**N**	**Mean ± SD, Median [Range] or %**	**N**	**Mean ± SD, Median [Range] or %**
Food Security						
Food Insecure	8	14.3%	5	11.6%	7	14.6%
Food Secure	48	85.7%	38	88.4%	41	85.4%
Social Support						
General Support	56	5.74 ± 1.40, 6.13 [1-7]	43	5.48 ± 1.76, 6 [1-7]	47	5.57 ± 1.66, 6 [1-7]
Family Encouragement	51	13.76 ± 5.24, 14 [5-25]	35	15.6 ± 5.53, 15 [5-25]	42	14.36 ± 5.33, 15 [5-24]
Family Discouragement	51	10.63 ± 4.98, 9 [5-25]	35	9.8 ± 3.89, 9 [5-21]	42	10.5 ± 4.79, 9 [5-24]
Friend Encouragement	51	9.76 ± 4.91, 8 [5-23]	34	10.15 ± 4.49, 9.5 [5-22]	42	10.33 ± 4.76, 9 [5-23]
Friend Discouragement	51	8.55 ± 4.21, 8 [5-23]	34	8.56 ± 3.51, 8 [5-15]	42	7.98 ± 3.63, 6.5 [5-16]

Table 3.2 Mixed effects models for relationships of food security and social support with health outcomes (N = 34)[a]				
Outcome Variable **Independent variables**	**Numerator df**	**Denominator df**	**F statistic**	***p* value**
Weight				
Time	2	74.04	20.07	< 0.001
Age	1	45.28	9.68	0.003
Race	2	37.96	0.92	0.407
Time*Race	4	74.04	2.44	0.055
Friend Discouragement	1	45.91	3.48	0.069
Time*Friend Discouragement	2	74.05	4.93	0.010
DSQ Fiber				
Time	2	68.32	6.39	0.003
Sex	1	44.27	19.29	< 0.001
Education	2	44.38	4.63	0.015
Time*Education	4	56.69	2.56	0.048
Attendance	1	91.08	1.85	0.177
Time*Attendance	2	68.04	4.54	0.014
Friend Encouragement	1	36.73	3.84	0.058
Time*Friend Encouragement	2	53.83	4.9	0.011
DSQ Added Sugars				
Time	2	57.03	4.56	0.015
Friend Encouragement	1	34.79	7.38	0.010
General Support	1	35.94	0.80	0.376
Time*General Support	2	57.03	4.23	0.019
DSQ Sugar-Sweetened Drinks				
Time	2	112	0.57	0.570
Friend Encouragement	1	33	4.32	0.045
DSQ Fr/Veg/Leg/FF				
Time	2	75.34	1.60	0.208
Sex	1	42.16	15.93	< 0.001
Education	2	41.00	6.16	0.005
Friend Encouragement	1	31.70	8.78	0.006
DSQ Veg/Leg/FF				
Time	2	74.51	2.35	0.102
Sex	1	36.72	19.25	< 0.001
Education	2	34.34	2.49	0.098
Friend Encouragement	1	24.83	10.77	0.003
Family Discouragement	1	42.81	0.85	0.361

Time*Family Discouragement	2	76.27	3.52	0.034
DSQ Fr/Veg/Leg				
Time	2	72.65	2.57	0.083
Sex	1	40.49	9.59	0.004
Education	2	39.28	7.05	0.002
Friend Encouragement	1	30.37	8.07	0.008
DSQ Veg/Leg				
Time	2	78.82	2.39	0.098
Sex	1	38.41	11.80	0.001
Education	2	36.00	2.72	0.079
Friend Encouragement	1	26.21	11.71	0.002
Family Discouragement	1	44.65	0.87	0.356
Time*Family Discouragement	2	80.61	3.61	0.032
Physical Health[b]				
Time	2	104	2.40	0.095
Family Discouragement	1	104	4.16	0.044
Mental Health[b]				
Time	2	71	0.03	0.968
Age	1	40	6.53	0.015
Friend Encouragement	1	39	9.73	0.003
Days Interfered[b]				
Time	2	110	1.82	0.166
Age	1	110	3.12	0.080
Education	2	110	0.52	0.598
Time*Education	4	110	3.40	0.012
Food Security	1	110	4.47	0.037
Sadness[b]				
Time	2	61	1.59	0.212
Age	1	38	4.05	0.051
Family Encouragement	1	39	4.43	0.042
Energy[b]				
Time	2	57	4.84	0.011
Age	1	40	4.51	0.040
Time*Age	2	57	4.54	0.015
Race	2	30	7.79	0.002
Family Discouragement	1	42	4.17	0.047

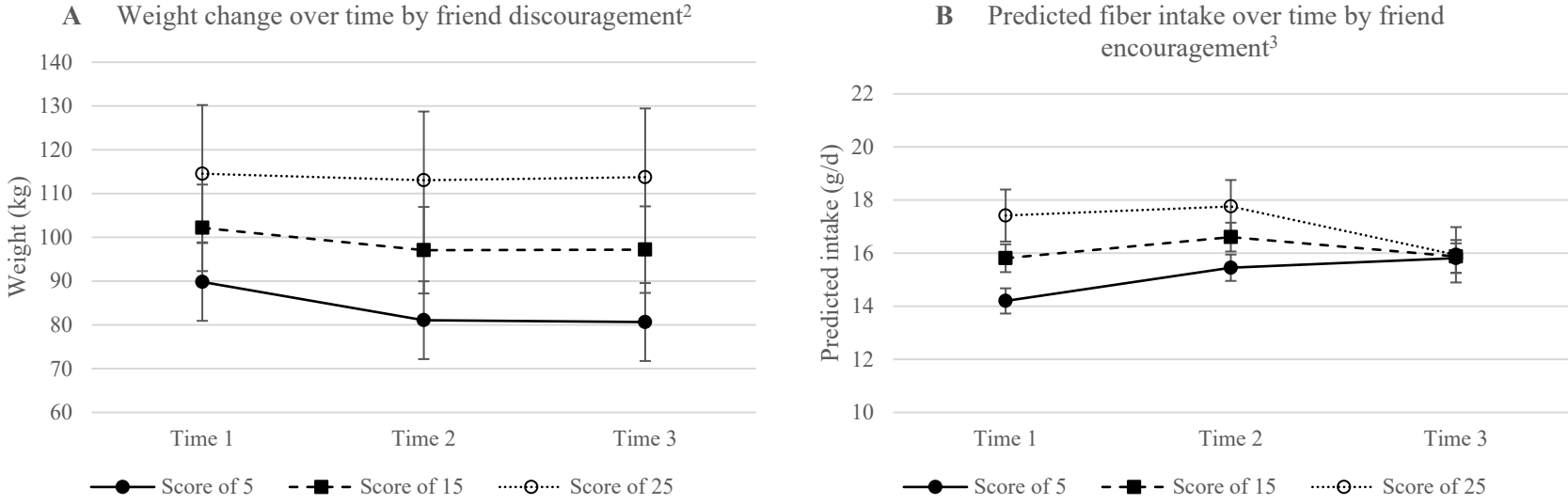
[a]Independent variables assessed in mixed effects models include food security, general social support, social support for healthy eating. time, age, race, education, attendance, Facebook engagement and interactions with time; final model includes only food security and social support variables with significant relationship ($p<0.05$) and/or interactions with time and the dependent variable (weight, physical activity, diet quality, health related quality of life)

Table 3.3 Pairwise comparisons for relationships of food security and social support with health outcomes (N = 34)					
Variable	**Comparison**	**Mean difference**	**Standard error**	**P-Value**	**95% CI**
Weight					
Friend Discouragement					
Score of 5	Time 1 – Time 2	8.74	1.54	< 0.001	4.96,12.52
	Time 2 – Time 3	0.42	1.60	1.000	-3.49,4.33
	Time 1 – Time 3	9.16	1.60	< 0.001	5.25,13.06
Score of 15	Time 1 – Time 2	5.11	1.58	0.005	1.24,8.99
	Time 2 – Time 3	-0.13	1.60	1.000	-4.04,3.77
	Time 1 – Time 3	4.98	1.60	0.008	1.07,8.89
DSQ Fiber					
Friend Encouragement					
Score of 5	Time 1 – Time 2	-1.25	0.36	0.003	-2.14,-0.36
	Time 2 – Time 3	-0.36	0.46	1.000	-1.50,0.78
	Time 1 – Time 3	-1.61	0.44	0.002	-2.71,-0.52
DSQ Added Sugar					
General Support					
Score of 1	Time 1 – Time 2	0.05	0.15	1.000	-0.32,0.41
	Time 2 – Time 3	-0.39	0.15	0.036	-0.77,-0.02
	Time 1 – Time 3	-0.35	0.13	0.036	-0.68,-0.02
Score of 4	Time 1 – Time 2	0.06	0.07	1.000	-0.11,0.22
	Time 2 – Time 3	-0.19	0.07	0.022	-0.36,-0.02
	Time 1 – Time 3	-0.14	0.06	0.092	-0.29,0.02
DSQ Veg/Leg/FF					
Family Discouragement					
Score of 25	Time 1 – Time 2	-0.04	0.17	1.000	-0.45,0.38
	Time 2 – Time 3	-0.38	0.19	0.144	-0.84,0.08
	Time 1 – Time 3	-0.42	0.16	0.027	-0.79,-0.04
DSQ Veg/Leg					
Family Discouragement					
Score of 25	Time 1 – Time 2	-0.04	0.19	1.000	-0.50,0.43
	Time 2 – Time 3	-0.43	0.21	0.139	-0.95,-0.09
	Time 1 – Time 3	-0.47	0.17	0.027	-0.89,-0.04
DSQ Dairy					

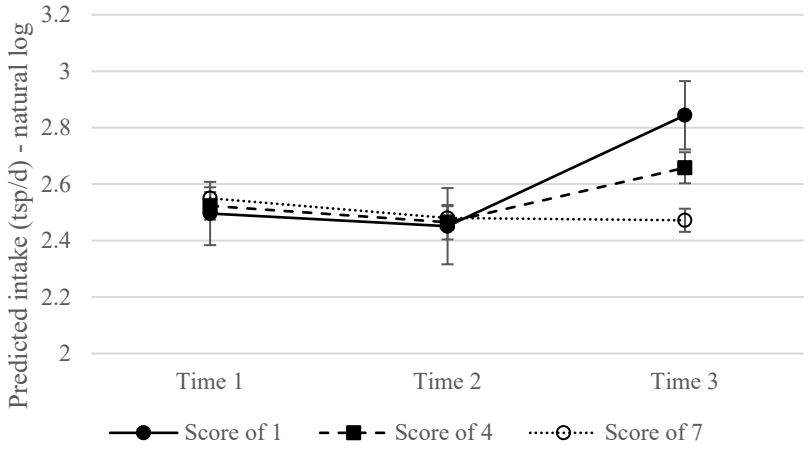
Food Insecure	Time 1 – Time 2	0.06	0.13	1.000	-0.25,0.38
	Time 2 – Time 3	-0.39	0.14	0.019	-0.73,-0.05
	Time 1 – Time 3	-0.33	0.13	0.036	-0.64,-0.02
Food Secure	Time 1 – Time 2	-0.04	0.05	1.000	-0.17,0.08
	Time 2 – Time 3	0.04	0.05	1.000	-0.09,0.18
	Time 1 – Time 3	-0.00005	0.05	1.000	-0.12,0.12
DSQ Calcium					
Food Insecure	Time 1 – Time 2	-3.87	38.79	1.000	-99.04,91.30
	Time 2 – Time 3	-93.22	39.77	0.067	-191.04,4.59
	Time 1 – Time 3	-97.09	38.79	0.044	-192.26,-1.92
Food Secure	Time 1 – Time 2	-20.88	15.36	0.536	-58.58,16.83
	Time 2 – Time 3	15.53	15.65	0.975	-22.96,54.02
	Time 1 – Time 3	-5.35	14.99	1.000	-42.15,31.46
Physical Health	Time 1 – Time 2	1.40	0.69	0.133	-0.27,3.07
	Time 2 – Time 3	-1.43	0.75	0.133	-3.17,0.31
	Time 1 – Time 3	-0.03	0.62	0.960	-1.26,1.20

Figures

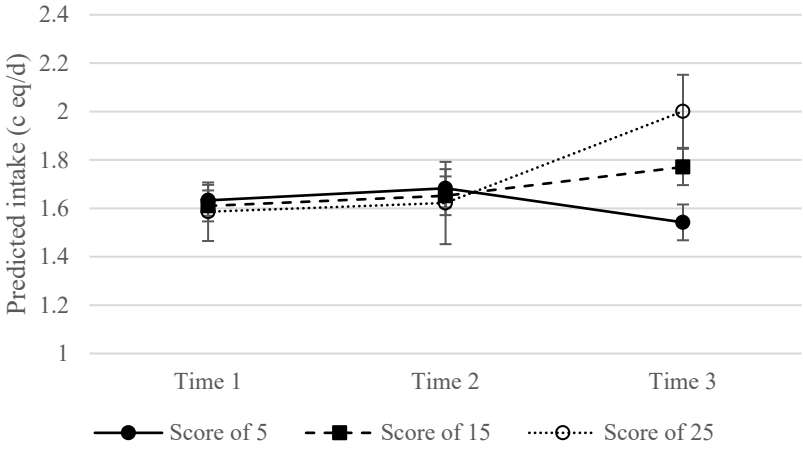
Figure 3.1 Selected weight, physical activity, and diet quality changes over time by social support and food security[1]



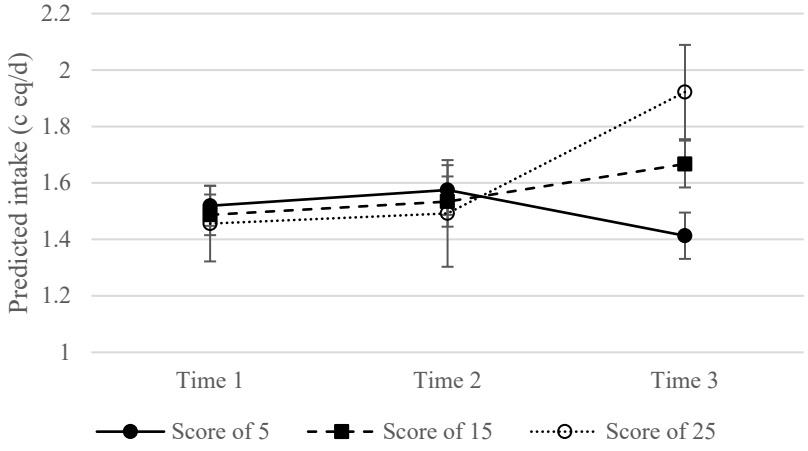
C Predicted added sugar intake over time by general social support[4]



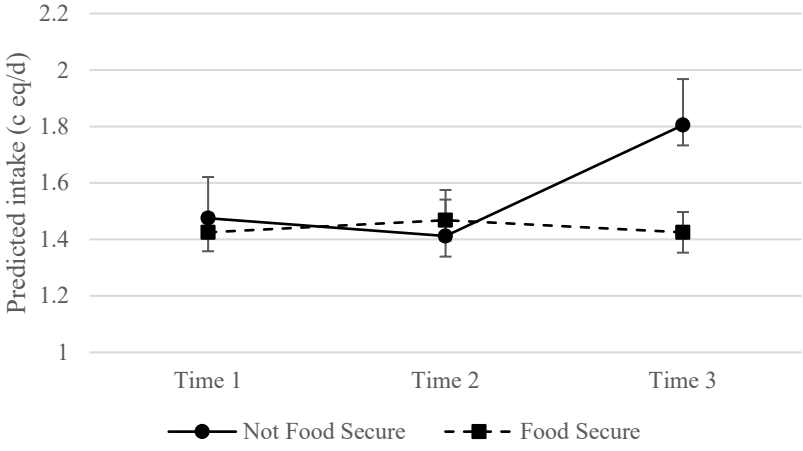
D Predicted vegetable/legume/french fry intake over time by family discouragement[4]



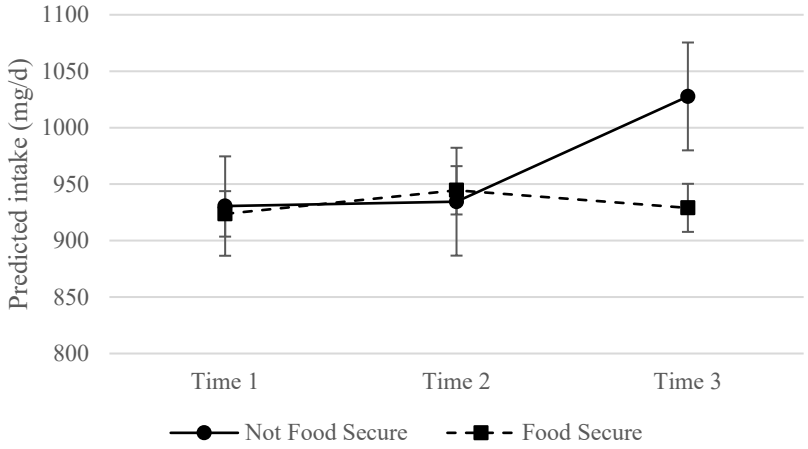
E Predicted vegetable/legume intake over time by family discouragement[4]



F Predicted dairy intake over time by food security status



G Predicted calcium intake over time by food security status



[1]Values are estimated marginal means (± SE) predicted from the regression models over time or modeled at various levels of an independent variable (e.g., Social support scale) and adjusted to average levels of other significant predictors in the model
[2]Adjusted for age
[3]Adjusted for attendance
[4]Adjusted for social support (friend encouragement)

CHAPTER 4

BARRIERS, FACILITATORS, AND IMPLEMENTATION OUTCOMES OF THE DIABETES PREVENTION PROGRAM IN GEORGIA COOPERATIVE EXTENSION[1]

[1]Wilson, H.K., Wieler, C., Bell, D.L., Bhattarai, A.P., Berg, A.C.

To be submitted to *Implementation Science*

Abstract

Background: With approximately one third of the U.S. population living with prediabetes and 5-10% of these individuals developing type 2 diabetes mellitus (T2DM) each year, the need for increased dissemination of diabetes prevention interventions is imperative [1]. The CDC's National Diabetes Prevention Program (DPP) effort aims to increase dissemination of the evidence-based DPP lifestyle change program in a variety of settings. Cooperative Extension Services (CES) are poised to be a sustainable delivery system for the DPP, with its potential to reach large and diverse populations and provide content and implementation support to DPP lifestyle coaches. Still, limited research on barriers, facilitators, and strategies for DPP implementation in CES exists.

Methods: The present study was part of a larger, hybrid type 2 effectiveness-implementation trial of the DPP in a state CES. Program data on recruitment, enrollment, primary outcomes, and number of programs adopted were used to evaluate implementation with the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) framework. CES professionals (n = 12) were interviewed at three timepoints (post-recruitment, mid-implementation, and post-implementation) using semi-structured interviews to evaluate barriers and facilitators of DPP implementation in their county. Interviews were coded primarily deductively according to the Consolidated Framework for Implementation Research (CFIR) by 5 analysts total in pairs using a qualitative consensus process. Constructs were rated for magnitude and valence to determine their influence on implementation as a barrier or facilitator and evaluated for their influence on RE-AIM domains.

Results: The program reached (R) 119 participants, was adopted (A) by 12 of 13 trained CES professionals, and average weight loss (Effectiveness, E) exceeded the CDC goal of 5% of initial

body weight (5.2% ± 5.0%). The program was implemented (I) according to CDC standards, with all agents exceeding the minimum 22-session requirement (average 26 session [range: 25-27]). At the conclusion of the present study, eight CES professionals had already begun or had plans to maintain (M) the intervention and begin a second DPP cohort within the next 6 months. Some barriers to Reach were discussed, including limited time (*Available Resources*) to recruit participants, while different aspects of communication (including an implementation strategy of technical assistance calls [*Networks and Communications*]) were facilitators of Implementation. CES leadership (*Leadership Engagement*) was also a consistent facilitator of both Adoption and Implementation of the program.

Conclusions: The structure of CES, with content experts to oversee programs and CES professionals to serve as lifestyle coaches, offers numerous facilitators to DPP implementation, supporting its value as an effective and sustainable delivery system for DPP dissemination and implementation. Implementation strategies that promote communication and access to information, resources, and support were discussed as facilitators of implementation of the DPP in CES. Extension Services may consider incorporating these implementation strategies and addressing the barriers to Reach, Adoption, and Implementation identified. Future research should aim to further test implementation strategies for the DPP in CES, as well as other barriers and facilitators of implementation of the DPP in other state Extension Services.

Background

The National Diabetes Prevention Program

Approximately one third of the U.S. population lives with prediabetes, increasing their risk for type 2 diabetes mellitus (T2DM) [1]. A variety of T2DM prevention lifestyle interventions exist, but the most widely recognized evidence-based intervention is the Centers for Disease

Control and Prevention (CDC's) National Diabetes Prevention Program (DPP) lifestyle change program [2, 182]. The DPP is based on a clinical trial that demonstrated significant (58%) T2DM risk reduction among individuals who lost at least 5% body weight and increased physical activity with a behavioral intervention, and the risk reduction persisted for more than 10 years [2, 89, 90]. Several research groups have explored translation of the DPP from clinical to community contexts [79, 89, 99, 101, 109, 110]. However, due to differences between clinical and community contexts for program implementation, numerous adaptations to the DPP have been made in community translations, compromising program fidelity and the rigor of DPP translational research [89]. In general, these studies show that while weight loss is observed, it is less than that achieved in the clinical studies, but generalizations as to why this is the case are limited due to decreased intensity and duration of these interventions, as well as limited evaluation of the program's implementation.

In 2012, the CDC began the National DPP effort to increase dissemination of the DPP lifestyle change program [4]. To encourage fidelity of the program and, thus, maximum potential effectiveness, the CDC created the Diabetes Prevention Recognition Program (DPRP) [95]. Community translations of the DPP that followed the standards now set by the CDC DPRP have observed outcomes closer to that of the clinical trial, with a hallmark example being the YMCA translations that used the clinical trial's curriculum but delivered the intervention in group settings [183]. This translation observed 6% (95% CI: 4.7-6.3%) average weight loss, higher than that observed in other community translations of lower intensity [183]. Other evaluations of YMCA DPP translations have observed high retention rates, further supporting the value of community DPP translations when implemented as intended [184].

Still, because of the challenges encountered in community translations, significant adaptations to the DPP continue, producing suboptimal outcomes as well as reach of the DPP [89, 99]. Thus, research on factors that help and hinder DPP implementation with fidelity in community contexts is warranted. Furthermore, with introduction of a new DPP curriculum (Prevent T2) in 2017, the need for research on implementation in communities using this new curriculum is even greater [97].

Translation of the DPP into Cooperative Extension Services

Cooperative Extension Services (CES) have a history of delivering health education and interventions to improve the lives of citizens. With its presence in almost every county in every state, as well as an infrastructure that includes CES state-level specialists with content, administrative, and implementation expertise in nutrition and health programming, CES is poised as an effective platform for dissemination and implementation of the DPP. In fact, many CES organizations are becoming DPP providers, with 31 CES organizations listed as CDC-recognized DPP providers [136]. Still, rigorous published implementation evaluations of the DPP in CES are lacking.

Implementation science in DPP translation

A relatively new focus area within nutrition and health programming research is that of implementation science, the study of not only how effective an intervention is but also how the intervention is utilized, changed, and sustained by organizations and systems within specific contexts [103]. Incorporation of implementation science in DPP translational research is imperative, as numerous adaptations are often made to an intervention when it is translated from the clinic to the community [89]. Even when intervention fidelity is maintained, it is important to evaluate intervention implementation and effectiveness over time to ensure the intended outcomes are still

achieved and best practices for enhancing program fidelity, intervention uptake, and maintenance are established [103].

Numerous theories, models, and frameworks exist within the field of implementation science to guide evaluation of various aspects of implementation [103]. The Consolidated Framework for Implementation Research (CFIR) and the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework are useful for determining the effect of the context of program implementation (for example, Cooperative Extension) on implementation outcomes [103, 118, 185-187]. These frameworks are often referred to as either *determinant* frameworks, which identify factors (typically contextual factors) that predict implementation outcomes, or *evaluation* frameworks, which guide evaluation of implementation outcomes [103]. The CFIR is a determinant framework, while RE-AIM is an evaluation framework [103]. Another key component of implementation research is implementation strategies, which are actions taken by systems to promote effective program implementation [103]. Implementation strategies encompass a wide variety of approaches targeted at different stakeholders within program implementation, from the consumer of the program to the implementer of the program [103, 116, 117]. While studies have investigated the implementation context, strategies, and outcomes of DPPs implemented in clinical contexts and in the context of the YMCA system, a review of the literature reveals no studies that have rigorously evaluated these three aspects of implementation within the community context of Cooperative Extension.

Purpose and Objectives

The purpose of the present study was to rigorously evaluate translation of the DPP into one state's CES, evaluating implementation barriers, facilitators, outcomes, and strategies. Support needs of DPP implementers in the present study were considered in the development of

the implementation strategies used and evaluated. By identifying implementation barriers, facilitators, outcomes, and strategies, DPP dissemination and implementation in the community context of CES may be improved, contributing to decreased burden of T2DM in the U.S.

Methods

Study Design

The present study was part of a 12-month, multi-site, hybrid type 2 effectiveness-implementation trial of implementation of the DPP in a state CES [103, 104, 114]. In light of the existing research supporting the DPP's effectiveness, but limited rigorous research on its effectiveness in CES, a study design with an effectiveness evaluation component was deemed necessary. Furthermore, implementation evaluations of the DPP since introduction of the Prevent T2 curriculum and in CES is lacking in the existing research. Thus, this hybrid study design was chosen as the approach for the present study. Detailed effectiveness outcomes will be published elsewhere (Wilson et. al, forthcoming). The implementation evaluation utilized qualitative semi-structured interviews with DPP implementers, as well as quantitative data from program reports and participant records to evaluate Adoption and recruitment (Reach), Implementation, Effectiveness, and Maintenance and determine barriers and facilitators to each RE-AIM domain and overall implementation of the DPP. All methods and procedures were approved by the University of Georgia Institutional Review Board of Human Subjects. DPP participants provided written informed consent, and DPP implementers provided verbal informed consent.

Setting

The present study was set in the context of the Cooperative Extension Service (CES) in [STATE]. The most updated DPP curriculum, referred to as the Prevent T2 curriculum, was used in the present study. Lifestyle coaches administering the DPP were Family and Consumer

Sciences (FACS) CES county professionals in [STATE] trained as lifestyle coaches by the Diabetes Training and Technical Assistance Center (DTTAC) at Emory University. Twelve FACS Extension professionals delivered 13 DPPs across all four regions of [STATE], 5 programs in the northeast region, 5 programs in the northwest region, 2 programs in the southeast region, and 1 program in the southwest region. Of the 13 counties in which the program was implemented, 7 counties were metropolitan and 6 were nonmetropolitan [143].

Program implementation began in person in January – March 2020 and continued through January – March 2021. Upon the onset of the COVID-19 pandemic, program implementation of all 13 DPPs was converted from in-person to distance education formats. Twelve groups met over Zoom and one group met over FreeConferenceCall.com® after the onset of the pandemic, and all groups remained in the distance education format for the remainder of the program [146, 147].

Implementation Strategies

Training

All CES professionals received the same training. All were trained as lifestyle coaches by DTTAC over 2 days [188]. A third day of training following the DTTAC training was led by the research team, including the CES state specialist assigned to chronic disease prevention and management programs, the DPP coordinator for CES who was a trained lifestyle coach and graduate student, and kinesiology collaborators providing expertise for the physical activity portion of the program. The third day covered data collection and methods specific to the effectiveness portion of the larger hybrid type 2 effectiveness-implementation trial, as well as information specific to the DPP in the context of CES, data collection and cohort tracking for CDC data reporting purposes. Trainings were held in October 2019 to allow for sufficient time

for recruitment and preparation for the start of program implementation in approximately January 2020.

Continuing education

Agent continuing education occurred following the initial October DTTAC and research measures training. DTTAC continuing education webinars on recruitment, program implementation with fidelity, virtual programming during the COVID-19 pandemic, and participant retention were made available approximately every quarter to the CES professionals implementing the program. Some CES professionals implementing the program also participated in other continuing education opportunities outside those in which the entire team participated, including an in-depth [STATE] CES training on T2DM and a DTTAC webinar on motivational interviewing in groups.

Technical assistance/support

Technical assistance calls with CES professionals were held every week from the time of initial training in October 2019 through mid June 2020 after the successful conversion of all programs to virtual platforms. Frequency of technical assistance calls were decreased to approximately every other week from mid June to the end of program implementation in approximately March 2021 per recommendation by the CES professionals. A platform for continual inter-agent communication was created through a group messaging mobile application (GroupMe) for all CES professionals implementing the DPP [189]. Furthermore, a private online course within the University's learning management system was created where CES professionals could access recruitment flyers, webinar links, and other resources available from DTTAC and the research team to support DPP recruitment and implementation. Lastly, all CES

professionals had access to the DTTAC Common Ground resource page, where all lifestyle coaches trained by DTTAC can share and inquire about available resources.

Conceptual Frameworks

CFIR

The Consolidated Framework for Implementation Research (CFIR) is a determinant implementation framework consisting of 39 constructs, grouped into 5 domains, that are believed to influence program recruitment and implementation in accordance with numerous implementation and change theories from which the CFIR is derived [108]. The present study utilized the CFIR, as well as published interview guides by Damschroder et al., creator of the CFIR, to develop the DPP implementer interview guides [113]. The CFIR was also used as a guide during qualitative data coding and analysis.

RE-AIM

The RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) framework was also used to evaluate implementation outcomes [122]. CFIR constructs found to have a strong or weak influence on DPP implementation were evaluated for their relationship with RE-AIM domains, using a methodology similar to Damschroder et al. [113, 114].

Participants

In summer of 2019, 13 CES county professionals were invited to implement the DPP in the [STATE] CES. All 13 CES professionals were trained as DPP lifestyle coaches by the Diabetes Training and Technical Assistance Center (DTTAC) at Emory University. Of the 13 CES professional trained, 12 began implementing the DPP in early 2020. One CES professional resigned in June 2020, and the 13th trained CES professional not implementing a DPP at the start of the study took over that cohort at that time. All 12 CES professionals who attended the

training and were implementing a DPP at the time of data collection were eligible to participate in the present study, with no exclusion criteria, and recruited to participate in the study via email and during technical assistance calls to support DPP implementation (see below). All 12 (12/12) CES professionals agreed to participate in the study, and verbal consent for all three interviews was obtained before the first interview began. The 13th CES professional was consented to participate when they took over the cohort in June 2020 and is represented in the post-intervention interviews.

Data Collection

Interviews with DPP implementers

Three semi-structured interviews were conducted via Zoom with CES professionals implementing the DPP: 1) following recruitment and within 4 weeks after the start of program implementation, 2) after completion of the core phase of the program (first 6 months/minimum of 16 weekly sessions), and 3) within 4 weeks after completion of the core maintenance phase (second 6 months/minimum of 6 monthly sessions). Interview guides were adapted from those used by Damschroder et al. (see Appendix A) to evaluate CES professionals' experiences recruiting for and implementing the DPP in the context of the state Cooperative Extension Service [113]. Interview questions addressed all domains of the CFIR contextualized for CES and were planned for approximately 1.5 hours per interview. Questions were primarily open-ended to explore CFIR constructs; and the interviewer used pre-determined prompts from the guide to elicit more information as needed. Several closed-ended and scaled questions were modeled after Damschroder et al. to supplement the qualitative data.

Implementation outcomes

Implementation outcomes were also assessed with the RE-AIM framework. Reach data was collected through program attendance records kept by CES professionals implementing the program. Effectiveness (E) was assessed according to quantitative methods described elsewhere (see Chapter 2). Adoption data was collected by DTTAC training attendance records and implementation records kept by the research team. The implementation process was assessed by the interviews described above, and implementation fidelity was assessed by reports completed by CES professionals following each session (see Appendix C). Due to the limited 1-year duration of this study, maintenance (M) could not be fully assessed [107, 121]. However, intention to offer another DPP, and stage of preparation if applicable, was assessed for each CES professional through interviews and program attendance and implementation records kept by the research team.

Measures

RE-AIM outcomes

Reach (R) was calculated as the number of eligible participants who participated in the intervention, compared to the number of participants that expressed interest in the program. Adoption (A) was measured as the number of trained CES professionals who actually implemented the program. Implementation (I) was assessed by fidelity to important program components (program and session duration, frequency and number of sessions, completion of required session components), as assessed by reports completed by CES professionals following each session (see Appendix C) and is described further in the Fidelity section below. Due to the limited 1-year duration of this study, maintenance (M) could not be fully assessed [107, 121]. The number of CES professionals that had already begun another DPP at the end of the present study

and the number of CES professionals with intentions to offer another DPP within the next 6 months was used to assess Maintenance.

Fidelity

As in other studies of community translation of the DPP [89, 99], fidelity of program implementation was assessed primarily through total program length and session frequency and number, and compared to the CDC DPRP standards. CES professionals were also asked to complete a session summary survey following each session to provide a self-reported measure of fidelity to the curriculum at each session. The self-report measure included session length, curriculum components completed and omitted, and additional resources or activities completed (Appendix C). The interview data was used to supplement this report as interviewees often discussed length of sessions and components added or removed during interviews.

Barriers and facilitators

Determinant implementation factors, i.e., barriers and facilitators to implementation, identified through the interviews guided by the CFIR framework were used to evaluate the implementation process. Interviews were audio recorded via Zoom Web Conferencing [146] and transcribed via a third-party transcriptionist [190]. Interview transcriptions were qualitatively analyzed using the CFIR framework with its five domains (Intervention Characteristics, Outer Setting, Inner Setting, Individual Characteristics, and Process) and thirty-nine constructs (CFIR Codebook: Appendix B). Qualitative data coding and analysis methods were similar to those used by Damschroder and Lowery's evaluation of implementation of the DPP and a weight management program in the context of Veterans' Affairs (VA) hospitals [113, 114].

Data Analysis

Quantitative

Descriptive statistics were calculated for the quantitative data regarding the RE-AIM components and scores on closed-ended, scaled interview questions, including frequencies, sums, means, and percentages. Detailed quantitative analysis of effectiveness outcomes is described elsewhere (Wilson H, Chapters 2 and 3). Average session length was calculated from session summary surveys.

Qualitative

Qualitative analysis coding was primarily deductive, as guided by the CFIR constructs, but allowed for inductive coding when the data was informative yet did not fit the CFIR constructs or researchers determined a refinement of a construct was necessary. ATLAS.ti version 9 was used as a tool for all qualitative coding and analyses [191]. Thirty-six transcripts were reviewed by 5 analysts total (3 analysts at baseline, with an additional 2 analysts at midpoint and post-intervention) in pairs using a qualitative consensus process. One researcher served as one of the two coders on all transcripts to provide consistency across all coding. Coding was done independently by pairs of analysts to reduce the impact of individual bias, and quotes were not predefined to allow for individual interpretation of the data. Following independent coding of transcripts, coders met to review all codes, discuss, and reach consensus on any discrepancies between coding. During the consensus process and between baseline, midpoint, and post-intervention, the codebook was revised as necessary to better operationalize the constructs for the state CES.

Inter-coder agreement (ICA) analyses were calculated as percentage of agreement between pairs of coders (percentage of agreement = number of units of coding on which coders

agree / total number of units coded x 100) at the initial stage for each transcript and ranged from 0.0% – 100.0%, though 100.0% agreement was reached for only a few constructs across all time points (baseline average: 20.2%; midpoint average: 25.2%; post-intervention average: 26.0%) [191, 192]. ICA accounts for agreement of not only the codes used but also the size of the quotes created and coded by each analyst [192]. Quotes were not predefined by the research team, therefore, influencing the degree to which analysts exactly agreed on coding. Moreover, even if two analysts used the same code to describe a unit of analysis (quote), if the length of the quote was different between coders, then a unit was not considered in agreement. Final codes were audited after all coding was completed to ensure consistent and accurate use of all constructs across transcripts and across time points. Codes added by the research team included *Implementation Strategy, Agent Networks, Experience, Facilitating, Time, Participant Receptivity, Zoom,* and *COVID.*

Each construct within each transcript was then rated for its influence on implementation, using similar methods to Damschroder et al. [113, 114]. Constructs were assigned both a valence (+ or -) and magnitude (1 or 2) to indicate the direction and strength of influence on implementation, respectively. If constructs were used descriptively and did not indicate a positive or negative influence on implementation, a rating of "0" was assigned to indicate a neutral influence of the construct on implementation. Each construct within each transcript was assigned either positive (+, facilitator) or negative (-, barrier) for its influence on implementation. The magnitude was then determined based on the number of times a construct appeared in a transcript and the number of consistent positive (+) or negative (-) ratings for that construct within the transcript. Transcripts with a construct consistently rated positive (+) or negative (-) more times than the average use of that construct across all transcripts was assigned a magnitude

of 2. Transcripts with a construct consistently rated positive (+) or negative (-) a number of times at or below the average use of that construct across all transcripts was assigned a magnitude of 1. If a construct was rated positive (+) and negative (-) an equal number of times within a transcript, an overall rating of "X" was assigned. For constructs that leaned slightly positive or negative within a transcript, a "*" was assigned to the rating (e.g., 1+*). For constructs missing within a transcript, "M" was assigned.

Construct ratings were recorded in tables and color coded to create a matrix. Visual inspection of the construct matrix and frequency of ratings was used to explore how constructs influenced implementation [108]. Following visual inspection of the data and examination of rating frequencies, constructs were considered to have strong influences on implementation if ratings were consistently positive (+) or negative (-) AND 25% or more (n=3 or more) of transcripts had a +2 or -2 rating. Constructs were considered to have weak influences on implementation if ratings were consistently positive (+) or negative (-) or 25% (n = 3) of transcripts had a +2 or -2 rating for the construct. Note that by using these methods, it is possible for constructs to have a weak influence on implementation of mixed effect (some positive and some negative). Rather, a construct can consistently influence implementation, but for some implementers the effect is negative and for some it is positive.

CFIR constructs with a weak or strong influence on implementation were then evaluated for the domain of implementation (RE-AIM) that CES professionals described them primarily influencing. Each quote within each transcript was coded with the corresponding RE-AIM domain (Reach, Effectiveness, Adoption, Implementation, Maintenance) that was being described. Occasionally, a quote described multiple aspects of RE-AIM, in which case all corresponding RE-AIM domains described were assigned to that quote. The co-occurrence of

each weak and strong construct with each RE-AIM component was then evaluated to determine the aspect of RE-AIM discussed most in relation to each construct.

Subjectivity Statement

The study participants (CES professionals) view me as a graduate student who works for one of the Extension Nutrition and Health Specialists at the university. The Specialist is responsible for providing evidence-based training, continuing education, and resources on topics related to food, nutrition, chronic disease prevention and management, and general health to county-level CES professionals. I served as the coordinator for this implementation effort, so I am connected to these CES professionals and had regular communication with them by email, web conferencing, phone, and occasionally text. I presented a portion of the training provided prior to implementation and also co-led many of the technical assistance calls provided. Thus, they are aware that I am closely familiar with most aspects of the implementation process for the program. However, the purpose of the interviews was to discuss their experiences recruiting for and implementing the program.

As mentioned, I am currently a graduate student pursuing a Doctorate of Philosophy in Foods and Nutrition and a dietetic internship. Thus, I have had almost 8 years of higher education focused on nutrition and health, in addition to a variety of clinical and community dietetics experiences. I had never worked for CES prior to graduate school, neither as a county CES professional or an intern in any county office. Thus, I have a gap in my understanding of the dynamics of CES from the perspective of a CES professional. However, I became familiar with CES working on a separate project for approximately 2 years prior to the DPP pilot implementation. In addition, I have lived in Georgia my whole life, in both rural and urban areas; so I appreciate the work CES professionals do to bring evidence-based information to Georgians

throughout the state and am passionate about supporting their efforts. Therefore, these interviews sought to understand CES professionals' experiences implementing the DPP in order to support better and sustained implementation of this program in CES in the future.

Results

Magnitude and valence of CFIR constructs and identification of constructs manifesting as strong or weak influencers of implementation are shown in Table 4.1. The co-occurrence of CFIR constructs and RE-AIM domains in each interview are presented in Table 4.2. A summary of the RE-AIM outcomes and the primary CFIR constructs that influenced the RE-AIM domains are presented in Table 4.3. The following sections discuss the RE-AIM outcomes and the CFIR constructs that manifested as barriers (-) and facilitators (+) (Table 4.1) of the RE-AIM domains across all interviews (baseline, midpoint, and post-intervention).

Responses to the scaled questions were highly skewed, with 73% of responses as 4 or 5 out of 5 (mean 4.0 ± 1.0, median: 4.4, range: 1-5) (Table 4.4). The few exceptions were related to CFIR constructs *Complexity*, *Learning Climate*, *Relative Priority, Adaptability, Cosmopolitanism, External Change Agents, and Leadership Engagement* when asked how these constructs may have acted as barriers, and these outcomes are discussed in the context of that CFIR construct and/or RE-AIM domain. Otherwise, the scaled questions primarily acted as "primer" questions that open-ended questions explored more thoroughly as reported below.

<u>Reach</u>

A total of 124 individuals attended a DPP informational session or otherwise expressed interest in participating in the DPP (Table 4.3). Of those, 119 were eligible for the program; and 89 were eligible for the research study on program outcomes (effectiveness). The five individuals ineligible for the program were ineligible due to an existing diagnosis of type 2 diabetes.

A CFIR construct that was discussed primarily in regard to Reach of the DPP in CES was *External Change Agents* (+) (Tables 4.1 and 4.2). Although they were discussed primarily in regard to other components of the RE-AIM framework, *Time* (-), *Structural Characteristics* (X), *Opinion Leaders* (+), *Other Personal Attributes* (+), *Formally Appointed Internal Implementation Leaders* (+), and *Patient Needs and Resources* (+) were also discussed in regard to Reach and primarily manifested as facilitators (Tables 4.1 and 4.2).

External Change Agents (facilitator, strong)

External Change Agents were community partners that, for most CES professionals, promoted recruitment for the DPP and, thus, Reach. These community partners included physicians, worksite wellness coordinators, local news outlets (radio, newspaper, television), and community professionals designated as a "program development team" for the CES professional. The value of these community partners for Reach of the DPP is conveyed well in the following quote: "Having the Wellness Coordinator...was extremely instrumental because...she's privy to everyone's blood tests, high-risk issues...So she's able to parlay that information into getting them in the pipeline to other programs that could be beneficial" (CES professional J).

Time (barrier, strong)

Time was discussed negatively in regard to Reach, as most CES professionals felt that they needed more time to recruit for the DPP. CES professionals began recruiting in late October/early November for a January start date, which presented recruitment challenges due to the holidays. Most felt that at least 3 months and as many as 4, 5, or even 6 months may be needed for effective DPP recruitment to optimize Reach.

Structural Characteristics (mixed influence, weak)

Structural Characteristics was discussed primarily in regard to Reach (Tables 4.1 and 4.2). Its influence, however, was mixed, with 2 CES professionals reporting strong positive influences and 1 CES professional reporting a strong negative influence (Tables 4.1 and 4.2). CES Professionals discussed poor visibility and awareness of CES in some communities as a barrier to recruitment, while others cited CES's high quality, established reputation as a facilitator to DPP recruitment: "the hospital...I already had a working relationship with...I've already proven why Extension programs work, so just bringing in this list, 'Hey, I have another resource.'" Other CES professionals discussed the structure of CES, with leaders at the county, district, and state levels in place to provide support for CES professionals' programming, including recruitment ideas. Notably, CES professionals did feel that reach of the DPP would likely be limited to counties with FACS agents (*Readiness for Implementation*).

Opinion Leaders (facilitator, strong); Formally Appointed Internal Implementation Leader (facilitator, strong)

While county- and district-level CES leaders (*Opinion Leaders*) primarily had influence on DPP Adoption, some CES professionals reported their *Opinion Leader(s)* offered collaboration and recruitment ideas that promoted DPP Reach. CES professionals also reported that support in the form of recruitment materials, ideas, and problem-solving from state-level CES leaders, including a *Formally Appointed Internal Implementation Leader* (program coordinator) and the program *Champion* (state program specialist), were valuable for increasing Reach of the DPP in their county.

Other Personal Attributes (facilitator, weak)

Other Personal Attributes of the CES professionals delivering the DPP was both a barrier to and facilitator of recruitment and ultimately, Reach. Many CES professionals identified the recruitment process to be the most challenging component of DPP implementation, consistently reporting this challenge across all three interviews. Some CES professionals found working with technology and online materials difficult, which was a barrier for some in using CDC recruitment materials for the DPP. Other attributes that were reported in reference to Reach included CES professionals' level of organization and attention to detail and experience or lack of experience. Many used detailed calendars, spreadsheets, note-taking software, or other planning resources to track potential participants to maintain communication and interest throughout the recruitment period and to determine if participants were eligible for the program, which facilitated recruitment. A limited number of CES professionals had prior experience implementing the DPP before this pilot intervention (*Other Personal Attributes, Experience*), and, thus, had unique insight into the DPP recruitment process that CES professionals new to the program were gaining during the pilot intervention. On the contrary, CES professionals newer to the organization or county had little time to develop relationships in the community to foster program recruitment, likely negatively influencing Reach (*Cosmopolitanism*).

Patient Needs and Resources (facilitator, weak)

Patient Needs and Resources was discussed primarily in regard to potential for large Reach of the DPP. Every CES professional cited high T2DM rates (and/or high overweight/obesity rates) in their communities. Most agents felt that there was a need for diabetes prevention interventions in their communities to prevent increasing diabetes rates, and this need could facilitate Reach of the DPP in their community.

Effectiveness

As stated in Chapters 2 and 3, mean weight loss was 5.2% ± 5.0% of initial body weight, with 46.7% of participants meeting the 5% weight loss goal by the end of the intervention. Average weekly minutes of self-reported moderate PA at the end of the intervention was 179 ± 122 minutes, with 56.7% of participants meeting the 150-minute moderate PA goal by the end of the intervention. Additional effectiveness outcomes are reported elsewhere (Wilson et al., forthcoming, Chapters 2 and 3).

Weak or strong CFIR constructs that were discussed as facilitators primarily in regard to Effectiveness of the DPP in CES included *Evidence Strength and Quality* (+) and *Relative Advantage* (+) (Tables 4.1 and 4.2). Although they were discussed primarily in regard to other components of the RE-AIM framework, *Participant Receptivity* (+), *Executing* (+), *Complexity* (-), and *COVID* (-) were also discussed in regard to Effectiveness (Tables 4.1 and 4.2).

Evidence Strength and Quality (facilitator, weak)

CES professionals discussed how the DPP's *Evidence Strength and Quality* translated to their individual program and its Effectiveness. CES professionals consistently felt that the DPP's evidence base was strong. At the end of the program, in response to the question, "Has your view of the program's evidence changed after completing the second 6 months of the program?", one CES professional responded, "No. If anything…it's just really confirmed what I felt about it to begin with by seeing how well it's worked with the people I've been involved with" (CES professional B). Another CES professional echoed this sentiment: "I saw one participant who continued to sustain their weight loss and continued to lose weight through the course of the program, so I think it just...further solidifed the benefits of the program..." Another stated, "I saw the change with my participants...my participants themselves were evidence."

Relative Advantage (facilitator, weak)

CES professionals spoke to the Effectiveness of the DPP, both effectiveness shown in the research literature and the effectiveness seen within their own cohort of participants, as an advantage of the DPP over other Extension health and wellness programs. One CES professional described the *Relative Advantage* of the DPP this way: "that's magical about the DPP program that you're not going to get [with other programs]...that [it's] lifestyle changing and they have to figure out how to make that change." Others spoke to the long length of the DPP as a distinction between the DPP and other CES programs that provided an advantage over other programs. While they felt that the length of the program made it more complex (*Complexity*), this disadvantage was also an advantage because of the potential for greater Effectiveness. CES professional C stated, "the advantage is also a disadvantage. The advantage is its longer, but the disadvantage is its longer." CES professional H also stated, "because it is a long-term program, you can get longer term results and keep people engaged for a longer period of time to make better changes and more changes to their health."

Participant Receptivity (facilitator, weak)

Participant Receptivity emerged as a subtheme of *Patient Needs and Resources* to capture discussion around participants' outcomes and receptivity to the DPP. The research team added this subtheme to the construct as it emerged as distinct from the other aspects of *Patient Needs and Resources*. As stated above, a majority of participants lost weight, with many meeting or exceeding the DPP's goal of 5% weight loss. Even for those participants who did not lose 5% of their initial body weight, CES professionals discussed other important outcomes and influences of the program on these participants that they perceived to be indicators of program Effectiveness. Many discussed that their participants saw changes in hemoglobin A1c levels (as

much as a 2-point reduction in hemoglobin A1c) and even were able to stop taking or decrease their dosage of some medications (including cholesterol medication and metformin). The value of these clinical outcomes in participants' receptivity to the program was stated by some CES professionals: "I think when they feel successful, then they believe in the program. I think it really goes back to individual results" (CES professional K).

Numerous health behavior changes of participants were discussed. Some participants started their own home gardens to help increase their vegetable intake. Others developed health-related skills, such as using nutrition labels or food tracking apps to make healthy food choices. CES professional F even stated, "I don't think they'd ever thought about looking on YouTube for recipes. They've learned a lot about technology because of the way we've had to do things, so that's an advantage." Others altered their cooking methods, using air fryers or roasting instead of frying foods.

Some CES professionals spoke to the dynamic of their group as a measure of DPP Effectiveness. CES professional K stated: "seeing the bonding among the participants…that's a huge accomplishment because some of my participants…really don't get out, they're older. That increases their quality of life…not just their health."

Many CES professionals viewed participant attendance and retention, especially amidst the COVID-19 pandemic, as an indicator of Effectiveness. CES professional B stated, "the consistent attendance…even considering we went away from in person, people still look forward to it…the fact that people are still showing up and…actively participating in the groups would show a success." CES professional J stated, "the failure stories are the people who just stop showing up…"

Executing (facilitator, weak)

Executing manifested as a facilitator of implementation when CES professionals reported implementing the DPP as intended, not omitting portions of the curriculum, and conveying how this promoted Effectiveness. Many CES professionals discussed the importance of fidelity in the program's Effectiveness. CES professional K stated: "I think if we start altering [the program/curriculum], I mean is it going to alter the impact that it's made?" However, many CES professionals felt that altering the program/curriculum sessions would make them more effective: "some of the sessions...you always thought you could add more to them or do more with them than the way the script was written. So it was always a challenge maybe not to adjust them or change them" (CES Professional I). In spite of their perception of the DPP's even greater Effectiveness with suggested modifications, CES professionals reported following the curriculum as intended so as not to jeopardize outcomes. Thus, their execution of the evidence-based DPP as intended was considered a facilitator. Still, many CES professionals provided their participants with additional resources and activities outside DPP session time so as not to compromise program fidelity. CES professional C stated: "when they ask questions...I still give them the information they want but not necessarily during class time." When these additional components were believed to have positive influences on Effectiveness, this form of *Executing* was considered to be a facilitator of implementation, specifically Effectiveness, of the DPP. For example, CES professional J provided participants with a handout on the new nutrition label format, as the Prevent T2 curriculum includes only the old nutrition label format. Because participants will see the new nutrition label in stores and this modification did not deviate from the intended lesson objectives, this addition likely better prepared participants to make healthy food choices, so this form of *Executing* was considered a facilitator of positive outcomes.

COVID (barrier, weak)

Overall, the COVID-19 pandemic had a negative influence on implementation, including Effectiveness of the DPP. Many CES professionals reported that their participants experienced weight re-gain during the height of the pandemic and shelter-in-place orders. CES professionals noted a variety of potential reasons for the poorer outcomes than may be expected under normal conditions. Many CES professionals felt that the program was less effective because participants were not able to attend sessions in person. Many perceived that the distance learning sessions provided less accountability than the in-person sessions, potentially contributing to participants' weight gain and limited health behavior changes. For example, CES professional B stated, "some people lost a little steam when you don't...see each other's faces every week." CES professionals also discussed the influence of the stress of the pandemic and long periods of isolation on participants' food choices and engagement in physical activity. CES professional L stated: "it's not just because the program switched to virtual but because it's outside other factors, just the stress of COVID." Some participants lost childcare access, significantly altering their daily schedules and exercise and meal plans. Other participants lost access to exercise facilities, negatively impacting their physical activity. Further descriptions of the influence of the COVID-19 pandemic on DPP participants' health behaviors, derived from interviews and participant focus groups, can be found elsewhere (Wilson et al., under review).

Lastly, some participants were lost to attrition at the onset of the COVID-19 pandemic, influencing DPP Effectiveness from the perspective of attendance and retention. CES professionals cited a variety of reasons for this attrition, including a lack of resources (computers, phones) needed to participate in the distance learning sessions and a lack of familiarity of the older adult population that comprised a large portion of the study sample. Some

participants were also essential workers (nurses/other healthcare professionals, public health employees, school nutrition employees) whose schedules were significantly affected by the pandemic, hindering their ability to participate in the program.

Adoption

Of the 13 CES professionals recruited to implement the DPP, 12 (92%) adopted the program and began implementation in winter 2020 as intended. The one CES professional who did not begin implementation was relocated shortly after the training and did not begin a cohort until fall 2021, which was not included in the present study. However, this individual took over a cohort included in the present study when one of the existing CES professionals implementing the program left the organization.

CFIR constructs *Intervention Source* (+) and *Tension for Change* (+) were discussed almost exclusively in regard to facilitating Adoption of the DPP (Tables 4.1, 4.2, and 4.3). *Evidence Strength and Quality* (+), *Patient Needs and Resources* (+), *Structural Characteristics* (+), *Implementation Climate* (+), *Compatibility* (+), *Organizational Incentives and Rewards* (+), *Leadership Engagement* (+), *Knowledge and Beliefs about the Intervention* (+), *Other Personal Attributes* (+), *Opinion Leaders* (+), *Formally Appointed Internal Implementation Leaders* (+), *Champions* (+), *Individual Identification with Organization* (+), and *Readiness for Implementation* (+) all emerged as strong or weak facilitators of Adoption, while *Cost* (-) and *Time* (-) emerged as barriers of Adoption of the DPP in CES (Tables 4.1 and 4.2).

Intervention Source (facilitator, strong)

Intervention Source was used primarily at baseline to describe where CES professionals perceived the idea of implementing the DPP in CES originated and how that influenced adoption. When thinking internal to CES, agents identified the state Extension Specialist

(*Champion*), their district- and county-level CES leaders (*Opinion Leaders*), and even the two CES professionals implementing the DPP prior to the larger scale pilot implementation. The involvement of these leaders (*Leadership Engagement*) was instrumental in Adoption, as seen in the following quotes:

> if it wasn't for…[state Extension Specialist], I wouldn't have known the program was out there so I would have never implemented the program because I wouldn't have known about it. (CES professional E)

> my PDC [*Opinion Leader*] is the one that brought it to me and we discussed how it could work. And if it could work because she just kind of helped me talk through that process, of making the decision. (CES professional G)

CES professionals also discussed the fact that the DPP being externally developed by a respected organization like the CDC strongly facilitated Adoption: "it being a CDC program. I mean, that comes with a lot of clout." The "clout" that came with CDC being the *Intervention Source* of the DPP influenced CES professionals' perception of the program's *Evidence Strength and Quality*, which also influenced their decision to adopt the program.

Tension for Change (facilitator, weak)

Tension for Change within CES toward more prevention-focused, evidence-based programs with measurable outcomes also facilitated Adoption: "We've done a lot of programs on managing chronic disease, being on that preventative side is important." Some CES professionals discussed how implementation of more evidence-based programs could improve the reputation of CES in their communities (*Structural Characteristics*). Some CES professionals also reported a perceived push toward programs that have funding potential. The DPP's potential for Medicare and other insurance provider reimbursement at the full CDC recognition level was another advantage of the DPP in light of this tension for funding.

Evidence Strength and Quality (facilitator, strong)

Some CES professionals also referred to the DPP's *Evidence Strength and Quality* influencing their "conviction" to adopting the program (*Knowledge and Beliefs about the Intervention*): "The evidence…the wide scope of it…how far reaching it was…[I]was like, 'Oh my goodness, this is definitely something that all Extension offices should be offering because of the positive impact that it has made nationwide.'" Others had personal experience consistent with the DPP's *Evidence Strength and Quality* for the value of health behavior change in improving health, facilitating their Adoption of the program: "I was prediabetic myself, and those were the exact changes that I implemented in myself. So I think it's a program that a lot of people can benefit from." Overwhelmingly, CES professionals believed in the value of the nutrition and physical activity behavior changes promoted by the DPP (*Knowledge and Beliefs about the Intervention*), which facilitated Adoption, as seen in the following quote: "I'm about prevention rather than treatment, and I do believe that with healthy eating and regular physical activity you can prevent a lot of things." Consequently, all CES professionals felt that the DPP is an important program for CES to be doing.

When asked about increasing Adoption of the DPP in other counties throughout the state, CES professionals felt that success stories from the pilot intervention, the support provided for implementation, and the value of the DPP's evidence base for building community rapport (*Evidence Strength and Quality; Structural Characteristics*) and CES professionals' impact statements (*Organizational Incentives and Rewards*) would be incentives for Adoption by other counties.

Cost (barrier, weak)

Although the Prevent T2 curriculum is freely available online, there are substantial costs associated with implementing the program that some CES professionals cited as a barrier to being able to adopt the program. Notably, the startup costs for these cohorts were grant funded; but CES professionals spoke to the costs as potential barriers to Adoption by other CES professionals. The training required to become a lifestyle coach able to deliver the DPP is over $500, a cost that many CES professionals would not be able to cover on their own without support from the state level of CES [188]. In addition, the cost to print session materials can be substantial, especially for large DPP groups. Many CES professionals stated that these printing costs would have been a barrier to Adoption as well without support from the state CES office. CES professional J stated that the state CES office covering the costs of training and printing "was huge because I certainly couldn't have come up with that kind of money out of my FACS account."

While cost was cited primarily as a barrier to Adoption, some CES professionals did discuss the potential for Medicare reimbursement if full CDC recognition were received, offsetting the above costs and serving as an incentive for program Adoption by other CES professionals.

Patient Needs and Resources (facilitator, weak)

Patient Needs and Resources facilitated Adoption of the DPP, as every CES professional cited high T2DM rates (and/or high overweight/obesity rates) and a need for T2DM prevention interventions in their communities to prevent increasing T2DM rates. This need was the primary facilitator of DPP Adoption for most CES professionals, as demonstrated in the following quote: "I'm just doing it for the health of the people in my community." Some CES professionals did

discuss that in light of the large percentage of their county population already with T2DM, they were interested in T2DM management programs as well. Some CES professionals were implementing T2DM management programs at the same time as the DPP, and others reported intent to pursue T2DM management programming in addition to but not in place of the DPP in the future (*Relative Priority, Compatibility*).

Compatability (facilitator, strong)

Compatibility also served as a primary facilitator of Adoption of the DPP. CES professionals spoke to the fit of the DPP with CES's mission and values of evidence-based programs (*Evidence Strength and Quality*): "I think it aligns extremely well [with the CES mission] because we're taking research-based programming and this is one of the best research-based diabetes programs that there has been" (CES professional A). Several CES professionals had experience with other T2DM or general nutrition and health programming (*Other Personal Attributes, Implementation Climate*), and all had a focus area in nutrition for health promotion and chronic disease prevention and management (*Individual Identification with Organization*), which influenced their Adoption of the DPP. While 2 CES professionals were relatively new to the nutrition and chronic disease focus area, most had past experience with at least some basic nutrition and health programming (*Implementation Climate*). Many of these programs were similar to the DPP, such as the Walk-A-Weigh weight management program [193] and the Right Bite T2DM self-management program (unpublished). Other agents had a percentage of their position appointments designated for the Expanded Food and Nutrition Education Program (EFNEP) or the nutrition education component of the Supplemental Nutrition Assistance Program (SNAP-Ed), making them further accustomed to CES nutrition programming.

Time (barrier, strong)

The only barrier to Adoption that emerged was the known time that it would take to implement the year-long DPP (*Complexity, Time, Available Resources*). However, many CES professionals did not view this as a completely negative factor when considering program Adoption: "because it's so time consuming program, I think…you [are] actually able to see the results..." The major negative influence of *Time* was found in relation to implementation of the DPP, discussed below.

Implementation

Average number of sessions delivered in each county was 26 (range: 25-27) over a 1-year period, with the minimum number of sessions delivered exceeding the CDC DPRP minimum requirement of 22 total sessions over 1 year (Table 4.3).

At least one session summary was provided for 11 of the 13 DPPs. Average number of surveys completed for each county was 14 surveys (range: 2-24). Average length of sessions reported was 58 minutes (range: 45-105 minutes). No agents reported omitting any required curriculum components. Some optional activities were omitted, particularly in the distance learning delivery format, but these were not designated as required components by the CDC. Some agents provided additional resources outside the DPP curriculum, with recipes, example exercises, and supplemental nutrition education handouts being the most common. These resources were often provided at the request of participants and in addition to the curriculum, not in place of the curriculum. One agent described her approach to providing additional resources without compromising program fidelity in this way:

> [W]hen they ask questions and then I give them additional information…I'm not really spending class time on that additional information…I email them copies or…mail them hard copies, or both. So I think, for me, that's the work around, is I still give them the information they want but not necessarily during class time...

Weak or strong CFIR constructs that were discussed primarily in regard to Implementation of the DPP in CES are shown in Tables 4.1 and 4.2. Several factors facilitated implementation, including *Networks and Communications* (+), *Agent Networks (+), Goals and Feedback* (+), *Learning Climate* (+), *Readiness for Implementation* (+), *Leadership Engagement* (+), *Access to Knowledge and Information* (+)), *Individual Identification with Organization* (+), *Other Personal Attributes* (+), *Opinion Leaders* (+), *Formally Appointed Internal Implementation Leaders* (+), *Champions* (+), *Executing* (+), *Implementation Strategy* (+) *Participant Receptivity* (+), and *Zoom* (+). Although they were discussed more so in regard to other domains of RE-AIM, the following constructs were partly discussed as facilitators to implementation: *Evidence Strength and Quality* (+), *Structural Characteristics* (+), *Organizational Incentives and Rewards* (+), *Individual Stage of Change* (+), *External Change Agents* (+), and *Knowledge and Beliefs about the Intervention* (+) (Tables 4.1 & 4.2).

Complexity (-), *Time* (-) and *COVID* (-) manifested as barriers to implementation, while *Cost (X)* had mixed influence on implementation (Tables 4.1 and 4.2).

Networks and Communications (facilitator, strong); Implementation Strategy (facilitator, weak)

Networks and Communication and various constructs related to leader and external partner involvement and communication (*Leadership Engagement, Formally Appointed Internal Implementation Leaders, Opinion Leaders, Champions, External Change Agents*) were discussed almost exclusively as facilitators of Implementation. *Networks and Communications* among agents (*Agent Networks*) and state Extension leaders (the state Extension Nutrition and Health Specialist as the *Champion*, a graduate student serving as the DPP coordinator as the *Formally Appointed Internal Implementation Leader*, general *Leadership Engagement*) was discussed extensively as a facilitator of DPP Implementation. Most of the implementation strategies aimed

to increase communication among the DPP "team," particularly the regular technical assistance calls conducted via Zoom. Extension professionals discussed the value of this communication from a variety of perspectives:

> I like hearing from other agents and their experiences because real life is real life so then you have to think about things that may come up that I may have not thought about and I may experience...it's good to have that communication with them. (CES professional H)

> it [the technical assistance calls] helps me to be more accountable and make sure that I am thorough in what it is I'm giving you, what you're asking for. (CES professional D)

> I think hearing from others and some of those lessons learned that people have offered. Also, knowing what's coming up is important. And what to expect...in the coming weeks. (CES professional K)

Goals and Feedback (facilitator, weak)

The clear *Goals and Feedback* for the program facilitated Implementation. CES professionals felt that the program effectiveness goals (weight loss, PA, attendance) and the goals for implementation (meeting CDC DPRP standards for session frequency, program length, weight and PA reporting requirements) were clearly defined by leadership and progress toward these goals was communicated back to the CES professionals: "there were clear goals set out there which makes it easy to know how and what needs to be done from my end to implement" (CES professional G).

Learning Climate (facilitator, weak)

CES professionals repeatedly described the environment surrounding the pilot implementation of the DPP as being safe and supportive. All CES professionals felt comfortable discussing problems, raising questions or concerns, sharing their opinions, or asking for help among themselves and between themselves and state-level staff (*Champion, Formally Appointed Internal Implementation Leader*). CES professionals felt that their concerns and opinions were heard and considered throughout the learning process of the pilot implementation, as seen in the

following quote by CES professional B: “You guys are very approachable and...offer questions and concerns about the program...yourself. So we don’t feel like we’re just barking at the wrong tree.” CES professional E described the environment surrounding the DPP pilot implementation as follows: “I feel like it’s been a very ‘go forth and try this.’ If it doesn’t work, let’s talk about why it didn’t work and let’s see if there are better ways to implement.” Taken together, CES professionals found this *Learning Climate* valuable for learning how to successfully implement the DPP in CES in order to maintain and potentially expand implementation in the future.

Readiness for Implementation (facilitator, weak): Leadership Engagement (facilitator, strong); Formally Appointed Internal Implementation Leaders, Opinion Leaders, Champions (facilitators, strong); Access to Knowledge and Information (facilitator, weak)

Along with the scheduled technical assistance calls, CES professionals spoke to the overall support for implementation from various levels of leadership and the organizational commitment as facilitators of Implementation. CES professionals noted the value of having support from leaders whenever they needed it (*Leadership Engagement*, *Readiness for Implementation*). Some agents spoke to the structure of Extension (*Structural Characteristics*), with its multiple levels of support from leaders at the county, district, and state level, as a facilitator of communication and program Implementation. Leaders engaged through regular emails, calls, and texts with CES professionals to answer questions, solve problems, and provide other support as necessary (e.g., coordinate mailing of print materials and incentives). CES professionals spoke to the value of this support for enhancing Implementation:

> it was very well explained that we would have the support of [Formally Appointed Internal Implementation Leader] and of [Champion] if we had any issues that we could call. That is greatly appreciated. I think that is... that is a benefit to the program. (CES professional K)

> Because of the support behind us, we'll be successful. (CES professional K)

> I think we've been receiving more support for this program than we ever have for any programs. (CES professional A)
>
> The planning it took...this is where...having a specialist [Champion]...or having [a Formally Appointed Internal Implementation Leader] and the specialist kind of helps. Y'all have to need stuff done by X, Y and Z dates and so there's a guideline to the planning. (CES professional G)

Others spoke to the value of having leaders with first-hand experience delivering the DPP for informing and troubleshooting Implementation:

> I think it speaks very highly of [Formally Appointed Internal Implementation Leader] and [Champion], because you are implementing the program...you have firsthand some of those same challenges that we have...I think that it's important. It's not just the knowledge from research or the curriculum, you actually have firsthand knowledge. (CES professional K)

One of the two CES professionals who had implemented the DPP prior to the large pilot implementation evaluated in the present study also spoke to the value of this support compared to when they were implementing the DPP on their own:

> I struggled...Because there was nobody else I could just call and say, "Hey, what about this, that or the other?"...If you're out there by yourself, you're not as confident...but definitely, there were some things that I didn't focus on, that if I had been with you all, it would've been, "Okay, are you doing this, this, and this?" I wouldn't have missed this little thing here or there. (CES professional C)

CES professionals also spoke to the value of access to leadership with nutrition content expertise as a facilitator of Implementation: “for something like this, I think anytime you can have [a registered dietitian] involved...you're definitely meeting a baseline need in my opinion” (CES professional J). The state Extension specialist (*Champion*) was an RD and the program coordinator (*Formally Appointed Internal Implementation Leader)* had completed dietetic training which provided that content expertise that this and other agents felt valuable for health-related programming like the DPP (*Access to Knowledge and Information*).

Individual Identification with Organization (mixed, weak)

Four CES professionals also served as County Extension Coordinators (CECs). These additional administrative responsibilities influenced how much time and effort (*Time, Available Resources*) they had available to devote to DPP Implementation, especially after the onset of the COVID-19 pandemic:

> being a CEC, there's just always something. I don't know that I ever feel like, on a daily basis, I'm doing everything I could do to support my programing as effectively as I would like to. (CES professional J)

Others had a percentage of their position devoted to other programs as discussed under "Adoption," limiting their available resources as well for DPP Implementation.

Lastly, some CES professionals had particularly high levels of investment in and commitment to the organization, the program, and the Specialist leading implementation (*Individual Identification with Organization*) which facilitated implementation:

> no matter what happens, I'm going to stay in touch with them and support them because I feel like I've made an obligation. (CES professional D).

> If you have a personal pride...especially when it's [Extension Specialist], you don't want to commit and then be like, "Oh sorry. It just didn't work out." (CES professional J)

Other Personal Attributes (facilitator, weak)

Naturally, each CES professionals' Implementation experience was slightly different, in part due to individual-level factors (*Other Personal Attributes*). CES professionals had different levels of "tolerance" for the *Complexity* of the program, including its length. Some had implemented an Extension weight management program based on the DPP for as long as 16 or even 32 weeks and, thus, felt more comfortable with the DPP's length. Others were very organized and structured, planning their DPP and work schedules far in advance to reduce any anxiety around adding the DPP to their current programming.

Different levels of experience in Extension or in FACS Extension, or expertise in an area of FACS other than nutrition and health, also influenced CES professionals' comfort implementing the DPP:

> There's some of the topics that I really have to make sure that I read just to make sure that I'm good. 'Cause some of the topics, just because my background really hasn't existed in this since college. Some of the topics, they're a little more difficult. And I don't know if it's so much the topics or the questions that you get. (CES professional G)

Executing (facilitator, strong)

Executing was used to capture CES professionals' implementation process and, thus, was largely descriptive. *Executing* was rated as a facilitator of Implementation if CES professionals reported implementing the DPP as intended, not omitting portions of the curriculum. Across all timepoints, overall ratings for *Executing* were almost exclusively positive, indicating that CES professionals implemented the DPP largely as intended. Further discussion of program fidelity is provided below. *Executing* was also used to capture discussion around participant outcomes, including meeting the CDC intervention goals of weight loss and 150 minutes of moderate PA/week, as well as health behavior changes, attendance, and retention. As discussed under Effectiveness, many CES professionals provided their participants with additional resources and activities outside DPP session time so as not to compromise program fidelity. When these additional components were believed to translate to positive outcomes, this form of *Executing* was considered to be a facilitator of Implementation.

Participant Receptivity (facilitator, weak)

Participant Receptivity was created by the research team as a subcode of *Patient Needs and Resources*, as *Patient Needs and Resources* alone did not seem to adequately capture discussions around participants' general response to the program, e.g., their reactions or perceived feelings toward it, their degree of commitment to it, etc. One CES professional

described their participants' response to the group setting of the program as follows: "the support group setting is very important because they enjoy that interction and it also is contagious if one is successful, that motivates the other people in that program to try harder that next week" (CES professional K). Another stated that the participants were so receptive to the program that the typical 1-hour sessions lasted up to 2 hours. Another stated that their participants said during the last session of the program, "I feel like we need a reminder of...what would [CES professional] say?...I think we need a bracelet with 'what would [CES professional] say?'" (CES professional L). Participants had overwhelmingly positive responses to the program, beyond just their physical health outcomes, highlighting *Participant Receptivity* as a facilitator of attendance at sessions and overall Implementation.

Evidence Strength and Quality (facilitator, strong)

While CES professionals felt that the program could be improved, their knowledge of the evidence base of the DPP (*Evidence Strength and Quality*) and the need to implement it as intended to meet CDC DPRP standards positively influenced Implementation: "I believe that it has been done and implemented for long enough that there is strong evidence that by following the program the way it's written, it does have value" (CES professional I).

However, CES professionals felt that incorporation of more hands-on physical activity components could improve implementation of the program. One CES professional said:

> the idea is that we spend at least one hour a week sitting with these folks and we've talked to them about fitness breaks. And I know that...the lesson on fitness breaks incorporates getting up and moving. But none of the other lessons, I don't believe has a fitness break worked into it. (CES professional B)

Organizational Incentives and Rewards (facilitator, strong)

CES professionals discussed how *Organizational Incentives and Rewards* offered by the state CES office, which included professional development opportunities like conference and

webinar attendance, data for impact statements, and scholarship opportunities like co-authorship on conference posters and presentations, facilitated their Implementation of the DPP. CES professional H stated, “the professional development was key...I learned a lot of things that I could have shared with my participants.” CES professionals discussed *Organizational Incentives and Rewards* extensively in regard to Adoption and Maintenance of the program as well, discussed in the appropriate sections.

Knowledge and Beliefs about the Intervention (mixed, strong)

When considering how Implementation of the DPP could be improved, CES professionals believed (*Knowledge and Beliefs about the Intervention*) that the Prevent T2 curriculum was lacking in areas and not meeting some of the needs of participants (*Patient Needs and Resources).* CES professionals felt that the depth of nutrition information included in the curriculum was lacking and did not develop nutrition-related knowledge and skills needed by participants to be able to reach the intervention weight loss goals. CES professionals felt that incorporation of food demonstrations, recipes, recipe demonstrations or tastings, and resources on more challenging nutrition topics (e.g., fad diets) could improve Implementation. One CES professional stated:

> I find it fascinating that there's really no recipes...I find it extremely frustrating to talk about food for an hour and then not do anything about it, or give an alternative, or have a tasting. Especially with some of these last six months programs, topics that are just extremely repetitive...in general, I'm surprised that it's so watered down that we really don't talk about some of the nuts and bolts of nutrition a little bit more. (CES professional J)

Even with these limitations, CES professionals felt that the program was valuable and had advantages (*Relative Advantage*) to other CES programs. CES professional F even stated, “What you get out of it, it makes it worth it.”

External Change Agents (facilitator, weak)

A key facilitator of Implementation for many CES professionals was the community partners with whom they were collaborating (*External Change Agents, Cosmopolitanism*). Prior to the switch to distance learning, many CES professionals held their in-person programming in a space provided by their community partner. Several CES professionals collaborated with worksites to implement the DPP. Wellness coordinators at these worksites proved invaluable for DPP Implementation, as they provided space for the program, encouraged participants, and even provided additional incentives at times, as seen in the following quote: "It's been helpful to know County Wellness Coordinator, and know that I can have some of the locations in the county and the county buildings available" (CES professional J).

Zoom (facilitator, weak)

As CES professionals implemented the DPP via distance learning, over time they began to discuss the Zoom implementation platform less in light of the COVID-19 pandemic and more in light of a potential permanent delivery platform. A *Zoom* code was created to capture these discussions for future Implementation as well as Maintenance of the program. In general, CES professionals found the Zoom platform user-friendly, both for themselves and for their participants.

Complexity (barrier, weak)

CES professionals did discuss several complex components of the program that made Implementation difficult. One of the most commonly discussed complexities was the long length of the program. In addition, CES professionals discussed the food tracking component of the program and their role in providing feedback on participants' food logs as a complex part of Implementation. CES professional A stated, "starting to do the food logs and get feedback is

going to be a little bit challenging." Another challenging component of DPP Implementation discussed was completing make-up sessions for participants who missed sessions, as this could become a time-consuming part of Implementation (*Time*).

One of the major complexities of Implementation was the role of CES professionals as facilitators rather than teachers. This aspect of implementation was discussed to such an extent that the research team created the code *Facilitating* to capture these discussions. CES professionals typically serve as teachers in their programs, educating their participants on the topic at hand. Conversely, their role in the DPP is less that of a teacher and more that of a facilitator, fostering discussion among participants around lifestyle change. CES professional D described this challenge of Implementation in the following way: "I'm such a teacher. I'm in teacher mode all the time...for me to be a facilitator and not a teacher is hard." CES professional J described their challenge with facilitation in the following way: "a challenge for me is the quiet time, just letting it, you put something out there and then you have to be willing to just...it feels like forever, but you have to be willing to just kind of sit."

Time (barrier, strong)

A consistently negative influence on Implementation was the *Time* it takes to implement the program. As discussed in previous sections, many CES professionals have many demands on their time, limiting the time they had available to devote to the DPP. One CES professional said: "The main challenge was having already had things on my schedule, trying to plan our days, having a day once a week to dedicate to it" (CES professional F).

Related to *Time* was other roles that CES professionals had within the organization (*Individual Identification with Organization).* Four CES professionals served in an administrative role as County Extension Coordinators (CECs). These additional administrative

responsibilities influenced how much time and effort (*Time, Available Resources*) they had available to devote to DPP Implementation, especially after the onset of the COVID-19 pandemic:

> being a CEC, there's just always something. I don't know that I ever feel like, on a daily basis, I'm doing everything I could do to support my programing as effectively as I would like to. (CES professional J)

Others had a percentage of their position devoted to other programs as discussed under "Adoption," limiting their available resources as well for DPP Implementation.

COVID (barrier, weak)

The COVID-19 pandemic had major and unprecedented influences on Implementation of the DPP, as nearly 10 of the 12 months of the program were impacted by the pandemic. The *COVID* construct was created by the research team to capture discussions around how the pandemic uniquely influenced Implementation. Notably, delivery method of the program was converted from in-person to distance education at the onset of the pandemic and throughout the remaining duration of the program. CES professionals generally felt that the pandemic had a negative influence on their Implementation of the DPP. Many professionals noted challenges conducting curriculum activities over Zoom, as well as difficulties maintaining participant engagement and obtaining required data of weight and physical activity minutes of participants. In general, CES professionals felt that their Implementation of the DPP suffered in some way because of the pandemic. Further descriptions of the influence of the COVID-19 pandemic on DPP Implementation can be found elsewhere (Wilson et al., under review).

Cost (mixed, weak)

Cost was discussed in relation to the quality of the printed session materials provided to participants, as well as additional participants incentives (*Available Resources*). CES

professionals discussed that the cost of printing session materials in color versus black and white, for example, would have been an implementation barrier had it not been for financial support from the state CES office. Additionally, participants were provided with traditional educational extenders, such as water bottles, resistance bands, and lunch boxes. CES professionals repeatedly cited the benefit of these incentives for Implementation and improving *Participant Receptivity*. Conversely, they discussed that the cost of these items would be an implementation barrier without the state CES office's financial support. Some participants even received body weight scales if they did not have them to enable home weight monitoring during the COVID-19 pandemic. CES professionals cited the value of these costs being covered for continued data collection.

Maintenance

At the conclusion of the present study (April 2021), 5 CES professionals had already started 6 new DPP cohorts (virtual), 1 CES professional had started 1 new in-person DPP cohort, and 2 CES professionals had plans to start 2 new in-person cohorts in fall of 2021 (Table 4.3).

A weak CFIR construct that was discussed primarily in regard to Maintenance of the DPP in CES was *Individual Stage of Change* (+) (Tables 4.1 and 4.2). Other weak or strong CFIR constructs that emerged as facilitators of DPP maintenance included *Organizational Incentives and Rewards* (+), *Compatibility* (+), *Evidence Strength and Quality* (+), *Relative Advantage* (+), *Implementation Climate* (+), *Learning Climate* (+), *Leadership Engagement* (+), *Access to Knowledge and Information* (+), *Formally Appointed Internal Implementation Leader* (+), *Implementation Strategy* (+), and *Agent Networks* (+) (Tables 4.1 and 4.2).

Individual Stage of Change (facilitator, weak)

Individual Stage of Change refers to the stage a program implementer is in when considering sustained program implementation, for example, the stages of having newly adopted the program, being in pilot implementation, or maintaining ongoing implementation. *Individual Stage of Change* was used to capture CES professionals' intention to offer the DPP again following the pilot implementation. All CES professionals stated that they intended to offer the program again, with many already planning or marketing for another cohort at the end of the pilot implementation, as discussed above.

Evidence Strength and Quality, Relative Advantage, Compatibility (facilitators, weak); Organizational Incentives and Rewards (facilitator, strong)

CES professionals spoke to the evidence base of the DPP and its *Compatibility* with CES's mission, being an evidence-based program for chronic disease prevention, as facilitators of Maintenance of the DPP in CES. Some spoke to the potential for Medicare reimbursement giving the DPP a higher *Relative Advantage* compared to existing CES programs without the potential for external funding. Lastly, CES professionals spoke to the value of implementing an evidence-based program like the DPP that helps them demonstrate local impact and contributes to their promotion process (*Organizational Incentives and Rewards*). Current CES professionals cited these as strong incentives for continuing to implement the program and for expanding the DPP into other counties within CES. CES professional B described the value of maintaining the DPP and expanding it into other counties in the following quote: "It's a nationwide program...it looks great on your dossier, and it makes a difference in the community."

Learning Climate (facilitator, strong)

Learning Climate was used to capture discussions around the "permanency" of the DPP in CES. Overwhelmingly, CES professionals felt that the DPP was not a temporary program for CES but would be continued in the future. CES professional E described their view on the permanency of the DPP in CES as follows: "I think that it's something that...we've shown...successful...it...definitely falls in line with our mission...I think that it's...definitely one that's here to stay."

Leadership Engagement, Implementation Strategy (facilitators, strong); Access to Knowledge and Information, Agent Networks (facilitators, weak)

CES professionals spoke to the need for continued involvement by leaders (*Leadership Engagement*) and support (*Implementation Strategy, Access to Knowledge and Information*) by leaders as the DPP is maintained in CES. They discussed, in particular, the regular technical assistance calls held during the pilot implementation and the value of those for maintaining implementation. When asked how leadership support for implementation could be improved for Maintenance of the program, CES professional E stated, "Just...continued communication, so I don't think improve, just...continue." CES professional B stated, "there are things that we do need, so it's not just give me the keys to the car."

CES professionals also spoke to the value of communicating with other CES professionals implementing the program (*Agent Networks*) through these calls and other avenues for DPP Maintenance. Some suggested new CES professionals interested in implementing the DPP in the future shadow an experienced CES professional to facilitate dissemination in new counties.

Champions, Formally Appointed Internal Implementation Leader (facilitators, weak)

Many CES professionals with a history working in Extension and with the Nutrition and Health Specialist (*Champion*) did discuss changes in the roles and responsibilities of the Specialist position as a potential barrier to long-term Maintenance of the DPP. Many Extension Specialists have a large percentage of their time devoted to items outside direct support of CES professionals' program implementation, limiting the *Available Resources* they have to devote to DPP support. CES professionals spoke to this barrier when thinking about continued support of DPP implementation in Extension:

> When I first started Extension, they were really specialists. Now, they've got all these other requirements...many of us in the county may or may not have a nutrition background, and so it's really critical that y'all have that knowledge and can pass that to...us. (CES professional C)

In light of these realities of the specialist position, CES professionals spoke to the need for a permanent DPP coordinator to serve as the *Formally Appointed Internal Implementation Leader* to support maintaining DPP implementation in CES.

Discussion

The present study provides important insights into the implementation outcomes of the DPP when implemented as intended in the context of a state CES. While results are not directly comparable to research in other DPP settings, the Reach of this program was moderate compared to intended reach (61%). Effectiveness with regard to weight loss outcomes (average 5.2% ± 5.0% of initial body weight) exceeded that reported by a national evaluation of translations of the DPP [138]. Adoption was similar to Damschroder's evaluation in a clinical setting, with a majority (92%) of trained individuals adopting the program [114]. Basic assessment of implementation fidelity indicated that the program was implemented as intended, with all CES professionals meeting requirements for session frequency and program length. Lastly, while Maintenance

could not be fully assessed, Maintenance in the state CES evaluated in the present study is promising, with 8 of the 13 CES professionals beginning or planning for another DPP cohort.

The present study provides important insight into barriers and facilitators of DPP implementation in the context of Cooperative Extension. Facilitators of DPP reach in Extension included community partners (*External Change Agents*) and the rapport of CES in communities (*Structural Characteristics*), while limited *Time* for recruitment was a barrier to reach. These findings highlight the importance of a CES professional having an established presence and network of community partners to promote recruitment for the program. These findings are consistent with other studies using the CFIR to evaluate implementation of other programs, reporting that programs with the highest referral rates were implemented by those who had strong community partner relationships [185, 194]. Some of the CES professionals in the present study were new to CES and, thus, had limited time to build those relationships with community partners. These CES professionals found recruitment a particular challenge. Having more time to recruitment (up to 6 months, as recommended by one CES professional) was suggested in interviews to allow time for establishing those community partners for new CES professionals. Even those with many years of experience in CES cited the potential benefit of a longer recruitment time (3-4 months was recommended by most CES professionals interviewed), as they had to build additional community relationships to recruit the specific target audience of the DPP. Thus, DPP dissemination and implementation efforts should consider allowing at least 3-4 months, and up to 6 months, for recruitment depending on the degree of implementers' networking in the community and any existing referral structures.

CES professionals' personal characteristics (*Other Personal Attributes*) also emerged in discussions of reach. Many were anxious throughout the recruitment process (*Other Personal*

Attributes) because of the unknowns of the final reach of their program, and that anxiety continued for many in regard to program retention throughout the 1-year program. While this anxiety did not seem to negatively influence reach of the program, it could serve as a barrier to maintenance of the program. Notably, the CES professional that cited the most anxiety around the recruitment process did not have specific plans to begin another DPP cohort in the near future at the present study's completion. Strategies to increase self-efficacy for DPP recruitment and retention should be considered by CES and other DPP delivery systems. It is important to note that reach was not compared across counties given their diverse sizes and potential participation rates, making a direct quantitative comparison potentially unfair.

CES professionals spoke to the DPP's evidence base (*Evidence Strength and Quality*) in regard to its effectiveness, as well as *Goals and Feedback* received by CES leadership. The effectiveness of the DPP, both reported in the research literature and observed by CES professionals in their own DPP groups, also contributed to CES professionals' perceived *Compatibility* of the DPP with CES and its *Relative Advantage* compared to other CES programs. While these findings are more descriptive, the role of *Goals and Feedback* in effectiveness highlights the importance of DPP leaders providing implementers with consistent feedback on the progress of their cohorts and potential areas for improvement. Notably, the present study utilized the Data Analysis of Participants System (DAPS) to track participant attendance, weight, and physical activity data [195]. This system was an *Available Resource* provided by CES to allow both DPP leaders and implementers to monitor participants' progress toward their goals. CES professionals highlighted the value of this system for implementation and keeping their cohort on track, likely influencing outcomes of many cohorts in the present study. Of course, with the present study being conducted during the COVID-19 pandemic,

COVID became a barrier to DPP effectiveness. Still, participant attendance and retention rates were comparable to other DPP evaluations conducted outside the pandemic (see Chapter 2)[138], highlighting the potential value of CES as a delivery system to increase DPP dissemination.

Participant Receptivity was created as a subcode of *Patient Needs and Resources* to capture participants' response to the program, including their outcomes. This method differs from that used by Damschroder et al., who used *Patient Needs and Resources* to capture both needs of the population served as well as the intervention meeting those needs and, thus, a positive participant response to the program [114]. However, in the context of the DPP, participant receptivity to the program itself was distinct from how agents perceived the program to meet other needs of the participants, like whether or not the program site was near their home or whether the DPP gave participants the knowledge and skills they needed to make health behavior changes. Thus, to more easily distinguish between discussions around participant needs related to rural versus urban residence, for example, and discussions around participants' satisfaction with the program**,** the *Participant Receptivity* subcode was created.

Most barriers and facilitators were discussed in regard to adoption and implementation of the DPP in CES. The DPP's source and associated evidence base in CDC (*Intervention Source, Evidence Strength and Quality*) facilitated adoption, a finding consistent with Damschroder et al.'s findings [114]. DPP marketing efforts to potential participants, community partners that may refer participants to the program, and even potential program implementers should emphasize the DPP as a CDC program to improve buy-in. The fit of the DPP with CES's mission and programming (*Compatibility, Implementation Climate*) was also a facilitator of adoption. CES professionals' perceived "fit" of the DPP with existing CES programming, along with the high adoption rate of the program among those trained to implement it in the present study, supports

the value of CES as a delivery system to increase dissemination. The high prevalence of T2DM (*Patient Needs and Resources*) and need for prevention rather than just disease management (*Tension for Change*) were also facilitators of DPP adoption. However, some CES professionals did feel that a T2DM management program may be more important in their county in light of the high percentage of the population already living with T2DM. While this belief was not a barrier to adoption in the present study, it could pose a barrier to maintenance in the future. In order to promote adoption and maintenance of the DPP in CES in the future, CES leaders may consider working with CES professionals to offer both the DPP and a T2DM program to address both needs in their communities.

Lastly, professional development and other incentives (*Organizational Incentives and Rewards*) contributed to CES professionals' interest in adopting the program, as well as helped to offset some of the *Cost* barrier of adoption. University settings like CES have the potential to obtain grant funding to support these types of adoption incentives, supporting the value of CES as a delivery system to increase DPP dissemination [130, 133, 196].

CES leadership (*Leadership Engagement, Champions, Formally Appointed Internal Implementation Leaders, Opinion Leaders, Structural Characteristics*) contributed to CES professionals' knowledge of the DPP (*Knowledge and Beliefs about the Intervention*) and decision to adopt the program. The value of CES leaders' support was discussed in regard to nearly all aspects of RE-AIM. Compared to other settings in which the DPP might be implemented as part of the National DPP effort, the support infrastructure of CES further positions it to be a strong delivery system [133, 197, 198]. Most Extension Services have a nutrition, health, and chronic disease prevention specialist, giving CES professionals access to expertise in these content areas related to the DPP [199]. Because of its basis in the university setting, CES

offers opportunities for collaboration with experts in other DPP-related areas, including physical activity [199].

The leadership structure may also pose challenges to the CES as a DPP delivery system. State Extension Specialists rarely are responsible for only one program, such as the DPP, and often have responsibilities beyond Extension programming, such as research and teaching responsibilities. Thus, the time and resources Specialists have available to devote to supporting DPP implementation is limited, a barrier cited by some CES professionals in the present study. This barrier is not specific to CES, as Damschroder et al. cited challenges to *Leadership Engagement* in their VA context as well [114]. CES professionals discussed the need for a permanent DPP coordinator (*Formally Appointed Internal Implementation Leader*) to assist the Specialist given the Specialist's other responsibilities as a way to overcome this challenge to Implementation and Maintenance of the DPP in CES.

Implementation strategies, including technical assistance calls (*Networks and Communications, Agent Networks*) that provided regular and updated *Goals and Feedback* on cohorts' progress toward meeting CDC DPRP standards, created a positive *Learning Climate* that CES professionals felt facilitated this pilot implementation of the DPP in CES. These results echo those reported by Damschroder et al., who also used bi-weekly meetings to provide pertinent updates and information and allow implementers time to discuss implementation progress and problem-solve issues [114]. Again, the associated support from CES leaders (*Leadership Engagement, Champions, Formally Appointed Internal Implementation Leaders, Opinion Leaders*) in the form of the training (*Access to Knowledge and Information*) and problem-solving were consistent facilitators of implementation. CES professionals spoke to the value of the additional day of training held after the lifestyle coach training. Again, this point

highlights the value of CES for its capacity for training DPP implementers. Damschroder et al. also found leadership involvement and support to be one of the most important facilitators of DPP implementation in the VA context [114]. Another study conducted in this state CES also found training and access to information as a facilitator of implementing another Extension program with fidelity [185]. This point also suggests that for DPP delivery systems that implement multiple DPP cohorts, additional training on implementation protocols specific to that delivery system may be beneficial for optimizing outcomes.

Personal characteristics of CES professionals, including experience in CES as a whole, experience with the DPP specifically, and any additional administrative CES responsibilities they held (*Other Personal Characteristics, Individual Identification with Organization*), served as both barriers and facilitators of DPP implementation. These influences were similar to those influences on program reach, with those with less experience and/or more administrative responsibilities encountering more challenges to implementation. Thus, a barrier of the context of CES as a DPP delivery system is competing demands on program implementers. Planning for implementation may be of particular importance for DPP implementers new to delivery systems or with high-level responsibilities to ensure they are able to meet CDC DPRP standards.

All CES professionals implemented the DPP largely as intended (*Executing*). The present study did not include an objective measure of implementation fidelity, compromising the validity of the present study's fidelity measures. However, CES professionals' sense of autonomy is an important part of the culture of CES; and the researchers felt it more important to maintain that sense of autonomy than obtain an objective measure of fidelity.

Lastly, CES professionals reported positive participant responses to the program (*Participant Receptivity*). Participant incentives, which were educational incentives like lunch

boxes and water bottles, were well received and highlighted by most CES professionals as a positive aspect of participation for many. This finding is consistent with a large-scale RE-AIM evaluation of a DPP that revealed non-monetary incentives also played a role in participant attendance and retention [200]. These consistent findings highlight the value of incentives as potential DPP delivery systems consider their readiness for implementation.

While the present study evaluated only one round of DPP implementation, maintenance of the program in CES was discussed, with many CES professionals beginning a new DPP cohort even before the completion of the present study (*Individual Stage of Change*). The DPP's *Compatibility* with CES, as well as its evidence base (*Evidence Strength and Quality*) giving it a *Relative Advantage* over other programs, were all discussed as facilitators of DPP maintenance in the state CES studied. Continued support from leaders in the form of consistent communication, continuing education and professional development (*Implementation Strategy, Agent Networks, Access to Knowledge and Information, Organizational Incentives and Rewards, Formally Appointed Internal Implementation Leader, Learning Climate*) were all cited as important components of quality implementation that would be necessary for maintenance as well as expansion of the DPP into other counties in CES.

In addition to the other barriers posed by the CES as a delivery system, CES professionals have a high degree of autonomy and may not feel the need to maintain fidelity to the program. In addition, most CES professionals are required to provide community programs in a variety of areas, such as youth development, financial literacy, relationships and human development, and housing. These competing demands make Time a limited resource and thus can be a challenge to implementation.

Strengths and Limitations

In using the CFIR in the present study and operationalizing construct definitions, the research team found some constructs to have such broad definitions that they became difficult to use. As discussed above, using *Patient Needs and Resources* to capture both participant needs and their response to the program seemed to dilute the influence of the construct on implementation. Similarly, *Available Resources* is a broad construct that encompasses a variety of factors, including incentives for participants and items to facilitate implementation like body weight scales, personnel resources, and even time. Because of the long program length compared to other CES programs, time was a recurring topic in evaluation of the DPP. The research team felt it beneficial to create a *Time* construct separate from *Available Resources* for this reason. Consideration should be given to creating these subconstructs or further specifying the meanings of broad constructs like *Patient Needs and Resources* and *Available Resources*. In their review of use of the CFIR, Kirk et al. found that less than half of studies used these two constructs [186]. This review highlighted other challenges to the use of the CFIR similar to the present study [186]. While challenges with different pairs of constructs were encountered, these studies found some constructs so similar that distinguishing between them was difficult [186]. The present study encountered this issue with the construct pair *Implementation Climate* and *Learning Climate*. In these cases, operationalized construct definitions may be so specific that they are not applicable to other uses of the CFIR, limiting its usability.

The present study is not without limitations. As mentioned previously, no objective measure of fidelity was included in the present study. While this was a limitation, a balance between research needs and the needs of the real-life setting in which this study was conducted was imperative. In addition, the research team involved in data collection and analysis was heavily involved in supporting implementation of the program, potentially introducing researcher

bias in data analysis and interpretation. However, the familiarity of the researchers with the implementation process did offer a more comprehensive understanding of the topics discussed by CES professionals in the interviews. Furthermore, three of the five data analysts were not involved in supporting implementation at all, introducing outside perspectives to the analysis process.

Conclusions

In spite of these limitations, the present study provides valuable and unique insight into barriers and facilitators of DPP implementation in CES and considerations for all DPP implementers as they consider the readiness of their organization for DPP implementation. CES offers numerous facilitators to DPP implementation, including a supportive leadership structure, compatible mission, access to content and implementation expertise, and established communication channels. Strong Reach, Effectiveness, Adoption, and Maintenance combined with the numerous facilitators support the value of CES as an effective and sustainable delivery system for DPP dissemination and implementation. Implementation strategies that promote communication and access to information, resources, and support seem to promote implementation of the DPP in CES as well. Future research should aim to further test implementation strategies for the DPP in CES, as well as potential enhancements to the DPP that CES is well-poised to implement and sustain.

Tables

Table 4.1 CFIR construct ratings of interviews

	Interview Timepoint*	A	B	C	D	E	F	G	H	I	J	K	L	Overall Strength
Intervention Characteristics														
Intervention Source	B	2+	1+	2+	2+	1+	1+	2+	2+	2+	M	0	M	Strong
	M	2+	1+	M	M	1+	M	M	0	M	M	M	M	
	P	2+	1+	M	M	1+	M	M	M	M	M	M	M	
Evidence Strength & Quality	B	2+	1+	1+	1+	1+	2+	1+	1+	2+	1+	2+	1+	Strong
	M	2+	1+	1+	1+	1+	2+	M	X	1+	1+	2+	1+	Weak
	P	2+	1+	1+	1+	2+	1+	1+	1+	2+	1+	M	1+	Weak
Relative Advantage	B	2+	1+	X	1+	0	1+	1+	1+	0	0	1+	2+	
	M	0	1-	1+	1+	1+	X	1+	1+	1-	X	0	X	
	P	M	0	1+	2+	2+	2+	X	1+	2+	1+	1+	1+	Weak
Adaptability	B	1-	1+	2-	X	1+	1+	1+	1-	1+	X	1+	1+	
	M	1-	1-	2-	1+	1+*	1-	1+	1-	X	1-	1-	1-	
	P	1-	X	2-	X	1-	X	1+	1+	1-	1-	1+	1-	
Trialability	B	1+	1+	1+	0	1+	1+	1+	1+	0	1+	0	X	
	M	M	M	1+	M	M	M	1+	1+	1+	1+	M	M	
	P	M	M	0	M	M	M	1+	M	M	M	M	0	
Complexity	B	1-	M	1-	M	2-	1-	M	X	2-	1-	1-	1+	
	M	1-	1+	2-	1-	X	1-*	1+	1-	2-	1-	1-*	1-	
	P	1-	1-	2-	1-	X	X	1-	1-	1-	X	1-	1-	Weak
Design Quality & Packaging	B	1-	X	2-	1-	X	1+	2+*	1-	X	1-	1-	1+	
	M	1+*	1-	2-	X	1+	1+	X	1-	X	1-	1-	X	
	P	X	1-	1-	1+	X	1-	1+	1-	1-	1-	0	1-	
Cost	B	1-	M	1-	0	1-	0	1-	1-	1-	1-	1-	1-	Weak
	M	2+	1+	1+	M	M	1+	2+	M	1+	1+	M	M	Weak
	P	M	M	1+	1-	M	M	M	M	1-	0	M	M	
Outer Setting														
Patient Needs & Resources	B	1+	2+	2+	1+	2+	2+	2+	1-	1+	1+	1+	1+	Weak
	M	1+	X	2-	1-	1+	1+	X	1-	1+	1-	1-	1+	
	P	X	1-	2-	X	X	0	1-*	1-	1+	1+	1-	0	
Cosmopolitanism	B	0	1+	1+	1+	1+	2-	1+	X	0	2+	M	1+	

	M	0	1+	1+	1+	0	1-	1+	1-*	0	1+	M	2+	
	P	1-	0	0	1+	0	1-	1+	0	0	1-	M	1+	
Peer Pressure	B	0	0	0	0	0	0	0	0	0	0	0	0	
	M	M	M	M	M	M	M	M	M	M	M	M	M	
	P	M	M	M	M	M	M	M	1-	M	M	M	0	
External Policy & Incentives	B	1+	1+	X	0	0	X	0	X	1+	0	1+	1+	
	M	1+	1+	2-	M	M	1+	M	X	M	X	M	M	
	P	M	M	2-	M	0	M	M	M	1-	0	X	1-	
Inner Setting														
Structural Characteristics	B	1+	1+	1+	1+	1+	1+	1+	1+	1+	2+	1+	0	Weak
	M	2-	M	1-	1+	0	2+	2+	1+	M	1+	0	1+	Weak
	P	M	M	1-	1+	M	1+	2+	M	1+	X	1+	M	
Networks & Communications	B	1+	1+	1+	2+	1+	2+	2+	1+	1+	2+	1+	1+	Strong
	M	1+	1+	1+	2+	1+	1+	2+	1+	1+	1+	1+	1+	Weak
	P	1+	1+	1+	1+	1+	1+	2+	1+	1+	1+	1+	1+	Weak
Culture	B	1-	M	1-	1+	1-	X	M	0	1+	X	1-	0	
	M	1-	1+	1-	1+	1+	2+	X	1+	1+	1+	1+	X	
	P	1-	1+	1+	1+	1+	0	1+	1+	1+	X	1+	1+	
Implementation Climate	B	1+	1+	2+	2+	M	1+	2+	1+	1+	1+	1+	M	Strong
	M	1+	M	M	1+	2+	1+	1+	2+	M	0	1+	1-	
	P	1+	1+	2+	M	M	1+	M	M	1+	1+	1+	M	Weak
Tension for Change	B	2+	1+	1+	M	1+	2+	M	1-	2+	2+	2+	M	Weak
	M	2+	M	M	M	M	1+	M	M	M	M	M	M	
	P	M	M	M	M	M	M	M	M	M	0	M	M	
Compatibility	B	1+	2+	1+	2+	2+	1+	2+	1+	1+	2+	1+	2+	Strong
	M	2+	X	1+	X	1+*	1+	1+	1+	2+	1+	1+	M	
	P	1+	1+	M	M	1+	M	1+	1+	1+	2+	1+	1+	Weak
Relative Priority	B	0	1+	1+	M	2+	1+	1+	M	0	X	2+	1+	
	M	1+	1-	1+	0	0	1+	X	1-	1-	X	0	1+	
	P	M	X	M	M	M	M	M	1+	1+	M	1+	M	
Organizational Incentives & Rewards	B	0	0	1+	0	1+	2+	1+	0	0	0	0	0	Weak
	M	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	Weak
	P	1+	2+	1+	0	1+	1+	1+	1+	1+	2+	2+	1+	Strong
Goals & Feedback	B	1+	1+	1+	0	2+	1+	2+	X	1+	1+	2+	0	Weak
	M	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	Weak
	P	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	2+	1+	Weak

Learning Climate	B	1+	M	M	M	1+	1+	M	M	1+	1+	M	M	
	M	1+	1+	1+	1+	1+	2+	1+	1+	1+	2+	1+	1+	Weak
	P	1+	0	1+	2+	1+	2+	1+	1+	2+	2+	1+	M	Strong
Readiness for Implementation	B	2+	M	2+	M	M	M	1+	M	M	M	0	M	
	M	X	2+	M	1+	1+	1+	2+	M	2+	M	1-	M	Weak
	P	M	M	M	X	1+	2+	M	M	M	1-	M	M	
Leadership Engagement	B	1+	1+	1+	1+	1+	2+	2+	1+	2+	1+	1+	1+	Strong
	M	1+	1+	2+	1+	1+	2+	2+	1+	2+	1+	1+	1+	Strong
	P	1+	1+	2+	1+	1+	2+	2+	1+	1+	2+	1+	1+	Strong
Available Resources	B	1+	1+	1+	X	1+	1+	1+	1+	1+	1+	1+	1+	
	M	1-	1+	1+*	1+	1+	1+	2+	1+	1+	X	1+	1+	
	P	1-	1+	1+	1+	1+	1+	1+	1+	1+	1-	1+	1+	
Access to Knowledge & Information	B	1+	1+	1-	X	1+	1+	1+	1+	1+	1+	1+	X	
	M	1+	1+	2+	1+	1+	1+	2+	1+	1+	1+	1+	1+	Weak
	P	1+	1+	X	1+	2+	2+	1+	2+	1+	1+	1+	0	Weak
Characteristics of Individuals														
Knowledge & Beliefs about the Intervention	B	2+	1+	1+	1+	1+	2+	1+	1+	1+	1+	1+	2+	Strong
	M	1+	1+*	1-	1+	1+	1+	1+	X	2+	1-	1+	1+	
	P	1-	1+	1+	1+	1+	2+	1+	1+	1+	1+	1+	1+	
Self-efficacy	B	1+	1+	X	1-	X	1+	1+	2+	1+	M	2+	1-	
	M	X	1+	1+	2+	1+	1+	2+	M	1+	1+	1+	1-	
	P	M	1+	M	1-	1+	2+	X	1+	1+	M	1+	2+	
Individual Stage of Change	B	M	M	M	M	M	M	M	M	M	M	M	M	
	M	M	M	2+	M	M	2+	2+	M	0	M	2+	M	Strong
	P	1+	1+	1+	2+	1+	1+	1+	1+	1+	1+	1+	1+	Weak
Individual Identification with Organization	B	1+	1+	1+	1+	0	1+	1+	1+	1+	1+	X	0	
	M	X	1+	2+	2+	1+	1+	2+	1+	1+	1+	1+	M	Weak
	P	0	0	0	1+	0	1+	0	1+	0	0	1-	0	
Other Personal Attributes	B	2+	1+	2+	2+	1+	1+	1+	X	1+	1+	X	X	Weak
	M	1+	1+	2+	1+	1+	1+	1+	1+	1+	1+	1+	1+	Weak
	P	1+	0	2+	1+	1+	1+	1+	1+	X	1-	1+	1+	
Process														
Planning	B	1+	1+	1+	1+	1+	1+	2+	1+	1-	1+	1+	X	
	M	1+	1+	1+	M	2+	1+	1+	1+	X	X	1+	M	
	P	M	0	M	0	0	1+	M	M	M	M	1+	M	
Engaging	B	1-	1+*	1+	X	X	X	1+	1-	0	1-	1+	X	

	M	X	0	1-	1-	1-	2-	1+	0	M	0	1-	1+	
	P	1+	0	X	1+	0	1-	1-	1-	0	1+	0	1-	
Opinion Leaders	B	M	M	M	M	2+	2+	2+	2+	2+	2+	1+	2+	Strong
	M	1+	M	M	M	1+	2+	2+	1+	M	X	1+	1+	Weak
	P	M	M	M	1+	M	1+	1+	1+	1+	1+	M	1+	
Formally Appointed Internal Implementation Leaders	B	0	1+	1+	1+	1+	2+	2+	2+	M	1+	0	1+	Strong
	M	1+	1+	1+	1+	1+	2+	1+	1+	1+	1+	1+	1+	Weak
	P	X	M	1+	2+	1+	2+	1+	2+	M	1+	1+	M	Weak
Champions	B	1+	1+	1+	1+	2+	2+	2+	1+	1+	1+	1+	1+	Strong
	M	2+	1+	1+	1+	1+	2+	2+	1+	1+	2+	1+	1+	Strong
	P	1+	1+	1+	1+	1+	1+	1+	1+	2+	1+	1+	1+	Weak
External Change Agents	B	M	1+	2+	1+	1+	1-	1+	1+	1+	2+	0	2+	Weak
	M	0	1+	2+	1+	0	M	1+	0	0	2+	M	1+	Weak
	P	1-	M	0	1+	M	1-	1+	M	M	2-	M	2+	
Intervention Participants	B	0	0	1-	0	1-	1+	1+	X	1+	1+	0	1+	
	M	0	0	1-	0	1-	1+	1-	1-	1+	1-	X	1+	
	P	2-	1+	1+	1+*	1+	1+	1+	X	1-	X	1+	X	
Executing	B	X	1+	1+	1+	X	1+*	1+*	1+*	X	1-*	X	1+	
	M	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	Weak
	P	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	X	1+	Weak
Reflecting & Evaluating	B	1+	0	1+	X	1-	2-	X	X	1-	1-	X	1+	
	M	1+	1+	0	1+	1+	1-	M	1+	0	M	M	1+	
	P	M	M	1+	0	M	1+	2+	M	X	0	1+	1+	
Other														
Implementation Strategy	B	1+	1+	1+	1+	1+	2+	1+	2+	1+	1+	1+	1+	Weak
	M	1+	1+	2+	1+	1+	1+	2+	1+	1+	1+	1+	1+	Weak
	P	2+	1+	1+	M	2+	2+	2+	2+	1+	1+	1+	1+	Strong
Agent Networks	B	1+	1+	1+	2+	1+	2+	1+	1+	1+	1+	1+	1+	Weak
	M	1+	1+	2+	1+	1+	1+	2+	1+	1+	1+	0	1+	Weak
	P	1+	1+	1+	1+	2+	1+	1+	1+	M	X	1+	M	Weak
Experience	B	0	M	2+	M	2-	M	M	1+	1+	1+	0	M	
	M	1+	0	2+	0	1+	1+	0	0	X	1+	1+	1+	
	P	M	M	X	0	M	0	M	1+	1+	1+	1+	0	
Facilitating	B	0	0	M	1-	2-	0	M	1+	M	M	1-	1+	
	M	M	M	M	1-	X	M	1-	1-	M	M	X	0	
	P	2-	M	M	1-	M	M	M	M	M	1+	M	1+	

Time	B	0	0	2-	2-	1-	1-	1-	2-	1-	1-	1-	2-	Strong
	M	1-	1+	1-	X	X	1+	1+	1-	1-	1-	1-	1-	
	P	1-	X	1-	1-	1-	1-	1-	X	1-	1-	1-	1-	Weak
Participant Receptivity	B	2+	M	1+	1+	1+	1+	1+	X	0	1+	1+	2+	
	M	2+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	Weak
	P	X	1+	1+	1+	1+	1+	1+	1+	1-	1+	X	1+	
Participant Networks	B	M	M	M	M	M	M	M	M	M	M	M	M	
	M	M	M	M	M	M	M	M	2+	M	M	M	0	
	P	2+	2+	M	2+	M	M	M	M	M	M	2+	M	
Zoom	B	M	M	M	M	M	M	M	M	M	M	M	M	
	M	M	M	M	M	M	M	M	M	M	M	M	M	
	P	0	1+	2-	M	M	M	1+	M	2-	1+	2-	1+	Weak
COVID	B	M	M	M	M	M	2-	M	M	M	M	M	M	
	M	X	1-	1-	1-	1-	1-	1-	1-	1-	1-	1-	1-	Weak
	P	1-	1-	1-	1-	0	X	1-	1-	1-	1-	1-	1-	Weak

*B = baseline, M = midpoint, P = post-intervention

Table 4.2 Co-occurrence of CFIR constructs with RE-AIM components

	Interview Timepoint*	Strength	Total Occurrence	Reach		Effectiveness		Adoption		Implementation		Maintenance	
				#	%	#	%	#	%	#	%	#	%
Intervention Characteristics													
Intervention Source	B	Strong	19	1	5%	0	0%	19	100%	0	0%	0	0%
Evidence Strength & Quality	B	Strong	44	0	0%	0	0%	42	95%	3	7%	0	0%
	M	Weak	34	1	3%	20	59%	4	12%	9	26%	1	3%
	P	Weak	24	0	0%	18	75%	1	4%	2	8%	3	13%
Relative Advantage	P	Weak	17	0	0%	12	71%	0	0%	3	18%	2	12%
Complexity	P	Weak	93	4	4%	12	13%	0	0%	74	80%	6	6%
Cost	B	Weak	18	0	0%	0	0%	15	83%	4	22%	0	0%
	M	Weak	21	0	0%	2	10%	7	33%	13	62%	2	10%
Outer Setting													
Patient Needs & Resources	B	Weak	67	7	10%	1	1%	57	85%	7	10%	1	1%
Inner Setting													
Structural Characteristics	B	Weak	14	1	7%	0	0%	12	86%	1	7%	0	0%
	M	Weak	24	6	25%	0	0%	8	33%	9	38%	3	13%
Networks & Communication	B	Strong	59	2	3%	0	0%	3	5%	55	93%	0	0%
	M	Weak	98	1	1%	0	0%	2	2%	98	100%	0	0%
	P	Weak	56	0	0%	0	0%	0	0%	53	95%	4	7%
Implementation Climate	B	Strong	52	3	6%	0	0%	46	88%	3	6%	0	0%
	P	Weak	15	0	0%	1	7%	0	0%	8	53%	6	40%
Tension for Change	B	Weak	14	0	0%	0	0%	14	100%	0	0%	0	0%
Compatibility	B	Strong	51	1	2%	0	0%	48	94%	3	6%	0	0%
	P	Weak	16	0	0%	3	19%	0	0%	4	25%	9	56%
	B	Weak	15	0	0%	0	0%	15	100%	0	0%	0	0%

Organizational Incentives & Rewards	M	Weak	30	0	0%	0	0%	19	63%	5	17%	8	27%
	P	Strong	15	0	0%	2	13%	0	0%	5	33%	9	60%
Goals & Feedback	B	Weak	20	0	0%	1	5%	0	0%	19	95%	0	0%
	M	Weak	72	0	0%	11	15%	0	0%	60	83%	1	1%
	P	Weak	36	0	0%	4	11%	0	0%	31	86%	1	3%
Learning Climate	M	Weak	57	1	2%	0	0%	1	2%	55	96%	1	2%
	P	Strong	35	0	0%	0	0%	0	0%	28	80%	7	20%
Readiness for Implementation	M	Weak	20	1	5%	1	5%	3	15%	13	65%	2	10%
Leadership Engagement	B	Strong	74	4	5%	0	0%	35	47%	38	51%	0	0%
	M	Strong	135	3	2%	0	0%	7	5%	124	92%	2	1%
	P	Strong	75	0	0%	3	4%	1	1%	64	85%	10	13%
Access to Knowledge & Information	M	Weak	116	1	1%	0	0%	7	6%	108	93%	2	2%
	P	Weak	52	0	0%	4	8%	1	2%	41	79%	7	13%
Characteristics of Individuals													
Knowledge & Beliefs about the Intervention	B	Strong	96	3	3%	8	8%	62	65%	25	26%	1	1%
Individual Stage of Change	M	Weak	13	1	8%	0	0%	0	0%	6	46%	7	54%
	P	Weak	36	2	6%	1	3%	0	0%	2	6%	32	89%
Individual Identification with Organization	M	Weak	39	1	3%	1	3%	7	18%	24	62%	6	15%
Other Personal Attributes	B	Weak	133	18	14%	6	5%	61	46%	55	41%	0	0%
	M	Weak	171	6	4%	10	6%	17	10%	141	82%	7	4%
Process													
Opinion Leaders	B	Strong	18	3	17%	0	0%	11	61%	5	28%	0	0%
	M	Weak	19	0	0%	0	0%	5	26%	14	74%	0	0%

Formally Appointed Internal Implementation Leaders	B	Strong	18	2	11%	0	0%	8	44%	9	50%	0	0%
	M	Weak	37	1	3%	0	0%	1	3%	36	97%	0	0%
	P	Weak	21	0	0%	0	0%	0	0%	18	86%	3	14%
Champions	B	Strong	38	1	3%	0	0%	31	82%	9	24%	0	0%
	M	Strong	74	3	4%	0	0%	2	3%	68	92%	2	3%
	P	Weak	35	0	0%	0	0%	1	3%	32	91%	3	9%
External Change Agents	B	Weak	47	43	91%	0	0%	2	4%	5	11%	0	0%
	M	Weak	21	13	62%	0	0%	0	0%	7	33%	2	10%
Executing	M	Weak	327	12	4%	64	20%	1	0%	263	80%	1	0%
	P	Weak	210	1	0%	62	30%	0	0%	147	70%	9	4%
Other													
Implementation Strategy	B	Weak	46	3	7%	0	0%	0	0%	43	93%	0	0%
	M	Weak	60	1	2%	0	0%	0	0%	60	100%	0	0%
	P	Strong	29	0	0%	0	0%	0	0%	26	90%	4	14%
Agent Networks	B	Weak	38	3	8%	0	0%	0	0%	36	95%	0	0%
	M	Weak	43	2	5%	1	2%	2	5%	41	95%	0	0%
	P	Weak	22	0	0%	0	0%	0	0%	18	82%	4	18%
Participant Receptivity	M	Weak	148	10	7%	57	39%	2	1%	78	53%	7	5%
Time	B	Strong	21	6	29%	0	0%	4	19%	14	67%	0	0%
	P	Weak	49	2	4%	3	6%	0	0%	42	86%	3	6%
Zoom	P	Weak	21	1	5%	2	10%	0	0%	16	76%	3	14%
COVID	M	Weak	160	8	5%	28	18%	2	1%	123	77%	3	2%
	P	Weak	107	0	0%	16	15%	0	0%	86	80%	7	7%

*B = baseline, M = midpoint, P = post-intervention

Table 4.3 Influence of CFIR constructs on RE-AIM domains in the DPP

RE-AIM Domain	Reach	Effectiveness	Adoption	Implementation	Maintenance
Outcomes	• 124 individuals screened • 119 eligible for program • 89 eligible for research	• Avg weight loss: • 5.2% ± 5.0% • Avg mod PA: 179 ± 122 min/wk • 46.7% of participants met 5% weight loss goal • 56.7% met PA goal	• 12 out of 13 (92%) of agents trained immediately adopted	• Avg sessions implemented: 26 (range: 25-27)	• 5 CES professionals started 6 new DPP cohorts (virtual) • 1 CES professional had started 1 new in-person DPP cohort • 2 CES professionals plans for 2 new in-person cohort
Facilitators/ Barriers	***Facilitators:*** + External Change Agents + Structural Characteristics ***Barriers:*** - Time	***Facilitators:*** + Evidence Strength & Quality + Relative Advantage - Complexity + Compatibility + Organizational Incentives & Rewards + Goals & Feedback + Executing + Participant Receptivity ***Barriers:*** - COVID	***Facilitators:*** + Intervention Source + Evidence Strength & Quality + Patient Needs & Resources + Implementation Climate + Tension for Change + Organizational Incentives & Rewards + Leadership Engagement + Knowledge & Beliefs about the Intervention + Other Personal Attributes + Opinion Leaders + Formally Appointed Internal Implementation Leaders + Champions X Structural Characteristics	***Facilitators:*** + Evidence Strength & Quality + Relative Advantage + Networks & Communications + Implementation Climate + Tension for Change + Organizational Incentives & Rewards + Goals & Feedback + Learning Climate + Readiness for Implementation + Leadership Engagement + Access to Knowledge & Information + Knowledge & Beliefs about the Intervention + Individual Identification with Organization	***Facilitators:*** + Evidence Strength & Quality + Relative Advantage + Implementation Climate + Compatibility + Organizational Incentives & Rewards + Learning Climate + Leadership Engagement + Access to Knowledge & Information + Individual Stage of Change + Formally Appointed Internal Implementation Leaders + Implementation Strategy + Agent Networks

			Barriers: - Cost	+ Other Personal Attributes + Opinion Leaders + Formally Appointed Internal Implementation Leaders + Champions + External Change Agents + Implementation Strategy + Agent Networks X Structural Characteristics ***Barriers:*** - Complexity - Cost - Time - COVID	

Table 4.4 Closed-ended interview question ratings

Question	Rating[1]			CFIR Construct	RE-AIM Domain				
	B	M	P		*Reach*	*Effectiveness*	*Adoption*	*Implementation*	*Maintenance*
"I feel that the DPP has a strong evidence base, meaning that it is an effective program in helping people prevent diabetes."	4.6	4.8	4.9	*Evidence Strength & Quality*		X	X		
"The DPP is consistent with how UGA Extension believes they can best serve Georgia communities."		4.7		*Compatibility*			X		X
"The DPP is compatible with other UGA Extension weight management and chronic disease prevention/management programs."		4.4		*Compatibility*			X		X
"The DPP has integrated well into UGA Extension nutrition and health programming."		4.8	4.6	*Compatibility*			X		X
"The DPP meets the needs of the members of my community."		4.5	4.8	*Patient Needs & Resources*			X		
"Overall, the DPP has more advantages than disadvantages."		4.6	4.6	*Relative Advantage*		X			
"The DPP has advantages compared to other UGA Extension weight management and chronic disease prevention programs like Walk-A-Weigh."		4.2	4.2	*Relative Advantage*		X			
"The DPP takes a backseat to other nutrition and health programs in UGA Extension."		2.0		*Relative Priority*			X		
"I had a clear plan for implementation of the DPP."		3.4		*Planning*				X	
"Implementing the first 6 months of the DPP was very complex and difficult."		2.3		*Complexity*				X	
"Implementing the second 6 months of the DPP was very complex and difficult."			2	*Complexity*				X	
"The DPP is very adaptable and, thus, feasible for counties with a variety of characteristics (e.g., rural, urban, suburban)."		4	4.3	*Adaptability*				X	
"Certain parts of the DPP are too rigid, creating problems or difficulties during implementation this first 6 months."		3.1	2.8	*Adaptability*				X	
"There is a clearly designated team of people leading and coordinating implementation of the DPP within UGA Extension."		5		*Leadership Engagement*				X	

"The DPP leaders and coordinators have the knowledge, skills, and qualities needed to lead/coordinate effective implementation of the DPP within UGA Extension."	5		*Champions, Formally Appointed Internal Implementation Leader*				X
"The team leading implementation has sufficient authority to take necessary action for successful implementation of the DPP in UGA Extension."	4.1		*Champions*			X	X
"UGA Extension leaders and agents involved in the DPP have strong, productive working relationships and communication within the Extension network."	4.8	4.5	*Networks & Communications*				X
"I and other agents have felt comfortable discussing problems related to DPP implementation."	4.5	4.5	*Learning Climate*				X
"If a mistake is made or problems are encountered during implementation, positive changes are made to prevent those during future implementation."	4.2	4.5	*Learning Climate*				X
"UGA Extension leaders and agents view the DPP as a program to be implemented only temporarily by UGA Extension."	1.7	1.3	*Learning Climate*				X
"Working with other people/organizations in my county to implement the DPP has been a challenge."	2.4	2.8	*Cosmopolitanism, External Change Agents*	X			X
"The state Extension office has provided excellent support and resources to implement the DPP in my county."	4.9	4.8	*Available Resources, Access to Knowledge & Information*				X
"I could implement the DPP just as successfully without the support of the state Extension office."	2.2	2.2	*Leadership Engagement*				X
"UGA Extension has sufficient staff at the state, district, and my county level to implement the DPP."	3.4	3.7	*Available Resources*				X
"I have adequate technology to implement the DPP in my county."		4.5	*Available Resources*				X
"I have not had enough time to devote to implementing the DPP."	2.0	1.9	*Available Resources, Time*	X			X

"I have had adequate materials (in terms of quantity and quality) and related resources to implement the DPP."	4.6	4.5	*Available Resources*			X	
"The quality of the packaging and content of the DPP curriculum and related materials has been excellent."	4.1		*Design Quality & Packaging*			X	
"I and the other agents had adequate training, continuing education, and technical assistance from DTTAC, my district office, and the state Extension office to implement the DPP."	4.7	4.7	*Available Resources, Access to Knowledge & Information*			X	
"My leaders have promoted and supported my implementation of the DPP in tangible ways."	4.4	4.6	*Leadership Engagement*			X	
"There has been a champion (someone dedicated to successful implementation of the DPP in UGA Extension) who has worked well with me and other agents."	4.6		*Champions*	X		X	
"My leaders have established clear goals for the UGA Extension DPP."	4.6	4.9	*Goals & Feedback*			X	
"My leaders provided us agents with the necessary instructions and tools to monitor progress of our DPP cohorts."	4.7	4.8	*Available Resources*			X	
"My leaders have conveyed that failure of the DPP in my county and throughout UGA Extension is not an option."	1.9	1.5	*Learning Climate*			X	
"I have had effective communication with other people/organizations outside UGA Extension that I am collaborating with to implement the DPP."	3.5	4	*Cosmopolitanism, External Change Agents*	X		X	
"Progress of the DPP has been monitored since the start of the program in January/February."	4.8		*Goals & Feedback*			X	
"UGA Extension leaders hold agents accountable for the success of the DPP in their county."	4.0		*Learning Climate*			X	
"The DPP is a successful program so far."	4.5	4.8	*Knowledge & Beliefs about the Intervention*		X		
"The DPP should be continued in my county and in UGA Extension."	4.9	5	*Individual Stage of Change*				X
"The DPP should be expanded to other Georgia counties by UGA Extension."	4.5	4.4	*Individual Stage of Change*				X

"I have everything I need to continue implementing the DPP in my county for the remaining 6 months of the program."	4.7		*Available Resources*	X
"I have everything I need to continue implementing the DPP after this cohort of participants completes the program."	4.1	4.4	*Available Resources*	X

[1]Rated on a 5-point Likert scale: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree

CHAPTER 5

CONCLUSION

This dissertation adds to the understanding of the effectiveness of the Diabetes Prevention Program (DPP) in the context of a state Cooperative Extension Service (CES), providing a comprehensive assessment of not only participant health outcomes but also implementation barriers, facilitators, outcomes, and strategies to support sustained implementation. As incidence and prevalence of T2DM and prediabetes rise, along with rising obesity rates, the urgency of disseminating evidence-based interventions like the DPP into a variety of settings is only increasing [1, 4, 6]. At the time of this dissertation submission, 31 CES are CDC DPRP DPP providers, indicating the need to explore CES as a relevant context for dissemination and implementation of the DPP.

While the DPP has a large evidence base supporting its efficacy and effectiveness [2, 3], the lack of published literature on its effectiveness and implementation in the context of CES, when implemented as intended and using the new Prevent T2 curriculum, necessitated a hybrid effectiveness-implementation evaluation of this type. Similar to the fact that the effects of an intervention in one population are not necessarily applicable to other populations, the effectiveness of an intervention in one context is not necessarily applicable to other contexts. Differences in contextual and systems factors affect the feasibility and effectiveness of an intervention when conducted in a community compared to a clinical setting, for example [103]. Thus, in order to best translate interventions shown to be effective in clinical contexts to community contexts, as is the goal of the current CDC National DPP dissemination effort, the

effect of contextual factors on the feasibility, implementation, and effectiveness is important to consider [103, 104, 107]. Furthermore, understanding the predictors of implementation outcomes in a new context can allow program implementers to identify implementation barriers to address and facilitators to capitalize on to improve implementation outcomes [103, 108]. While implementation science studies have investigated the implementation context, strategies, and outcomes of DPPs implemented in clinical contexts and various community contexts, a review of the literature shows no studies that have rigorously evaluated these three aspects of implementation within the community context of Cooperative Extension [89, 109-111, 113-115, 201].

This hybrid effectiveness-implementation study design proved valuable to inform DPP integration into the state CES while addressing these gaps in the literature. Although one would assume similar participant health outcomes across similar community settings, CES is somewhat unique with its educators in the community, yet base of support in the university setting. Unlike in other community-based organizations or compared to other lay leaders who may be implementing the DPP as a volunteer not associated with an organization, CES professionals have structured access to information and resources from state-level specialists with content and program implementation expertise. Thus, we hypothesized that outcomes of the program in our setting of CES may be better than those in other community settings without the level of support and expertise available in CES.

Furthermore, a review of the published literature revealed no studies that explicitly stated using the new Prevent T2 curriculum, the curriculum used in the present study. As discussed elsewhere, the revisions made in the development of the Prevent T2 curriculum diluted much of the nutrition information in the original 2012 curriculum, eliminating specific energy intake goals, for example. While the new curriculum did incorporate the Diabetes Plate Method rather

than the standard USDA MyPlate in accordance with the research literature supporting this plate method for the prediabetes population [135], this plate method is only discussed in one out of the twenty-six lessons available to be used in the program. Because of the complexity of the field of nutrition, the amount of nutrition education and counseling patients/clients may need in order to navigate the food environment in the U.S. and make significant and lasting changes in their food choices is, in my experience, much greater than that offered in the Prevent T2 curriculum. Thus, while CES may promote better outcomes than other community settings, the Prevent T2 curriculum may limit outcomes due to insignificant dietary changes that participants are able to make with the information presented to them.

Health-Related Outcomes of a Social Support-Enhanced Cooperative Extension Diabetes Prevention Program (Chapter 2)

Chapter 2 focused on participant changes in weight, physical activity, diet quality, and health-related quality of life when the DPP was implemented as intended in the setting of a state CES. Weight significantly decreased over the course of the intervention. Interestingly, the average weight loss achieved by participants in the present study was greater than that seen in the national-level evaluation of the DPP lifestyle change program [138]. While no statistical comparisons were made between our study and Ely et al.'s, this comparison is worth noting as it may support the value of CES as a DPP delivery system, especially in light of our participants losing weight even amidst the COVID-19 pandemic when the average American was gaining weight [163].

Physical activity significantly improved over the course of the intervention. While our PA assessments had limitations (see Limitations section below), data from surveys and focus groups seem to support that participants increased their PA at least by some amount. The *2018*

Physical Activity Guidelines for Americans highlight that any increase in activity offers benefits [202]. Even for those participants that did not meet the 150-minute moderate PA goal, many benefited from slight increases in activity over the course of the intervention. Still, I feel that there are opportunities for improvement in the PA component of the Prevent T2 curriculum. While a large number of the lessons focus on PA, the information presented is limited in detail and often repetitive, similar to the nutrition information. While general recommendations for exercises are included, like walking, tennis, swimming, resistance band exercises, etc., these recommendations provide no specifics on exercise duration or frequency, other than the 150-minute moderate PA weekly goal. Furthermore, from my experience, participants often do not understand the difference between cardiorespiratory and muscle strengthening exercises and, thus, either count any muscle strengthening exercises in their 150 minutes or engage in no muscle strengthening exercises because they do not understand the importance or need. This issue is concerning, as many participants of the DPP in the present study and in other studies are middle-age and older adults, populations in which both types of exercise, in addition to flexibility and balance exercises, are important for maintaining heart health, promoting blood glucose control, maintaining muscle mass, and overall preventing disease and maintaining independence and physical function in older age [202]. In interviews with CES professionals and focus groups with participants, a recurring recommendation for Prevent T2 revisions was the incorporation of example exercises and even a group physical activity component, such as a walking session.

No changes in the total Healthy Eating Index score were observed. This null result is not surprising in light of the small sample size of complete 24-hour dietary recalls obtained through ASA-24. These results do provide insight, however, into the feasibility of using ASA-24 to

collect 24-hour dietary recalls in community settings like CES. Mean nutrient and food group intakes reported by participants via ASA-24 were reasonable as reported by our group elsewhere [203], but some intakes were different than what would be expected based on average intakes of Americans and other DPP participants [204]. Large standard deviations for energy and some nutrients also indicate that further instruction may be needed to improve the accuracy of reported intakes. Lastly, with 38% of participants failing to complete any recalls with ASA-24 at midpoint of the intervention, there is a need to explore potential barriers participants face to using ASA-24.

While some changes in diet quality were observed (fiber and fruit and vegetable intake), many of these changes were limited to individuals with certain characteristics in the sample (for example, college graduates). These limited changes highlight the need for reconsideration of the nutrition changes made in the development of the Prevent T2 curriculum. While these curriculum changes were made to allow for individuals from a variety of backgrounds to be able to implement the DPP, if diet quality is not improving over the course of the intervention because of these changes, consideration should be given to whether the benefit of greater dissemination outweighs the cost of poorer outcomes.

Some changes in health-related quality of life were also observed, primarily in days of poor physical health, days of pain in older adults, and days full of energy in younger adults. While these results, particularly HRQoL measures related to mental health, are highly confounded due to the context of the COVID-19 pandemic, they are still consistent with the literature supporting the value of weight loss for improving physical health, decreasing pain in older adults, and increasing energy levels. Use of the CDC HRQoL measure in the present study contributes to the data available on this measure and may be interesting to compare to results of

the national Behavioral Risk Factor Surveillance System data during the COVID-19 pandemic. Researchers should continue to explore changes in HRQoL in the context of the DPP, as this outcome will likely be influenced by the pandemic for years to come.

Our results indicate a social media enhancement in the form of a private Facebook group did not influence participant outcomes. This lack of influence could be due to many participants not having Facebook or not using it on a regular basis, as only 38% enrolled in the group, and of those, 73% were "active" users. This lack of influence could also be due to some CES professionals sharing the Facebook content with participants who did not engage with the Facebook group otherwise. Results from this study suggest that a private Facebook group may not be appropriate for the population that will likely participate in the DPP in this state CES over time. However, the sample size of Facebook users was small; so it is possible that an influence may be observed with a larger sample size. The utility of a Facebook enhancement may be dependent upon the specific cohort and the percentage of the cohort that uses Facebook on a regular basis.

A more effective approach to enhance DPP outcomes may be to create a resource page for CES professionals to share with participants, providing consistent, evidence-based resources related to each session topic. This suggestion emerged from the data presented in Chapter 4, as many CES professionals were already pulling information from the Facebook group and other sources to provide to their participants. Having a central resource page to ensure that CES professionals are delivering a consistent "dose" and quality of information in DPPs across the state CES may be a more effective and feasible way to enhance the DPP, while still delivering it as intended, in CES.

Association of Social Support and Food Security with Health-Related Outcomes of a Cooperative Extension Diabetes Prevention Program (Chapter 3)

Chapter 3 explored the relationships of social support and food security with the health outcomes discussed in Chapter 2. Social support, including general social support and family and friend encouragement and discouragement for healthy eating, did not change over the course of the intervention. However, participants' social support at the beginning of the intervention was associated with some outcomes.

Greater social support from friends (less friend discouragement) was related to weight loss over the course of the intervention, but no other measures of social support were related to weight loss. Friend encouragement for healthy eating was a predictor of many components of diet quality, with those with higher friend encouragement having greater predicted intakes of fruits and vegetables and lower predicted intakes of added sugars from sugar-sweetened beverages.

Low social support at the beginning of the intervention, however, was related to some improvement in diet quality. Individuals who had either low encouragement or high discouragement from friends or family improved fiber intake and fruit and vegetable intake., highlighting the potential value of the DPP for supporting individuals to make these changes. Still, lower levels of general social support were related to increases in predicted added sugar intake over time. Thus, these results do support the potential influence of social support on diet quality, but the exact relationship warrants further investigation.

There were no relationships between social support and physical activity measures which may, again, support the need for incorporation of more group-level involvement in PA to facilitate greater support in this area. However, the social support measures used in this

dissertation did not evaluate the specific influence of participants' Social Support for Exercise on PA outcomes. While this survey was administered to participants, these outcomes are reported in another graduate student's dissertation (Isaura Castillo-Hernandez, summer 2021).

Lastly, social support from friends and family was related to some measures of health-related quality of life. Family discouragement was a significant predictor of physically unhealthy days and days full of energy, with participants with higher levels of family discouragement having a higher likelihood of reporting a physically unhealthy day and a lower likelihood of reporting a day full of energy. Conversely, family encouragement was a predictor of days experiencing sadness, with participants with higher levels of family encouragement having a lower likelihood of reporting a sad day. Similarly, participants with higher levels of friend encouragement had a lower likelihood of reporting a mentally unhealthy day. Again, these results highlight the importance of the DPP providing participants with social support to improve not only immediate indicators of health but also participants' quality of life influenced by health.

Lastly, food insecurity was related to few outcomes, but the sample size of food insecure participants was low. Food insecurity was associated with increases in calcium and dairy intake over time, but no other measures of diet quality. Participants that were food insecure had a higher likelihood of reporting a day interfered by poor health than those who were food secure, but food security was not related to any other HRQoL measures.

While social support did not change over the course of the intervention, and most relationships of social support with outcomes were not relationships with changes over time, these results still support the role of social support in participants' health outcomes. The COVID-19 context of the present study no doubt influenced the outcomes observed. Future research must further investigate the role of social support in DPP outcomes in community contexts like CES.

In spite of no significant changes in social support over the course of the intervention and limited associations with changes over time, in focus groups at the midpoint and end of the program, participants still cited the social support received from their fellow DPP group members as an important component of their DPP participation and behavior changes, especially in light of the pandemic and isolation. The data from these focus groups will be explored in future analyses to possibly explain the relationships found in the present study and to inform what might be important to measure with regard to social support in future DPP studies in CES.

Again, the limited sample size of food insecure participants in the present study limited the power available to explore the relationship of food insecurity with DPP outcomes. Future research should further investigate this influence, especially in light of the rising food insecurity rates as a result of the COVID-19 pandemic.

Barriers, Facilitators, and Outcomes of Implementation of the Diabetes Prevention Program in Cooperative Extension (Chapter 4)

Chapter 4 focused on barriers and facilitators of implementation of the DPP in CES, as well as implementation outcomes and the value of implementation strategies for promoting implementation. Numerous CFIR constructs were observed to facilitate or hinder one or more aspects of implementation as evaluated by the RE-AIM framework (Reach, Effectiveness, Adoption, Implementation, Maintenance), with communication and leadership support consistently facilitating implementation. These facilitators are likely not unique to the context of CES and may be valuable for other delivery systems to consider. Facilitators unique to CES include its support structure and basis in the university setting, giving DPP implementers unique access to content and implementation expertise that other delivery systems or individuals implementing the DPP may not have. While the barrier of limited time to devote to DPP

implementation at the CES level and to DPP support at the CES Specialist level is a barrier unique to CES, the continual access to graduate students in the university setting and ability to apply for grant funding to support a DPP coordinator can mitigate this barrier of CES as a DPP delivery system.

Using the CFIR in combination with RE-AIM proved valuable to better understand the influence of barriers and facilitators as CES works with CES professionals in different stages of DPP implementation. For example, CES professionals new to the program and adopting it for the first time have different challenges and successes than those in the maintenance phase of implementation, or those experiencing general difficulties with recruitment. Connecting CFIR constructs to RE-AIM as modeled after Damschroder et al. will be highly valuable as the implications of this dissertation research are incorporated into maintenance of the DPP in this state CES as well as into other state Extension Services implementing the DPP.

Using the CFIR to deductively code interview transcripts certainly increased the rate at which interviews were coded, compared to a more inductive approach. Analysis of the thirty-six interviews included in the present study would have far exceeded the time and personnel resources available for analysis if a deductive approach using CFIR were not taken.

However, some limitations to the CFIR were identified through its extensive use in the present study. Many CFIR constructs were so broad that the research team felt that either a new code needed to be created (for example, *Participant Receptivity* created as a subcode of *Patient Needs and Resources, Time* created as a subcode of *Available Resources*), or the thought needed to be double coded to most accurately capture the concept (for example, *Executing* and *Participant Receptivity* double coded to capture participant outcomes). While the creators of the CFIR suggest researchers create new codes to cover aspects of implementation that the CFIR

does not cover, creation of new codes may make it difficult to use the CFIR and to compare across studies over time. Furthermore, double coding makes rating of constructs, as well as interpretation of results, much more convoluted. Consideration should be given to further defining broader constructs like *Patient Needs and Resources, Available Resources,* and *Executing* to allow researchers using the CFIR to better operationalize existing constructs.

A major implication of this study was the value of implementation strategies that promote communication among CES professionals and between CES professionals and leadership, like the technical assistance calls held as part of this study. CES professionals cited these calls as having an important influence on staying on track with implementing the program as intended, encouraging attendance, and collecting all required data. While no cause-effect relationship can be drawn, the state CES included in the present study was able to achieve full CDC recognition as a DPP provider at the conclusion of the present study, highlighting the potential value of these implementation strategies and the context of CES for DPP implementation.

Limitations

Community-based work is never without limitations, especially in the context of the COVID-19 pandemic. First, this study included no control group, highly limiting its internal validity. While advanced statistical methods were used to account for as much variability as possible, it is still possible that the outcomes observed could be due to factors outside the DPP intervention.

Second, weight was completely self-reported at midpoint and post-intervention due to the pandemic. While participants were encouraged to wear similar clothing to that worn at baseline measurement, it is highly possible that these instructions were not followed and that participants may have misreported weight due to social desirability bias. Physical activity minutes, both

collected as part of the program and collected via the IPAQ-Short, were also self-reported. In spite of repeated explanations of what counts as moderate PA, some individual participants consistently over-reported moderate PA, limiting the validity of this data.

Third, the research team involved in data collection and analysis was heavily involved in supporting implementation of the program, potentially introducing researcher bias in data analysis and interpretation. However, the familiarity of the researchers with the implementation process did offer a more comprehensive understanding of the topics discussed by CES professionals and participants in the interviews and focus groups, respectively. Second, all interviews and focus groups were conducted over Zoom, eliminating much of the non-verbal cues data that can often be gathered from in-person interviews and focus groups. While most CES professionals and some participants did have webcam capabilities, many focus group participants did not have a webcam available, making consistent interpretation of body language infeasible. However, in-person interviews and focus groups were not possible at midpoint and post-intervention in light of social distancing requirements and shelter-in-place orders at the time of the focus groups and most interviews. Furthermore, the researchers' original intention prior to the pandemic was to complete interviews with CES professionals over Zoom; and consideration was given to completing focus groups over Zoom as well prior to the pandemic due to limited personnel resources to complete 39 trips across the state to all 13 counties at all 3 time points.

Lastly and arguably most importantly, the outcomes of this dissertation research are highly specific to the context of the COVID-19 pandemic. It is impossible to parcel out outcomes influenced and uninfluenced by the pandemic, as the extraordinary circumstances affected nearly every area of life for most individuals. While this research encompassed program implementers and participants in a variety of counties and settings, offering promising external validity, the

generalizability of these findings outside the context of the COVID-19 pandemic is likely limited.

Overall Conclusions

With approximately one third of the U.S. population living with prediabetes and 5-10% of these individuals developing T2DM each year, the need for increased dissemination of diabetes prevention interventions is imperative. With its capacity for multi-site implementation to reach large and diverse populations and a statewide network of county CES professionals who receive training and support from state Extension specialists with expertise in nutrition, physical activity, and weight management as well as program administration and implementation, Cooperative Extension Services are poised to increase dissemination of the CDC's National Diabetes Prevention Program lifestyle change program. Still, the effectiveness of this intervention in the context of CES, as well as barriers and facilitators to its implementation in this context, is largely unknown. This dissertation research provides insight into the effectiveness of the DPP in CES, as well as facilitators to capitalize on and barriers to address to promote Reach, Effectiveness, Adoption, Implementation, and Maintenance of the DPP in CES. Revisions or enhancements to the DPP Prevent T2 curriculum's nutrition and physical activity content should be considered, perhaps in the form of detailed nutrition handouts, food demonstrations or recipe tastings, or an organized group physical activity component. Other state Extension services may consider utilizing the implementation strategy of technical assistance calls as a strategy to promote DPP implementation in their context, as well as the other facilitators and barriers identified based on their stage of DPP implementation. Chronic disease prevention through health behavior change is a challenge influenced by a variety of factors, most

recently the COVID-19 pandemic. Future research should continue to investigate strategies to enhance DPP participant outcomes and promote greater dissemination of the DPP.

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APPENDIX A

INTERVIEW GUIDES

Adapted from Damschroder et al., 2015 [113]

Agent Interview 1: Post-Recruitment, Pre-Implementation		
CFIR Domain/Construct	**Closed-ended Questions (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree; OR yes, no)**	**Open-ended Questions**
To begin, I would like to ask you a few questions to make sure I understand your role and responsibilities within UGA Extension.		
Characteristics of Individuals *Individual Identification with Organization*		1. For the record, can you confirm your role within UGA Extension? 2. Can you describe your primary responsibilities? 3. Who do you report to?
Now, I would like to ask you a few questions to make sure I understand your role and responsibilities with the DPP specifically.		
Characteristics of Individuals *Individual Identification with Organization*		1. For the record, what is your role in the UGA Extension Diabetes Prevention Program (DPP)? 2. When taking on the DPP as a new program, did you have to reallocate your time to manage the additional responsibility of the DPP?
I would like to know more about how you and your colleagues viewed the DPP before you began implementing it in your county.		
Intervention Characteristics *Intervention Source* **Inner Setting**		1. How did your county become involved with the UGA Extension DPP?

Implementation Climate *Compatibility*		a. How was it decided that your county would participate in the DPP? b. Who participated in making that decision? c. Were you involved? If so, how? 2. How do you feel the DPP fits with the Extension mission and your role as a FACS Extension agent?
Intervention Characteristics *Evidence Strength & Quality* **Outer Setting** *Peer Pressure* *External Policy & Incentives* **Inner Setting** *Organizational Incentives & Rewards* *Structural Characteristics* *Culture*	On a scale of 1-5, tell me how true this statement is for you. 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree "I feel that the DPP has a strong evidence base, meaning that it is an effective program in helping people prevent diabetes."	1. What kind of information or research evidence did you know about showing the effectiveness of the DPP? a. For example, information or evidence from your own research, published research articles, guidelines from professional organizations or government agencies? From co-workers or supervisors? From members of your county? 2. What is your perception of this evidence? a. Does it make you think it will work for the members of your county? Or are you uncertain? 3. How much does this evidence affect your opinion of the DPP? 4. Prior to being approached about implementing the DPP, did you ever think about implementing the DPP or a similar program? 5. Do you think this is an important program for Extension to be doing? 6. Did Extension's ability to get CDC recognition influence your decision to be a part of the project? a. To what extent does the potential for insurance reimbursement for the program influence your perception of the program or your desire to do the program? b. Do you feel any pressure to offer the DPP because it would make us competitive with peer organizations? 7. Did our reputation as Extension and/or your role as a health educator in your community influence your decision? 8. Did the fact that you would receive a professional development stipend influence your decision to implement the DPP?

		9. Did the fact that you would receive program incentives for participants influence your decision to implement?
Intervention Characteristics *Relative Advantage* **Characteristics of Individuals** *Knowledge & Beliefs about the Intervention* **Outer Setting** *Patient Needs & Resources* **Inner Setting** *Implementation Climate* *Tension for Change*		1. What kind of weight management programs are you already offering to members of your community who are overweight or obese (any format, e.g., phone, internet, etc.)? a. Please describe the program(s). i. How do they compare with the DPP? b. Are these programs multidisciplinary; and if so, to what extent? c. How much do the program sessions build on each other? d. Are there other programs or efforts you are involved in to encourage members of your community to eat healthy and be physically active? e. Do you have an Extension prediabetes program currently in your county? If so, how does it differ from the DPP? f. Do you have an Extension diabetes program currently in your county? If so, how does it differ from the DPP, other than the different target audiences? 2. Do you feel that the DPP is a better option for overweight and obese people at high risk for T2DM in your community compared to other weight management, prediabetes, or even diabetes programs you offer? Why or why not? 3. Did you have to give up any programs to be able to implement the DPP? If so, do you feel that there is an advantage to offering the DPP over these other programs? Why or why not?
Outer Setting *Patient Needs & Resources* **Inner Setting** *Implementation Climate* *Tension for Change*		1. Before your county decided to implement the DPP, did you see a need for a diabetes prevention program for members of your community? Why or why not? 2. Did other people in your county or district Extension office feel that the DPP was needed? 3. How well do you feel that the DPP will meet the needs of people at high risk for T2DM in your community?

Now, I would like to know more about your planning process and your marketing/recruitment efforts.		
Characteristics of Individuals *Experience* **Process** *Planning* *Engaging* *Opinion Leaders* *Champions* *External Change Agents* *Formally Appointed Internal Implementation Leaders (FAIIL)* **Inner Setting** *Implementation Climate* *Goals and Feedback* **Characteristics of Individuals** *Knowledge & Beliefs about the Intervention*		1. Is this your first time implementing the DPP? 2. Can you describe the planning it took to begin implementing the DPP in your county? 3. Was/is there a clear plan and goals for implementation of the DPP? 4. Who was involved in the planning? a. Were the appropriate people involved in the planning? b. How engaged/involved were they? How much did they contribute to the planning process? c. Were there issues with buy-in of other community members or organizations that you are collaborating with or tried to collaborate with? d. Is there someone strongly in favor of the DPP who has had a major influence? Do you think you need such a champion or opinion leader? e. Is there someone formally appointed to support you in implementing the DPP? 5. How did you keep track of what tasks you needed to do during planning? a. How did you decide who would do each task? b. How did you keep track of progress with and completion of each task? 6. What kind of communication/marketing/recruitment activities were done? 7. What issues/challenges/barriers did you encounter when planning implementation of the DPP? Related to… a. Recruitment/referrals b. Space c. Scheduling d. Staffing i. How is planning for and implementing the DPP working with your current job requirements and

		the job requirements of any other employees helping you? ii. Have you had to hire additional employees to help you? If so, how has the hiring process gone? e. Anything else that has come up
Outer Setting *Cosmopolitanism* **Process** *Planning*		1. What connections outside Extension have you had to make in order to implement the DPP? For example, connections with local physicians, human resources departments, health department staff, worksite wellness coordinators, etc. 2. What are/were challenges you faced?
Now, I want to know more about how you determined if participants were eligible to participate in the program. While we provided guidelines for this overall, we also understand that sometimes those plans don't work out. So, please answer as this occurred in your county.		
Process *Planning/Executing*		1. What process have you used to identify members of your community with prediabetes or at high risk for T2DM eligible for the DPP? a. How are/were people screened for DPP eligibility? i. What specific factors did you use to determine their eligibility? Blood tests (A1c, FBG, OGTT)? Prediabetes or T2DM risk tests? Prior gestational diabetes? ii. How did you determine whether to exclude a member of your community from the program based on previous medical diagnoses (i.e., individuals who are pregnant, have an eating disorder, or with self-reported current diagnoses of diabetes, chronic kidney disease, liver disease, cancer, Alzheimer's or other dementias, or severe physical or cognitive limitations) b. How are/were people enrolled in the DPP in your county?
	Yes or no	

	Did you hold an interest session (separate from your session 0) as part of program recruitment and enrollment?	
Process *Reflecting and Evaluating*		1. Describe any processes that were changed or added to determine eligibility of members of your community for the DPP, if any (e.g., receiving referrals from physicians)? 2. What issues have you encountered while determining eligibility of members of your community for the DPP? 3. Based on your experiences, what recommendations do you have for identifying, referring, screening, and enrolling eligible participants for the DPP?
Characteristics of Individuals *Knowledge & Beliefs about the Intervention*		1. How will you know if the program is successful? Is there an evaluation component built in?
Characteristics of Individuals *Knowledge & Beliefs about the Intervention* *Self-efficacy* *Individual Stage of Change* **Process** *Planning*		1. Did you attend the DTTAC training in Athens in October 2019? a. If not, did you attend the training at another time? b. Do you feel that you are adequately prepared to teach the DPP after the training? Why or why not? c. Do you feel like you understand the DPP (program evidence base, program implementation and data collection requirements, curriculum content, etc.) after taking the course? Why or why not? 2. Did you feel that the separate, Extension-specific training was helpful? a. Do you feel that you are adequately prepared to teach the DPP in the specific context of Extension after the Extension-specific training? b. If you had just had the 2 days of the DTTAC training, would that have been sufficient?

Intervention Characteristics *Adaptability* **Process** *Planning*		1. As you approach beginning implementation of the DPP or are just starting implementation, have you had to make any changes to the program to be able to implement it in your county? If so, what changes did you make? 2. Is there anything that can be done to make the DPP more flexible and a better fit for your county?
Process *Planning* *Engaging* *FAIIL* *Reflecting and Evaluating* **Inner Setting** *Networks & Communications* *Readiness for Implementation* *Leadership Engagement* *Available Resources* *Access to Knowledge & Information*		1. What kinds of support are/were you hoping to receive from the state Extension office? 2. Have these needs been met so far? 3. Do you regularly participate in the bimonthly phone calls with the state Extension office and the other agents implementing the DPP throughout the state? a. Do you find these phone calls helpful? Why or why not? b. Did the calls offer you a time to reflect and evaluate on your progress in implementation? Please elaborate. c. Is the timing, format, mode, etc. of these calls good? d. Any suggestions to improve these? 4. Did you participate in the November webinar on recruitment for the DPP? a. Did you find this webinar helpful? Why or why not? b. Was the timing, format, etc. of this webinar good? c. Any suggestions to improve these? d. Any topic suggestions for our next webinar in March? 5. Do you utilize the GroupMe mobile app for communicating with other UGA Extension agents about planning for the DPP? a. Have you found this platform for communication with your fellow agents helpful? b. Any suggestions to improve communication with your fellow agents implementing the DPP?
Now, I would like to know more about how you plan to implement the DPP in your county.		
Process *Planning*		1. Do you anticipate/have you had difficulty recruiting 10-20 people for your DPP class? Why or why not?

		a. If so, is this challenge unique to the DPP or similar to other programs you have implemented? 2. Have you encountered the issue of having more people eligible and interested in participating than you are able to have in one class? a. If so, how have you handled that?
Intervention Characteristics *Design Quality & Packaging* *Cost* **Inner Setting** *Readiness for Implementation* *Available Resources* *Access to Knowledge & Information* **Outer Setting** *Cosmopolitanism* *FAEIL*		1. Are the DPP program materials helpful to you? 2. What is your experience so far with the DPP supporting materials (i.e., the Lifestyle Coach Guide, the Participant Guide, the activities, etc.)? 3. Do you feel that there are other materials that are important but are not included in the DPP? If so, what are they? 4. What impact, if any, has the fact that the state office is taking on all the costs of the program (i.e. training cost, printing, marketing) had in your decision to implement the program? a. If you had to absorb all the costs in your county, would you be implementing the program? 5. Has the state Extension office provided you with all the materials you feel you need? 6. Have you reached out to state Extension support staff for assistance? 7. Have you reached out to the DTTAC support staff yourself for assistance? a. If so, what was your experience? For example, did they get back to you in a timely manner? Did they answer your questions to your satisfaction?
Inner Setting *Readiness for Implementation* *Available Resources*		1. Will you please describe the physical space you are using for your DPP classes? a. What kind of space are you using? b. Is it located in your county Extension office or offsite? c. Did you have any issues finding a space for your DPP class? If so, please describe the specific issues you faced.

Inner Setting *Readiness for Implementation* *Leadership Engagement* *Implementation Climate* *Relative Priority* *Goals & Feedback* *Learning Climate*		1. What level of involvement did Extension leaders/supervisors in your county and in your district have with the DPP? a. Do they know about/that you are implementing the DPP? b. What kind of support do they give you? E.g., moral support, help with problem-solving, general interest in how things are going? c. Are your interactions with them typically formal (e.g., via email) or informal (e.g., conversations in the hallway)? d. Do they provide you with any feedback? If so, what kind of feedback? e. Do you feel that they are too involved or not involved enough? Please explain why or why not. f. Has the DPP been on the agenda/discussed at any of your staff meetings in the county or in regular meetings with district supervisors (i.e. PDCs or DEDs)?
Inner Setting *Readiness for Implementation* *Available Resources* *Access to Knowledge & Information* **Intervention Characteristics** *Adaptability* *Trialability*		1. Do you feel that you have adequate information and resources to make the DPP work in your county? a. From your county Extension office? b. From your district Extension office? c. From the state Extension office? 2. How adaptive do you think the recruitment process for the DPP is? 3. Did knowing that you were part of a pilot group for the implementation and research protocols influence your decision to be involved?
Thank you for hanging in there with me throughout this interview! I have a couple final questions to conclude.		
Intervention Characteristics *Complexity*		1. On a scale of 0-10 (with 0 being easy/no difficulties and 10 being extremely difficult), how difficult has it been so far to implement the DPP in your county? a. Please explain why. 2. On a scale of 0-10 (with 0 being easy/no difficulties and 10 being extremely difficult), how difficult do you think it will be to

		implement the DPP in your county as you move throughout the coming year? a. Please explain why. 3. On a scale of 0-10 (with 0 being a complete fail to 10 being a complete success), how successful has the DPP been so far in your county? 4. Lastly, on a scale of 0-10 (with 0 being not at all confident to 10 being extremely confident), how confident do you feel in implementing the rest of the program?
Process *Reflecting & Evaluating*		If you could go through the recruitment process all over again, what would you do differently?
		Finally, is there anything else you want to tell me about your experience with the DPP so far?
That completes the interview! Thank you so much for taking the time to talk with me today!		

Agent Interview 2: Post-Core Phase		
CFIR Domain/ Construct	**Closed-ended Questions (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)**	**Open-ended Questions**
Thank you for taking the time to be interviewed again today!		
Characteristics of Individuals *Individual Identification with Organization*		1. How much of your time has been dedicated to implementing the DPP? 2. Has that changed (increased or decreased) since you began recruiting for, planning for, and first implementing the DPP?
Process *Executing* *Reflecting & Evaluating*		1. Can you describe your experience with the DPP during this first 6 months of implementation? a. What major accomplishments have you/your participants achieved with the program during this first 6 months? b. What major setbacks have you encountered?
Process *Executing* *Reflecting & Evaluating* **Inner Setting** *Available Resources*		1. Can you walk me through how the DPP has run in your county on a day-to-day basis during this first 6 months? a. Can you describe how you run a typical session? b. Can you describe how you run any activities outside the weekly sessions (e.g., make-up sessions, individual discussions with participants, social media platform if applicable)? i. Do you utilize formats other than in-person (and now Zoom) for these outside activities, such as phone, email, etc.? 2. Have you had any issues getting the materials you need for your participants (participant guides, handouts, etc.)?
I am now going to ask you several closed-ended questions. For each statement, please let me know if you 1-strongly disagree, 2-disagree, 3-are neutral, 4-agree, 5-strongly agree, or do not know or feel that the statement is not applicable to the DPP in your county. I will then ask follow-up questions to better understand your response.		

These first questions are about the DPP within UGA Extension.		
Intervention Characteristics *Evidence Strength & Quality*	"I feel that the DPP has a strong evidence base, meaning that it is an effective program."	1. What key factors influenced that (high/low) response? 2. Has your view of the program changed after completing the first 6 months of the program, compared to before you began implementation?
Inner Setting *Structural Characteristics* *Culture* *Implementation Climate* *Compatibility*	"The DPP is consistent with how UGA Extension believes they can best serve Georgia communities."	1. Please explain. 2. What key factors influenced that (high/low) response? 3. What could be done to make that better? 4. What would need to change to make that better?
	"The DPP is compatible with other UGA Extension weight management and chronic disease prevention/management programs."	
	"The DPP has integrated well into UGA Extension nutrition and health programming."	
Outer Setting *Patient Needs & Resources*	"The DPP meets the needs of the members of my community."	1. What impact has the DPP had on your participants? 2. What feedback have you heard from them? a. Any success or failure stories? 3. Are there any unique characteristics of the participants in your program (e.g., mostly women, mostly middle-aged or older adults, participants from a particular occupation, etc.)? 4. What barriers to participants in your community being able to enroll or participate in the DPP have you noticed? a. For what reasons do you think participants missed DPP sessions?
Intervention Characteristics *Relative Advantage*	"Overall, the DPP has more advantages than disadvantages."	1. Can you describe these advantages and disadvantages?
	"The DPP has advantages compared to other UGA Extension weight management and chronic disease	1. Can you describe these advantages?

	prevention programs like Walk-A-Weigh."	
Inner Setting *Implementation Climate* *Relative Priority*	"The DPP takes a backseat to other nutrition and health programs in UGA Extension."	1. What do you perceive to be the highest priority program for UGA FACS Extension leaders?
Process *Planning*	"I had a clear plan for implementation of the DPP."	1. How did this plan (or lack of a plan) help or hinder implementation of the DPP in your county during these first 6 months. a. What advice do you have for future DPP implementation planning?
Intervention Characteristics *Complexity*	"Implementing the first 6 months of the DPP was very complex and difficult."	1. What was the most difficult or complex part of implementation of the DPP during these first 6 months? 2. What was the easiest part of implementation during these first 6 months?
Intervention Characteristics *Adaptability*	"The DPP is very adaptable and, thus, feasible for counties with a variety of characteristics (e.g., rural, urban, suburban)."	1. What parts of the DPP are the most important to be able to adapt? 2. If you could change parts of the DPP, what would it be? a. How important are these changes for the DPP to work in your county?
	"Certain parts of the DPP are too rigid, creating problems or difficulties during implementation this first 6 months."	1. What parts were too rigid? 2. Do you feel that the problems created by this rigidity are specific to your county or are applicable to other counties? 3. How would you fix these rigid parts of the program?
Now, I want to ask some questions about all the people involved in implementing the DPP and how they worked together.		
Process *Engaging* *FAIIL*	"There is a clearly designated team of people leading and coordinating implementation of the DPP within UGA Extension."	1. Who do you see as part of this team?
	"The DPP leaders and coordinators have the knowledge, skills, and	1. What knowledge, skills, and qualities do you feel are the most important for these leaders to possess?

	qualities needed to lead/coordinate effective implementation of the DPP within UGA Extension."	
	"The team leading implementation has sufficient authority to take necessary action for successful implementation of the DPP in UGA Extension."	1. What key factors influenced that (high/low) response?
Inner Setting *Networks & Communications*	"UGA Extension leaders and agents involved in the DPP have strong, productive working relationships and communication within the Extension network."	1. Within these relationships… a. What has worked well? b. What has been most challenging? 2. What platform of communication have you utilized the most and found to be most helpful to you (e.g., email, calls, webinars, GroupMe communication, etc.)? a. Do you feel that more frequent or less frequent communication would be more helpful? b. Do you feel that different types of communication would be more helpful? If so, what kind?
Inner Setting *Implementation Climate* *Learning Climate*	"I and other agents have felt comfortable discussing problems related to DPP implementation."	1. Are you aware of a situation when you or another agent tried something that did not work? a. (If yes) How did other agents and leaders respond? b. Did they help you or your colleague devise solutions? c. If not, why not? 2. Who have you most frequently discussed implementation issues with? a. Do they provides suggestions or possible solutions? 3. If another agent or leaders offer suggestions or solutions that you know are not feasible or will not work, do you feel comfortable expressing your opinions?
	"If a mistake is made or problems are encountered during implementation, positive changes are made to prevent those during future implementation."	
	"UGA Extension leaders and agents view the DPP as a program to be implemented only temporarily by UGA Extension."	

Outer Setting *Cosmopolitanism* **Process** *External Change Agents*	"Working with other people/organizations in my county to implement the DPP has been a challenge."	1. Why has collaboration with them worked well or been a challenge?
Now, I want to ask some questions about training, continuing education, technical support, personnel, materials, supplies, and other resources needed to implement the DPP.		
Inner Setting *Available Resources* *Access to Knowledge & Information* **Process** *Engaging* *FAIIL*	"The state Extension office has provided excellent support and resources to implement the DPP in my county."	1. What areas of support were the most important/helpful for you? a. Planning for implementation b. Problem solving c. Trustworthy knowledge d. Availability/accessibility of the support e. Respect/trust 2. How could support from the state Extension office be improved? 3. How necessary is this support from the state Extension office for future implementation of the DPP by UGA Extension?
	"I could implement the DPP just as successfully without the support of the state Extension office."	1. What specific area of support has been the least necessary for successful implementation during this first 6 months?
Inner Setting *Available Resources*	"UGA Extension has sufficient staff at the state, district, and my county level to implement the DPP."	1. What resources have contributed the most to you being able to implement the DPP during the first 6 months? 2. What have been the biggest barriers to implementation in terms of resources that you have encountered during this first 6 months?
	"I have not had enough time to devote to implementing the DPP."	1. How do your other responsibilities fit with your new responsibilities with the DPP? a. Do other work priorities compete for your time over the DPP? b. (If yes) What priorities are these?

		c. Were you able to cut down on your responsibilities and duties in other areas when you took on the DPP?
	"I have had adequate materials (in terms of quantity and quality) and related resources to implement the DPP."	Materials include Lifestyle Coach Guide, Participant Guides and Handouts, scales, other supplies 1. What materials have been most useful? a. How have you used them? 2. Are there other materials or related resources that you have not had that you wish you had (e.g., resistance bands, additional nutrition handouts, etc.)?
Intervention Characteristics *Design Quality & Packaging*	"The quality of the packaging and content of the DPP curriculum and related materials has been excellent."	1. Do you think these materials could be improved? If so, how?
Inner Setting *Access to Knowledge & Information*	"I and the other agents had adequate training, continuing education, and technical assistance from DTTAC, my district office, and the state Extension office to implement the DPP."	Please elaborate on your response.
Inner Setting *Available Resources Access to Knowledge & Information*		1. What webinars have you participated in to support your implementation of the DPP? 2. What other resources have you utilized to support your implementation of the DPP? a. eLC resources? i. If so, which ones? (e.g., Facebook resources) b. Common Ground? c. Zoom calls?
Now, I want to ask you some questions about how your leaders have engaged and supported you in implementing the DPP.		
Inner Setting *Implementation Climate*	"My leaders have promoted and supported my implementation of the DPP in tangible ways."	Leaders include your Program Development Coordinator (PDC), your district coordinator, and state specialists (primarily Nutrition and Health Specialist)

Organizational Incentives & Rewards *Goals & Feedback* *Readiness for Implementation* *Leadership Engagement* **Process** *Engaging*		1. How have your leaders showed their support (or lack of support) for the DPP? a. Do you have an example of when you went to one of your leaders for support with DPP problem-solving? If so, how did that go? 2. What actions taken by your leadership were necessary for you to implement the DPP? That is, what actions, if they had not been done, would have caused the program to fail? 3. Which leader(s)'s support do you feel has had the greatest influence on the success of the DPP?
Opinion Leaders *FAIIL Champions*	"There has been a champion (someone dedicated to successful implementation of the DPP in UGA Extension) who has worked well with me and other agents."	1. What is the role of this champion in UGA Extension and in relation to the DPP? 2. What have they done to make them a "champion" for the DPP in UGA Extension?
	"My leaders have established clear goals for the UGA Extension DPP."	1. What are these goals?
	"My leaders provided us agents with the necessary instructions and tools to monitor progress of our DPP cohorts."	
	"My leaders have conveyed that failure of the DPP in my county and throughout UGA Extension is not an option."	1. What kind of feedback have you received from leadership in terms of your success/performance?
Process *Engaging*	"I have had effective communication with other people/organizations outside UGA Extension that I am collaborating with to implement the DPP."	1. How do you communicate with them? Phone, email, formal meetings? 2. Do you have ongoing and/or scheduled communication with them?

This next question is different than the other closed-ended questions. I am going to describe four different organizational cultures (similar to the concept of work environments). Please pick the one that best describes how you perceive the culture of UGA Extension at the state, district, and county levels to be.		
Inner Setting *Culture*	Team culture: A welcoming work environment in which team-based approaches are valued and supported by leadership. Leaders take less of an authoritarian approach and instead focus on mentoring and supporting Extension agents' programming efforts to promote growth and improvement over the long term. Hierarchy culture: A structured and formal work environment in which accuracy and immediate outcomes of programming efforts are valued by leadership. Leaders take the roles of coordinators, monitors, and administrators of programming efforts. Entrepreneurial culture: An active work environment in which Extension agents' creativity is encouraged and supported by leadership. Leaders value improvements made by and originality of Extension agents. Market culture: A competitive work environment in which leaders emphasize productivity and efficiency (getting a lot of things done and getting them done fast).	How do you feel this "culture" of UGA Extension helps or hinders implementation of the DPP?

	Leaders serve as drivers of productivity.	
Now, I have a few questions about the switch to distance education with the COVID-19 pandemic.		
Intervention Characteristics **Effectiveness**		1. Tell me how you felt about the change to online sessions. 2. Tell me about your experience using the technology (Zoom) itself. a. Has it been easy/hard?
Effectiveness		1. How has changing to online affected your ability to implement the program? a. Do you feel that implementing the program via Zoom made your implementation more or less effective/successful? b. Do you feel that changing to online affected your participants' progress with their goals/success in the program?
Implementation	Have you provided your participants with more support outside your weekly/biweekly sessions since the change to online?	1. If so, what kinds of additional support have you provided them?
Intervention Characteristics	Imagine that the COVID-19 crisis was not happening. Do you feel that the online format for sessions would allow more people in your county to participate in the program than in-person sessions?	1. If so, what are some of the barriers to in-person participation that the online format helps your participants to overcome? 2. If you were going to implement in the program in the future, what format do you feel would be the most feasible and effective for your county? a. In-person? Distance education? Combination?
I know I have asked you A LOT of questions, so I appreciate your being so willing to provide me with as much information about your experience with the DPP as possible. I have just a few more questions about how the success of the DPP is evaluated and your thoughts on future DPP implementation within UGA Extension. Again, let me know if you 1-strongly disagree, 2-disagree, 3-are neutral, 4-agree, 5-strongly agree, or do not know or feel that the statement is not applicable to the DPP in your county. I will then ask follow-up questions to better understand your response.		

Characteristics of Individuals *Knowledge & Beliefs about the Intervention* **Inner Setting** *Implementation Climate* *Goals & Feedback* **Process** *Reflecting & Evaluating*	"Progress of the DPP has been monitored since the start of the program in January/February."	1. How do you feel progress is (or is not) being monitored? a. What measures and sources of information are used? i. Enrollment numbers, participation rates, weight outcomes, physical activity outcomes, participant satisfaction? 2. What is your role in determining the progress of the DPP? a. When and how do you report your relevant participant information to state Extension staff?
Inner Setting *Implementation Climate* *Organizational Incentives*	"UGA Extension leaders hold agents accountable for the success of the DPP in their county."	1. What incentives do you and the other agents have to implement the DPP? 2. What incentives do you and the other agents have to continue implementing the DPP after your current cohort is complete? 3. Is the success of your DPP cohort considered in your performance evaluations? 4. What other incentives do you think would be needed for other counties to start implementing the DPP? a. UGA Extension performance measures? b. CDC program recognition?
Characteristics of Individuals *Knowledge & Beliefs about the Intervention*	"The DPP is a successful program so far."	1. What has made the DPP successful or unsuccessful during this first 6 months in your county?
	"The DPP should be continued in my county and in UGA Extension."	1. How feasible do you feel continuing DPP implementation in your county is?
	"The DPP should be expanded to other Georgia counties by UGA Extension."	1. Do you have any other suggestions for new DPP implementation sites that we have not already covered?
Inner Setting *Available Resources*	"I have everything I need to continue implementing the DPP in	1. What resources do you not have that you need, if any?

	my county for the remaining 6 months of the program."	
	"I have everything I need to continue implementing the DPP after this cohort of participants completes the program."	1. What resources are needed to sustain implementation long-term?
That completes the interview! Is there anything else you would like to share with me that we did not cover? If not, thank you so much for taking the time to talk with me today!		

Agent Interview 3: Post-Core Maintenance Phase		
CFIR Domain/ Construct	**Closed-ended Questions (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)**	**Open-ended Questions**
Thank you for taking the time to be interviewed again today! Some of these introductory questions were asked in our first and second interviews earlier this year, but I want to ask them again to ensure we have the correct information. You may also recognize many of the other questions from our second interview this summer, but I want to understand any changes in your experiences now that you have implemented the entire program. All of these questions are about your experiences during the second 6 months, also known as the core-maintenance phase, of the program, unless specified otherwise.		
Characteristics of Individuals *Individual Identification with Organization*		1. Has your role in Extension or in implementing the DPP changed since the midpoint of the program?
Process *Executing* *Reflecting & Evaluating*		1. Can you describe your experience with the DPP during this second 6 months of implementation and overall throughout the entire 12 months? a. Can you describe the general implementation process during this second 6 months?
Process *Executing* *Reflecting & Evaluating* **Inner Setting** *Available Resources*		1. Has anything changed in terms of how you run a typical session and the DPP program on a day-to-day or session-to-session basis during this second 6 months? a. Any changes to how you run any activities outside the weekly sessions (e.g., make-up sessions, individual discussions with participants)? b. Have you utilized outside activities more or less during the second 6 months compared to the first 6 months? Why or why not (e.g., to keep participants engaged)? c. How much of your time has been dedicated to the DPP during the second 6 months or core-

		maintenance phase of the program and has that changed since the core phase or first 6 months?
Intervention Characteristics *Complexity*	"Implementing the second 6 months of the DPP was very complex and difficult."	1. What was the most difficult or complex part of implementation of the DPP during the second 6 months? Overall? 2. What was the easiest part of implementation during the second 6 months? Overall?
I am now going to ask you several closed-ended questions. For each statement, please let me know if you 1-strongly disagree, 2-disagree, 3-are neutral, 4-agree, 5-strongly agree, or do not know or feel that the statement is not applicable to the DPP in your county. I will then ask follow-up questions to better understand your response.		
These first questions are about the DPP within UGA Extension.		
Intervention Characteristics *Evidence Strength & Quality*	"UGA Extension leaders and agents feel that the DPP has a strong evidence base, meaning that it is an effective program."	1. What key factors influenced that (high/low) response? 2. Has your view of the program's evidence changed after completing the second 6 months of the program?
Inner Setting *Structural Characteristics Culture Implementation Climate Compatibility*	"The DPP has integrated well into UGA Extension nutrition and health programming."	1. Please explain. 2. What key factors influenced that (high/low) response? 3. What could be done to make that better? 4. Has this influenced your intentions to offer the program in the future?
Intervention Characteristics *Relative Advantage*	"Overall, the DPP has more advantages than disadvantages."	1. Can you describe these advantages and disadvantages?
	"The DPP has advantages compared to other UGA Extension weight management and chronic disease prevention programs like Walk-A-Weigh."	1. Can you describe these advantages?
Intervention Characteristics *Adaptability*	"The DPP is very adaptable and, thus, feasible for counties with a variety of characteristics (e.g., rural, urban, suburban)."	1. What parts of the DPP are the most important to be able to adapt? 2. If you could change one thing about the DPP, what would it be?

		a. How important is this for the DPP to work in your county?
	"Certain parts of the DPP are too rigid, creating problems or difficulties during implementation these second 6 months."	1. What parts were too rigid? 2. Do you feel that the problems created by this rigidity are specific to your county or are applicable to other counties? 3. How would you fix these rigid parts of the program?
Now, I want to ask some questions about all the people involved in implementing the DPP and how they worked together.		
Inner Setting *Networks & Communications*	"All UGA Extension leaders and agents involved in the DPP have strong, productive working relationships and communication."	1. Do you feel that DPP-related communication between state staff and agents could be improved? a. In the second 6 months of the program? b. Throughout the entire course of the program?
Inner Setting *Implementation Climate* *Learning Climate*	"I and other agents have felt comfortable discussing problems related to DPP implementation."	1. Are you aware of any problems related to DPP implementation that arose during the second 6 months of the program? a. (If yes) How did other agents and leaders respond? b. Did they help you or your colleague devise solutions? c. If not, why not? d. If another agent or leader offered suggestions or solutions that you knew were not feasible or would not work, did you feel comfortable expressing your opinions?
	"UGA Extension leaders and agents view the DPP as a program to be implemented only temporarily by UGA Extension."	
	"If a mistake is made or problems are encountered during implementation, positive changes are made to prevent those during future implementation."	
Outer Setting *Cosmopolitanism* **Process** *External Change Agents*	"Working with other people/organizations in my county to implement the DPP has been a challenge."	1. Remind me what people/organizations you are collaborating with to implement the DPP in your county. 2. To what extent have they been involved in implementation during this second 6 months? 3. How often do you communicate with them? 4. Why has collaboration with them worked well or been a challenge?
This next question is about the culture of UGA Extension at the state, district, and county level.		

Inner Setting *Culture*	For reference: Team culture: A welcoming work environment in which team-based approaches are valued and supported by leadership. Leaders take less of an authoritarian approach and instead focus on mentoring and supporting Extension agents' programming efforts to promote growth and improvement over the long term. Hierarchy culture: A structured and formal work environment in which accuracy and immediate outcomes of programming efforts are valued by leadership. Leaders take the roles of coordinators, monitors, and administrators of programming efforts. Entrepreneurial culture: An active work environment in which Extension agents' creativity is encouraged and supported by leadership. Leaders value improvements made by and originality of Extension agents. Market culture: A competitive work environment in which leaders emphasize productivity and efficiency (getting a lot of things done and getting them done fast). Leaders serve as drivers of productivity.	In our last interview, you stated that you felt the culture (or work environment) of UGA Extension at the state, district, and county levels could be best described as a _____ culture, defined as _____. 1. How do you feel this "culture" of UGA Extension has helped or hindered implementation of the DPP in this second 6 months?

Now, I want to ask some questions about training, continuing education, technical support, personnel, materials, supplies, and other resources needed to implement the DPP.		
Inner Setting *Available Resources* *Access to Knowledge & Information* **Process** *Engaging* *FAIIL*	"The state Extension office has provided excellent support and resources to implement the DPP in my county."	1. What kinds of support were the most important/helpful for you during these second 6 months? For example… a. Problem solving b. Trustworthy knowledge c. Availability/accessibility of the support d. Respect/trust 2. Is this different than what was helpful in the first six months? 3. Was anything not helpful to you? Did it change from the beginning of the program? 4. How could support from the state Extension office be improved? 5. What would you need for support for future implementation of the DPP and how is that different or not, from what you needed at the beginning?
	"I could implement the DPP as successfully without the support of the state Extension office."	
Inner Setting *Available Resources*	"UGA Extension has sufficient staff at the state, district, and my county level to implement the DPP."	1. What resources have contributed the most to you being able to implement the DPP during these second 6 months? Resources can be human/people or things. 2. What have been the biggest resource constraints that you have encountered during these second 6 months?
	"I have adequate technology to implement the DPP in my county."	1. Have you had any issues with technology for your online sessions? 2. Are the platforms UGA has available for virtual delivery (Zoom) adequate for delivering the DPP?
	"I have not had enough time to devote to implementing the DPP."	1. How have your other responsibilities fit with the DPP? a. Do other work priorities compete for your time over the DPP? i. (If yes) What priorities are these?

		b. Has COVID brought on additional responsibilities that have competed with the DPP for your time?
	"I have had adequate materials (in terms of quantity and quality) and related resources to implement the DPP."	Materials include Lifestyle Coach Guide, Participant Guides and Handouts, scales, other supplies 1. Are there other materials or related resources that you have not had this second 6 months that you wish you had (e.g., handouts on additional nutrition topics)?
Inner Setting *Access to Knowledge & Information*	"I and the other agents had adequate training, continuing education, and technical assistance from DTTAC, my district office, and the state Extension office to implement the DPP."	Please elaborate on your response. 1. How do you feel your continuing education and technical assistance needs have changed over these second 6 months?
Now, I want to ask you some questions about how your leaders have engaged and supported you in implementing the DPP.		
Inner Setting *Implementation Climate* *Organizational Incentives & Rewards* *Goals & Feedback* *Readiness for Implementation* *Leadership Engagement* **Process** *Engaging* *Opinion Leaders* *FAIIL Champions*	Leaders include your Program Development Coordinator (PDC), your district coordinator, and state specialists (primarily Nutrition and Health Specialist) "My leaders have promoted and supported my implementation of the DPP in tangible ways."	Leaders include your Program Development Coordinator (PDC), your district coordinator, and state specialists (primarily Nutrition and Health Specialist) 1. How have your leaders showed their support (or lack of support) for the DPP during these second 6 months? a. Do you have an example of when you went to one of your leaders for support with DPP problem-solving during these second 6 months? If so, how did that go? 2. What actions taken by your leadership were necessary for you to implement the DPP during these second 6 months and overall? That is, what actions, if they had not been done, would have caused the program to fail? 3. Which leader(s)'s support do you feel has had the greatest influence on the success of the DPP during these second 6 months?
	"My leaders have established clear goals for the UGA Extension DPP."	1. What kinds of goals have been communicated?

		2. What goals are specific to the second 6 months of the program?
	"My leaders provided us agents with the necessary instructions and tools to monitor progress of our DPP cohorts."	
	"My leaders have conveyed that failure of the DPP in my county and throughout UGA Extension is not an option."	1. What kind of feedback have you received from leadership in terms of your success/performance?
Process *Engaging*	"I have had effective communication with other people/organizations outside UGA Extension that I am collaborating with to implement the DPP."	1. How has your communication with them changed from the first to the second 6 months of the program?
Outer Setting *Patient Needs & Resources*	"The DPP meets the needs of the members of my community."	1. What impact has the DPP had on your participants during these second 6 months and overall? 2. What feedback have you heard from them during these second 6 months? a. What major accomplishments have you/your participants achieved with the program during this second 6 months? b. Any success or failure stories? 3. For what reasons do you think participants missed DPP sessions during this second 6 months? 4. What do you think is unique about your participants?
I know I have asked you A LOT of questions, so I appreciate your being so willing to provide me with as much information about your experience with the DPP as possible. I have just a few more questions about how the success of the DPP is evaluated and your thoughts on future DPP implementation within UGA Extension.		
Characteristics of Individuals	"The DPP is a successful program."	1. What has made the DPP successful or unsuccessful during these second 6 months and overall in your county?

Knowledge & Beliefs about the Intervention	"The DPP should be continued in my county and in UGA Extension."	1. How feasible do you feel continuing to offer the DPP is in your county now that you have implemented the entire program? 2. Do you plan to offer the program in the future? Why or why not? a. (If yes) Can you describe where you are in the planning process for your second cohort?
	"I have everything I need to continue implementing the DPP with a new cohort of participants."	1. What resources are needed to sustain implementation long-term?
	"The DPP should be expanded to other Georgia counties by UGA Extension."	1. Do you have any other suggestions for us as we expand to other agents and counties that we have not already covered?
		1. What reasons do you and the other agents have to continue implementing the DPP with a new cohort of participants? 2. What other incentives do you think would be needed for other counties to start implementing the DPP? a. UGA Extension performance measures? b. CDC program recognition?
That completes the interview! Is there anything else you would like to share with me that we did not cover? If not, thank you so much for taking the time to talk with me today!		

APPENDIX B

CFIR CODEBOOK

Adapted from published CFIR qualitative codebook [118]

I. Intervention Characteristics	
A. Intervention Source	Definition: Perception of key stakeholders about whether the intervention is externally or internally developed. Inclusion Criteria: Include statements about the source of the intervention and the extent to which interviewees view the change as internal to the organization, e.g., an internally developed program, or external to the organization, e.g., a program coming from the outside. Note: May code and rate as "I" for internal or "E" for external. Can refer to where the agents perceive the idea of implementing the intervention to have originated, e.g., Nutrition and Health Specialist, PDC, themselves, etc. Exclusion Criteria: Exclude or double code statements related to who participated in the decision process to implement the intervention to Engaging, as an indication of early (or late) engagement. Participation in decision-making is an effective engagement strategy to help people feel ownership of the intervention.
B. Evidence Strength & Quality	Definition: Stakeholders' perceptions of the quality and validity of evidence supporting the belief that the intervention will have desired outcomes. Inclusion Criteria: Include statements regarding awareness of evidence and the strength and quality of evidence, as well as the absence of evidence or a desire for different types of evidence, such as pilot results instead of evidence from the literature. Exclusion Criteria: Exclude or double code statements regarding the receipt of evidence as an engagement strategy to Engaging: Key Stakeholders.

	Exclude or double code descriptions of use of results from local or regional pilots to Trialability.
C. Relative Advantage	Definition: Stakeholders' perception of the advantage of implementing the intervention versus an alternative solution. Alternative solution would be another weight management program Extension agents could offer (e.g., Walk-A-Weigh). Inclusion Criteria: Include statements that demonstrate the intervention is better (or worse) than existing programs. Statements saying that the DPP is better (or worse) than another weight management program (e.g., Walk-A-Weigh) or diabetes prevention program offered by Extension. Note that there is currently not another UGA Extension diabetes prevention program. Exclusion Criteria: Exclude statements that demonstrate a strong need for the intervention and/or that the current situation is untenable and code to Tension for Change.
D. Adaptability	Definition: The degree to which an intervention can be adapted, tailored, refined, or reinvented to meet local needs. Inclusion Criteria: Include statements regarding the (in)ability to adapt the intervention to their context, e.g., complaints about the rigidity of the protocol. ~~Suggestions for improvement can be captured in this code but should not be included in the rating process, unless it is clear that the participant feels the change is needed but that the program cannot be adapted~~. (see Exclusion Criteria) However, it may be possible to infer that a large number of suggestions for improvement demonstrates lack of compatibility, see exclusion criteria below. Statements referring to how some components (e.g., recipe sampling, handouts) are adaptable – able to be chosen for yourself. Statements about wishing that the target audience could be broadened, that the session time/session frequency/program duration could be altered should be coded as Adaptability (negative). Exclusion Criteria: Exclude or double code statements that the intervention did or did not need to be adapted to Compatibility. Exclude statements about suggestions to the program and code as Suggestions. Statements about difficulty finding participants (due to time, county, eligibility criteria, etc.) should be coded as Engaging: Intervention Participants.

	Statements about the trouble it takes to find audience, general statements about being difficult, should be coded as Complexity.
E. Trialability	Definition: The ability to test the intervention on a small scale in the organization, and to be able to reverse course (undo implementation) if warranted. Inclusion Criteria: Include statements related to whether the **site piloted** the intervention in the past or has plans to in the future, and comments about whether they believe it is (im)possible to conduct a pilot. True trialability, in that they view the DPP as we could implement it once and decide not to implement it again. Exclusion Criteria: Exclude or double code descriptions of use of results from local or regional pilots to Evidence Strength & Quality.
F. Complexity	Definition: Perceived difficulty of the intervention, reflected by duration, scope, radicalness, disruptiveness, centrality, and intricacy and number of steps required to implement. Inclusion Criteria: Code statements regarding the complexity of the intervention itself. For the Extension DPP, Complexity can be referring to the number of components or difficulty finding the target audience. Complexity in terms of the target audience would be more general statements about capturing and retaining the population as a whole (takes a lot of effort to find and keep them for such a long program, etc.) as compared to specific strategies used to capture one sample of people (this would be coded as Engaging: Intervention Participants). Exclusion Criteria: Exclude statements regarding the complexity of implementation and code to the appropriate CFIR code, e.g., difficulties related to space are coded to Available Resources and difficulties related to engaging participants in a new program are coded to Engaging: Intervention Participants. Code statements about recruitment efforts that were not effective or difficult/complex as Engaging: Intervention Participants or double code when appropriate. Engaging: Intervention Participants is more descriptive of what was done but did not work vs. the effort involved to do it (Complexity). It may be appropriate to double code. Examples of Complexity from King et al. study: - "…with the prevalence of cancer in Georgia, and in County, I think it's really important. Um, I think it's harder with the

	specifications that it needs to be, um, no insurance or underinsured.…It's very hard to find those people." - "Absolutely, because that was a big concern in the beginning and I think that's probably a concern of others is "Where do I find these people?" (talking generally about the difficulty of recruitment) Example of Engaging and Complexity from King et al. study: - "So I feel like I tried a lot of things. Maybe it wasn't as targeted as it could have been. It might have been a little more aimless because it was my first one." (talking about the difficulty of recruitment, but also describing the specific strategies she employed this year) Example of Engaging from King et al. study: - "So what I normally do is contact the people from my advisory committee, the people that I know in the community also, and try to find the target audience we need for the class." - "Um, I think giving the right information, the fliers, posting the flier in a place that people can see and remember, um, and giving the information to people eto put it in their houses and put it in their schedules." (in response to what made recruitment successful)
G. Design Quality & Packaging	Definition: Perceived excellence in how the intervention is bundled, presented, and assembled. Inclusion Criteria: Include statements regarding the quality of the materials and packaging. Statements about how the materials are nice, packaged well, how the materials are bundled/packaged together nicely, OR improvements that should be made to materials. Exclusion Criteria: Exclude statements regarding the presence or absence of materials and code to Available Resources. Exclude statements regarding the receipt of materials as an engagement strategy and code to Engaging. Exclude statements about the helpfulness of the website for accessing information and code to Access to Knowledge & Information.
H. Cost	Definition: Costs of the intervention and costs associated with implementing the intervention including investment, supply, and opportunity costs. Inclusion Criteria: Include statements related to the cost of the intervention and its implementation.

	Exclusion Criteria: Exclude statements related to physical space and time, and code to Available Resources. In a research study, exclude statements related to costs of conducting the research components (e.g., funding for research staff, participant incentives).
II. Outer Setting	
A. Patient Needs & Resources	Definition: The extent to which the needs of those served by the organization (e.g., patients), as well as barriers and facilitators to meet those needs, are accurately known and prioritized by the organization. Prevalence of prediabetes and/or diabetes in the community Inclusion Criteria: Include statements demonstrating (lack of) awareness of the needs and resources of those served by the organization. Analysts may be able to infer the level of awareness based on statements about: 1. Perceived need for the intervention based on the needs of those served by the organization and if the intervention will meet those needs; 2. Barriers and facilitators of those served by the organization to participating in the intervention; 3. Participant feedback on the intervention, i.e., satisfaction and success in a program. In addition, include statements that capture whether or not awareness of the needs and resources of those served by the organization influenced the implementation or adaptation of the intervention. Statements discussing prediabetes and/or diabetes prevalence, lack of access to preventive health care services, community having low-income/underinsured individuals, lack of knowledge/awareness in community, beneficial to community etc. Also statements about the ability of DPP to expand an Extension agent's reach, reach a new population, etc. Exclusion Criteria: Exclude statements that demonstrate a strong need for the intervention and/or that the current situation is untenable and code to Tension for Change. Exclude statements related to engagement strategies and outcomes, e.g., how intervention participants became engaged with the intervention, and code to Engaging: Intervention Participants.
B. Cosmopolitanism	Definition: The degree to which an organization is networked with other external organizations. Relationships in the community that **already** exist with or without the DPP (e.g., family connections collaborative) Organizations that agent has relationship with – community partners

	Inclusion Criteria: Include descriptions of outside group memberships and networking done outside the organization. Statements that speak to the Extension agent meeting with individuals they have relationships with in the community and/or community leaders, relationships that are established regardless of if the partner becomes involved with the DPP. Statements about the value an agent places on being networked with the community for the overall good of Extension and the county office. Cosmopolitanism (negative): inability to find the appropriate community partner, speaking generally and not specific to the Process of DPP and what methods were used to engage a community partner (that would be coded as Engaging). Exclusion Criteria: Exclude statements about general networking, communication, and relationships in the organization, such as descriptions of meetings, email groups, or other methods of keeping people connected and informed, and statements related to team formation, quality, and functioning, and code to Networks & Communications. Exclude statements about seeking out **new** community partners for the DPP in order to reach the target audience and code to Engaging: External Change Agents. Statements about how the community partner benefits program and how specific partners are involved (recruitment, logistics, registration) should be coded to External Change Agent.
C. Peer Pressure	Definition: Mimetic or competitive pressure to implement an intervention, typically because most or other key peer or competing organizations have already implemented or are in a bid for a competitive edge. Inclusion Criteria: Include statements about perceived pressure or motivation from other entities or organizations in the local geographic area or system to implement the intervention. Exclusion Criteria:
D. External Policy & Incentives	Definition: A broad construct that includes external strategies to spread interventions including policy and regulations (governmental or other central entity), external mandates, recommendations and guidelines, pay-for-performance, collaboratives, and public or benchmark reporting.

	Inclusion Criteria: Include descriptions of external performance measures from the system. Might include mentioning encouragement from CDC to increase dissemination of the DPP OR some type of community initiative that may impact. Could include the influence of Extension's ability to get CDC recognition/insurance reimbursement for the DPP in agents' decision to implement the program. Could also include external policies that negatively impact dissemination/implementation/participation, such as participants' inability to take time off work to attend. Exclusion Criteria:
III. Inner Setting	
A. Structural Characteristics	Definition: The social architecture, age, maturity, and size of an organization. Code statements referring to Extension's reputation, including visibility in the community or lack thereof, to Structural Characteristics. Inclusion Criteria: Exclusion Criteria: Exclude statements referring to Extension's receipt of payment for services and code to Culture.
B. Networks & Communications	Definition: The nature and quality of webs of social networks, and the nature and quality of formal and informal communications within an organization. Inclusion Criteria: Include statements about general networking, communication, and relationships in the organization, such as descriptions of meetings, email groups, or other methods of keeping people connected and informed, and statements related to team formation, quality, and functioning. Communication between Extension leaders and agents, specialist with agents (i.e., agent communicating with Nutrition and Health Specialist or DPP coordinator and having them for support) Exclusion Criteria: Exclude statements related to implementation leaders' and users' access to knowledge and information regarding using the program, i.e., training on the mechanics of the program

	(one agent observing another, discussing the program) and code to Access to Knowledge & Information and Agent Networks Exclude statements related to engagement strategies and outcomes, e.g., how key stakeholders became engaged with the intervention and what their role is in implementation, and code to Engaging: Key Stakeholders. Exclude descriptions of outside group memberships and networking done outside the organization and code to Cosmopolitanism.
C. Culture	Definition: Norms, values, and basic assumptions of a given organization. Statements referring to norms for Extension programming, including teaching rather than the facilitating involved in DPP implementation. Also include statements that refer to the Extension norm of not excluding anyone from participating in a program. Inclusion Criteria: Inclusion criteria, and potential sub-codes, will depend on the framework or definition used for "culture." For example, if using the Competing Values Framework (CVF), you may include four sub-codes related to the four dimensions of the CVF and code statements regarding one or more of the four dimension in an organization. Exclusion Criteria:
D. Implementation Climate	Definition: The absorptive capacity for change, shared receptivity of involved individuals to an intervention, and the extent to which use of that intervention will be rewarded, supported, and expected within their organization. Inclusion Criteria: Include statements regarding the general level of receptivity to implementing the intervention. More general statement about the environment of the agents surrounding implementation of the DPP. Include statements that list agents' current and past nutrition and health programming in addition to the DPP. Exclusion Criteria: Exclude statements regarding the general level of receptivity that are captured in the sub-codes.
1. Tension for Change	Definition: The degree to which stakeholders perceive the current situation as intolerable or needing change.

		Needing change within Extension (e.g., toward more evidence-based programs), since this is part of the Inner Setting. Not the need for change in the community, because that is Outer Setting. Code that to Needs & Resources of those served by the Organization. Inclusion Criteria: Include statements that (do not) demonstrate a strong need for the intervention and/or that the current situation is untenable, e.g., statements that the intervention is absolutely necessary or that the intervention is redundant with other programs. Note: If a participant states that the intervention is redundant with a preferred existing program, (double) code lack of Relative Advantage, see exclusion criteria below. Exclusion Criteria: Exclude statements regarding specific needs of individuals that demonstrate a need for the intervention, but do not necessarily represent a strong need or an untenable status quo, and code to Needs and Resources of Those Served by the Organization. Exclude statements that demonstrate the intervention is better (or worse) than existing programs and code to Relative Advantage.
2.	Compatibility	Definition: The degree of tangible fit between meaning and values attached to the intervention by involved individuals, how those align with individuals' own norms, values, and perceived risks and needs, and how the intervention fits with existing workflows and systems. Program compliments current programming and goals of UGA FACS Extension Nutrition and Health. Inclusion Criteria: Include statements that demonstrate the level of compatibility the intervention has with organizational values and work processes. Include statements that the intervention did or did not need to be adapted as evidence of compatibility or lack of compatibility. Include statements that compare the DPP to other UGA FACS Extension Nutrition and Health programming, and how the DPP compliments that current programming. Exclusion Criteria: Exclude or double code statements regarding the priority of the intervention based on compatibility with organizational values to Relative Priority, e.g., if an intervention is not prioritized because it is not compatible with organizational values.
3.	Relative Priority	Definition: Individuals' shared perception of the importance of the implementation within the organization.

		Choosing to do the DPP over other programs they could do as a FACS agent. Top-down prioritizing program, nutrition/health more important than another FACS area within Extension Inclusion Criteria: Include statements that reflect the relative priority of the intervention, e.g., statements related to change fatigue in the organization due to implementation of many other programs. Exclusion Criteria: Exclude or double code statements regarding the priority of the intervention based on compatibility with organizational values to Compatibility, e.g., if an intervention is not prioritized because it is not compatible with organizational values.
4.	Organizational Incentives & Rewards	Definition: Extrinsic incentives such as goal-sharing, awards, performance reviews, promotions, and raises in salary, and less tangible incentives such as increased stature or respect. Inclusion Criteria: Include statements related to whether organizational incentive systems are in place to foster (or hinder) implementation, e.g., rewards or disincentives for staff engaging in the intervention. Speaking to personal benefits to be gained from implementing the program, e.g., promotion, professional awards, impact statements, etc. This is really about agent incentives for participating Exclusion Criteria: when we discuss participant incentives, code to Available Resources
5.	Goals & Feedback	Definition: The degree to which goals are clearly communicated, acted upon, and fed back to staff, and alignment of that feedback with goals. Inclusion Criteria: Include statements related to the (lack of) alignment of implementation and intervention goals with larger organizational goals, as well as feedback to staff regarding those goals, e.g., regular audit and feedback showing any gaps between the current organizational status and the goal. Goals and Feedback include organizational processes and supporting structures independent of the implementation process. Evidence of the integration of evaluation components used as part of "Reflecting and Evaluating" into **on-going or sustained** organizational structures and processes may be (double) coded to Goals and Feedback. Exclusion Criteria: Exclude statements that refer to the implementation team's (lack of) assessment of the progress toward and impact of implementation, as well as the interpretation of

	outcomes related to implementation, and code to Reflecting & Evaluating. Reflecting and Evaluating is part of the implementation process; it likely ends when implementation activities end. It does not require goals be explicitly articulated; it can focus on descriptions of the current state with real-time judgment, though there may be an implied goal (e.g., we need to implement the intervention) when the implementation team discusses feedback in terms of adjustments needed to complete implementation.
6. Learning Climate	Definition: A climate in which: 1. Leaders express their own fallibility and need for team members' assistance and input; 2. Team members feel that they are essential, valued, and knowledgeable partners in the change process; 3. Individuals feel psychologically safe to try new methods; and 4. There is sufficient time and space for reflective thinking and evaluation. Inclusion Criteria: Include statements that support (or refute) the degree to which key components of an organization exhibit a "learning climate." Agents feel they are supported to ask questions and learn together. Their feelings about piloting the intervention with the assumption that we're going to continue it. Exclusion Criteria:
E. Readiness for Implementation	Definition: Tangible and immediate indicators of organizational commitment to its decision to implement an intervention. We believe it's referring more to an organizational (Extension-level) readiness rather than a personal (agent-level) readiness. If Extension in general or a specific district or even county provided a specific, tangible indicator of readiness. If it's an agent talking about preparation, it is probably Planning. Inclusion Criteria: Include statements regarding the general level of readiness for implementation. Exclusion Criteria: Exclude statements regarding the general level of readiness for implementation that are captured in the sub-codes.
1. Leadership Engagement	Definition: Commitment, involvement, and accountability of leaders and managers with the implementation of the intervention. Inclusion Criteria: Include statements regarding the level of engagement of organizational leadership.

		When referring to regular involvement in managing the program, whether talking about Nutrition and Health Specialist, DPP coordinator, or Kinesiology team, code to Leadership Engagement Exclusion Criteria: Exclude or double code statements regarding leadership engagement to Engaging: Formally Appointed Internal Implementation Leaders or Champions *if* an organizational leader is also an implementation leader, e.g., if a director of primary care takes the lead in implementing a new treatment guideline. Note that a key characteristic of this Implementation Leader/Champion is that s/he is also an Organizational Leader.
2.	Available Resources	Definition: The level of resources organizational dedicated for implementation and on-going operations including physical space and time. Inclusion Criteria: Include statements related to the presence or absence of resources specific to the intervention that is being implemented. Could be materials that are available (or additional materials needed), time, the location/characteristics of the program space, grant money, etc. Time: having enough time to plan the program (more like a resource from the organization) rather than how much time it took to plan/implement (time it took to plan/implement can be coded as Planning or Executing) Exclusion Criteria: Exclude statements related to training and education and code to Access to Knowledge & Information. Exclude statements related to the quality of materials and code to Design Quality & Packaging. In a research study, exclude statements related to resources needed for conducting the research components (e.g., time to complete research tasks, such as IRB applications, consenting patients).
3.	Access to Knowledge & Information	Definition: Ease of access to digestible information and knowledge about the intervention and how to incorporate it into work tasks. Inclusion Criteria: Include statements related to implementation leaders' and users' access to knowledge and information regarding use of the program, i.e., training on the mechanics of the program. Statements about training. Can refer to training/implementation guides being sufficient or lacking in a certain area or topic.

	Include statements referring to use of DTTAC training/resources. Exclusion Criteria: Exclude statements related to engagement strategies and outcomes, e.g., how key stakeholders became engaged with the intervention and what their role is in implementation, and code to Engaging: Key Stakeholders. Exclude statements about general networking, communication, and relationships in the organization, such as descriptions of meetings, email groups, or other methods of keeping people connected and informed, and statements related to team formation, quality, and functioning, and code to Networks & Communications. Exclude statements about having the materials pre-printed and pre-packaged and code to Design Quality & packaging
IV. Characteristics of Individuals	
1. Knowledge & Beliefs about the Intervention	Definition: Individuals' attitudes toward and value placed on the intervention, as well as familiarity with facts, truths, and principles related to the intervention. Inclusion Criteria: Statements may discuss prior experience with the program for the few agents already implementing the program before the start of the study. It may also speak to the agent's perception of the program being a lot of work, the target audience being hard to find, effective, rewarding, etc. Awareness of the target audience and reaching them as the goal of the program. Exclusion Criteria: Exclude statements related to familiarity with evidence about the intervention and code to Evidence Strength & Quality.
2. Self-efficacy	Definition: Individual belief in their own capabilities to execute courses of action to achieve implementation goals. Inclusion Criteria: Exclusion Criteria:
3. Individual Stage of Change	Definition: Characterization of the phase an individual is in, as s/he progresses toward skilled, enthusiastic, and sustained use of the intervention. Inclusion Criteria: Exclusion Criteria: All agents are in Action phase since none have a very well-established history of implementation. May not be

	appropriate to use this code unless they discuss personal resistance to the program and/or overcoming that resistance. Code to Knowledge and Beliefs, Other Personal Attributes, Self-Efficacy, or Experience as appropriate.
4. Individual Identification with Organization	Definition: A broad construct related to how individuals perceive the organization, and their relationship and **degree of commitment** with that organization. Organization = Extension Inclusion Criteria: Exclusion Criteria:
5. Other Personal Attributes	Definition: A broad construct to include other personal traits such as tolerance of ambiguity, intellectual ability, motivation, values, competence, capacity, and learning style. Things not explicitly stated but hint at the individual's tolerance for stress, preference for organization, flexibility, etc. Inclusion Criteria: Exclusion Criteria:
V. Process	
A. Planning	Definition: The degree to which a scheme or method of behavior and tasks for implementing an intervention are developed in advance, and the quality of those schemes or methods. Inclusion Criteria: Include evidence of pre-implementation diagnostic assessments and planning, as well as refinements to the plan. Efforts made to have a plan for implementation and recruit the target audience, choosing location, etc. May be effort of agent alone, agent + community partner Exclusion Criteria: Efforts involving what was actually done to recruit the target audience (not what was planned) should be coded as Engaging: Intervention Participants.
B. Engaging	Definition: Attracting and involving appropriate individuals in the implementation and use of the intervention through a combined strategy of social marketing, education, role modeling, training, and other similar activities. Creating/facilitating/engaging relationships specific to the DPP and that will help the program (community partner OR participants)

		When in doubt, double code with the group that is being engaged (likely External Change Agent or Intervention Participant) Inclusion Criteria: Include statements related to engagement strategies and outcomes, i.e., if and how staff and intervention participants became engaged with the intervention and what their role is in implementation. Note: Although both strategies and outcomes are coded here, the **outcome of engagement efforts determines the rating**, i.e., if there are repeated attempts to engage staff that are unsuccessful, or if a role is vacant, the construct receives a negative rating. In addition, you may also want to code the "quality" of staff - their capabilities, motivation, and skills, i.e., how good they are at their job, and this data affects the rating as well. E.g., statements about meeting with outside organizations and telling them about the DPP, recruiting them as a partner. **Exclusion Criteria: Exclude statements related to specific sub constructs, e.g., Champions or Opinion Leaders.** Exclude or double code statements related to who participated in the decision process to implement the intervention to Intervention Source, as an indicator of internal or external intervention source.
1.	Opinion Leaders	Definition: Individuals in an organization that have formal or informal influence on the attitudes and beliefs of their colleagues with respect to implementing the intervention. Leaders within Extension (e.g., PDCs), who are mentioned as providing information or having a role but did not strongly "champion" implementation Inclusion Criteria: Include statements related to engagement strategies and outcomes, e.g., how the opinion leader became engaged with the intervention and what their role is in implementation. Note: Although both strategies and outcomes are coded here, the outcome of efforts to engage staff determines the rating, i.e., if there are repeated attempts to engage an opinion leader that are unsuccessful, or if the opinion leader leaves the organization and this role is vacant, the construct receives a negative rating. In addition, you may also want to code the "quality" of the opinion leader here - their capabilities, motivation, and skills, i.e., how good they are at their job, and this data affects the rating as well.

		Exclusion Criteria: Code comments about Nutrition and Health Specialist or DPP coordinator specifically as a champion to "Champion"
2.	Formally Appointed Internal Implementation Leaders	Definition: Individuals from within the organization who have been formally appointed with responsibility for implementing an intervention as coordinator, project manager, team leader, or other similar role. Inclusion Criteria: Include statements related to engagement strategies and outcomes, e.g., how the formally appointed internal implementation leader became engaged with the intervention and what their role is in implementation. Note: Although both strategies and outcomes are coded here, the outcome of efforts to engage staff determines the rating, i.e., if there are repeated attempts to engage an implementation leader that are unsuccessful, or if the implementation leader leaves the organization and this role is vacant, the construct receives a negative rating. In addition, you may also want to code the "quality" of the implementation leader here - their capabilities, motivation, and skills, i.e., how good they are at their job, and this data affects the rating as well. Exclusion Criteria: Exclude or double code statements regarding leadership engagement to Leadership Engagement *if* an implementation leader is also an organizational leader, e.g., if a director of primary care takes the lead in implementing a new treatment guideline.
3.	Champions	Definition: "Individuals who dedicate themselves to supporting, marketing, and 'driving through' an [implementation]", overcoming indifference or resistance that the intervention may provoke in an organization. Inclusion Criteria: Include statements related to engagement strategies and outcomes, e.g., how the champion became engaged with the intervention and what their role is in implementation. Note: Although both strategies and outcomes are coded here, the outcome of efforts to engage staff determines the rating, i.e., if there are repeated attempts to engage a champion that are unsuccessful, or if the champion leaves the organization and this role is vacant, the construct receives a negative rating. In addition, you may also want to code the "quality" of the champion here - their capabilities, motivation, and skills, i.e., how good they are at their job, and this data affects the rating as well. When agents specifically mention, Nutrition and Health Specialist, we code Champions

		Exclusion Criteria: Exclude or double code statements regarding leadership engagement to Leadership Engagement *if* a champion is also an organizational leader, e.g., if a director of primary care takes the lead in implementing a new treatment guideline. Code PDC as source of intervention to Opinion Leaders
4.	External Change Agents	Definition: Individuals who are affiliated with an outside entity who formally influence or facilitate intervention decisions in a desirable direction. Community organizations that partner with Extension to help plan and implement the program. Inclusion Criteria: Include statements related to engagement strategies and outcomes, e.g., how the external change agent (entities outside the organization that facilitate change) became engaged with the intervention and what their role is in implementation, e.g., how they supported implementation efforts. Note: Although both strategies and outcomes are coded here, the outcome of efforts to engage staff determines the rating, i.e., if there are repeated attempts to engage an external change agent that are unsuccessful, or if the external change agent leaves their organization and this role is vacant, the construct receives a negative rating. In addition, you may also want to code the "quality" of the external change agent here - their capabilities, motivation, and skills, i.e., how good they are at their job, and this data affects the rating as well. The role of the community partner and how they helped with the process of implementation. Statements about the outcomes of the recruitment process that include the External Change Agent should be coded as Executing. Exclusion Criteria: Note: It is important to clearly define what roles are external and internal to the organization. Exclude statements regarding facilitating activities, such as training in the mechanics of the program, and code to Access to Knowledge & Information *if* the change agent is considered internal to the study, e.g., a staff member at the national office. If the study considers this staff member internal to the organization, it should be coded to Access to Knowledge & Information, even though their support may overlap with what would be expected from an External Change Agent.
5.	Key Stakeholders	Definition: Individuals from within the organization that are directly impacted by the intervention, e.g., staff responsible for making referrals to a new program or using a new work process. Inclusion Criteria: Include statements related to engagement strategies and outcomes, e.g., how key stakeholders became engaged

	with the intervention and what their role is in implementation. Note: Although both strategies and outcomes are coded here, the outcome of efforts to engage staff determines the rating, i.e., if there are repeated attempts to engage key stakeholders that are unsuccessful, the construct receives a negative rating. Exclusion Criteria: Exclude statements related to implementation leaders' and users' access to knowledge and information regarding using the program, i.e., training on the mechanics of the program, and code to Access to Knowledge & Information. Exclude statements about general networking, communication, and relationships in the organization, such as descriptions of meetings, email groups, or other methods of keeping people connected and informed, and statements related to team formation, quality, and functioning, and code to Networks & Communications.
6. Intervention Participants	Definition: Individuals served by the organization that participate in the intervention, e.g., patients in a prevention program in a hospital. Characteristics of the target audience, the audience that attends the program, may double code with Engaging when discussing how the audience was reached. (i.e., difficulties recruiting using particular methods for a certain program) Inclusion Criteria: Include statements related to engagement strategies and outcomes, e.g., how intervention participants became engaged with the intervention. Note: Although both strategies and outcomes are coded here, the outcome of efforts to engage participants determines the rating, i.e., if there are repeated attempts to engage participants that are unsuccessful, the construct receives a negative rating. Exclusion Criteria: Exclude statements demonstrating (lack of) awareness of the needs and resources of those served by the organization and whether or not that awareness influenced the implementation or adaptation of the intervention and code to Needs & Resources of Those Served by the Organization. Code statements about how many people they reached that meet the target audience criteria as Executing. Code statements about how well the participants responded to the program as Participant Receptivity.
C. Executing	Definition: Carrying out or accomplishing the implementation according to plan.

	Inclusion Criteria: Include statements that demonstrate **how implementation occurred with respect to the implementation plan.** Note: Executing is coded very infrequently due to a lack of planning. However, some studies have used fidelity measures to assess executing, as an indication of the degree to which implementation was accomplished according to plan. Statements about how the plan translated to outcomes (# enrolled, reaching target audience, retention, etc.), or details about how the plan was carried out in comparison to original plan. This can be used for recruitment and for implementation. Using the screening tools and using screening tools appropriately to make sure attendees fit the target audience Ratings: + if they followed the plan + if they did something extra that translated to positive outcomes - if they didn't follow the plan Exclusion Criteria:
D. Reflecting & Evaluating	Definition: Quantitative and qualitative feedback about the progress and quality of implementation accompanied with regular personal and team debriefing about progress and experience. Discussion of how the program turned out in terms of reaching the target audience, since that is a formal method of evaluating the program. Also, could be agent reflecting on changes they have made from year to year, indicating personal reflection/evaluation about their progress and experience (interpreting the outcomes) Do NOT include statements that indicate reflection as a result of a question being asked, for example, "would you do anything differently next year?" – Code as Individual Implementation Changes Inclusion Criteria: Include statements that refer to the **implementation team's (lack of) assessment of the progress toward and impact of implementation, as well as the interpretation of outcomes related to implementation**. Reflecting and Evaluating is part of the implementation process; it likely ends when implementation activities end. It does not require goals be explicitly articulated; it can focus on descriptions of the current state with real-time judgment, though there may be an implied goal (e.g.,

	we need to implement the intervention) when the implementation team discusses feedback in terms of adjustments needed to complete implementation. Exclusion Criteria: Exclude statements related to the (lack of) alignment of implementation and intervention goals with larger organizational goals, as well as feedback to staff regarding those goals, e.g., regular audit and feedback showing any gaps between the current organizational status and the goal, and code to Goals & Feedback. Goals and Feedback include organizational processes and supporting structures independent of the implementation process. Evidence of the integration of evaluation components used as part of "Reflecting and Evaluating" into on-going or sustained organizational structures and processes may be (double) coded to Goals and Feedback. **Exclude statements that capture reflecting and evaluating that participants may do during the interview, for example, related to the success of the implementation, and code to Knowledge & Beliefs about the Intervention.**
VI. Additional Extension–specific Codes	
A. Participant Receptivity	Definition: The participants' responses to the program (positive or negative) Inclusion Criteria: Statements about how the participants received the program, their reactions or perceived feelings towards it, how much they interacted during the program. Also include statements about participants' issues with technology used for virtual programming. *Do not code additional comments that participants made about handouts, time, etc. as Design Quality and Packaging, Time, etc. We are interested in agent's opinions regarding these constructs. Exclusion Criteria: Statements about participants being recruited (engaged) should be coded to Engaging: Intervention Participants.
B. Time	Definition: the time it takes to implement the program or the time to prepare for the program (organizing paperwork, gathering materials for activities, etc.) Inclusion Criteria: Statements that discuss the time needed on the day of each session to prepare, time in reference to the 1-hour time slot that is taught in training and whether that is adequate, accommodating any time constraints of the community partner, general comments about the time it takes to prepare for the school.

	Double code with Executing or Planning as appropriate. Exclusion Criteria: Talking about time in the context of the organization (Extension office or district) allotting additional time for planning (top-down) should be coded as Available Resources. Discussing not letting the agents know how much time it can take or to plan additional time should be coded as Access to Knowledge & Information.
C. Experience	Definition: Agent's prior experience with the DPP Inclusion Criteria: Statements about repeated implementation of the program and what they have learned because of that, improvements they have made in planning and implementation. Exclusion Criteria: Do not code statements related to an agent's overall experience if it is not specific to the DPP – Code as Other Personal Attributes
D. Agent Networks	Definition: communication between agents for questions about program, getting advice, observation Inclusion Criteria: Agents observing one another or having conversations about the DPP, utilization of GroupMe for inter-agent communication Exclusion Criteria: Any statements about agent communication that would not affect DPP outcomes (probably will not see this)
E. Individual Implementation Changes	Definition: participant's reflecting on what they would do differently next year with implementation of the program (method of recruitment, community partner, program time, program preparation, activities, etc.) Inclusion Criteria: Statements that answer the question if they would do anything differently or any general statements earlier in the interview about things that they would change for future programs. Exclusion Criteria: Providing more general suggestions or feedback to the program as a whole. Code this to Design Quality & Packaging, Available Resources, Time, etc. as appropriate as well as Suggestions
F. Suggestions	Definition: agent makes general suggestions about improving the materials, training or program in the future

	Inclusion Criteria: Any statements about things they think should be changed. Exclusion Criteria: Statements about poor quality of the handouts, etc. should be coded as Design Quality & Packaging. Statements about something missing from training should be coded as Access to Knowledge & Information.
G. COVID	Definition: any references to the COVID-19 pandemic
H. Facilitating	Definition: agent references to their role in the DPP as a facilitator, rather than a teacher and any challenges or benefits that come with that facilitator role
I. Implementation Strategy	Definition: agent references any of the implementation strategies implemented – Zoom calls, webinars, etc.

General Coding Rules:

When two codes are in question for a passage, consider the primary meaning of the passage to assign code; consider what the participant is truly saying. Analysts may wish to err on the side of inclusion or double coding.

General Rating Rules:

Ratings						
M	-2	-1	0	X	+1	+2

In general, ratings are determined based on two factors: 1) valence and 2) strength.

Valence: positive or negative influence on implementation

Rating component: X, 0, +, -
The valence component of a rating is determined by the influence the coded data has on the implementation process, i.e., contextual factors that facilitate or hinder implementation. Due to limited data, analysts may have to infer the influence on implementation based on simple presence or absence of a construct. For example, if a participant states that the intervention has advantages over existing programs, but does not state how this has influenced implementation, the analyst can infer that the presence of relative advantage facilitated implementation. However, whenever the data allows, the analysts should apply ratings based on the influence the construct has on implementation, not the presence or absence of a construct; presence or absence of a positive construct (e.g. relative advantage) does not always constitute a matching positive or negative influence on implementation.

In the event that comments are mixed, i.e., some comments are negative and some comments are positive, try to tip the rating to a weak positive or weak negative, based on the aggregate of the comments. However, if you feel the comments are equally positive and negative, apply a mixed (X) rating. Some users of the CFIR have denoted level of agreement among participants in their rating by adding a * to the rating if comments were mixed. For example, if the aggregate of mixed comments was positive, the rating was +1*. Some users feel it's important to record discord among participants because it indicates a negative influence on implementation.

In the event that the comments are neutral, i.e., comments are related to a construct but have no bearing on the implementation, apply the neutral (0) rating.

Strength: weak or strong influence on implementation

Rating component: 1, 2

The strength component of a rating is determined by a number of factors, including: level of agreement among participants, strength of language, and use of concrete examples. However,

sometimes analysts may choose to apply relative ratings, versus absolute ratings, in order to differentiate between organization in the study.

APPENDIX C

FIDELITY SURVEY

Q1 County:

- ○ Chattooga
- ○ Clarke
- ○ Cobb
- ○ Coweta
- ○ Crisp
- ○ Elbert
- ○ Forsyth
- ○ Fulton
- ○ Gilmer
- ○ Laurens
- ○ Madison
- ○ Oglethorpe
- ○ Spalding
- ○ Washington

Q2 Session number:

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10
- ○ 11
- ○ 12
- ○ 13
- ○ 14
- ○ 15
- ○ 16
- ○ 17
- ○ 18
- ○ 19
- ○ 20

- ○ 21
- ○ 22
- ○ 23
- ○ 24
- ○ 25
- ○ 26

Q3 Session topic:

- ○ Introduction to the Program
- ○ Track Your Food
- ○ Eat Well to Prevent T2
- ○ Get Active to Prevent T2
- ○ Track Your Activity
- ○ Get Support
- ○ Burn More Calories Than You Take In
- ○ Cope with Triggers
- ○ Find Time for Fitness
- ○ Take Charge of Your Thoughts
- ○ Shop and Cook to Prevent T2
- ○ Manage Stress
- ○ Eat Well Away from Home
- ○ Keep Your Heart Healthy

- ○ Get More Active
- ○ Stay Motivated
- ○ When Weight Loss Stalls
- ○ More about Carbs
- ○ Take a Fitness Break
- ○ Get Back on Track
- ○ Have Healthy Food You Enjoy
- ○ Get Enough Sleep
- ○ Stay Active Away from Home
- ○ Stay Active to Prevent T2
- ○ Prevent T2 - for Life!
- ○ More about T2

Q4 Approximately how long was the class?

- ○ 15 min
- ○ 30 min
- ○ 45 min
- ○ 1 hour
- ○ 1 hour 15 min
- ○ 1 hour 30 min
- ○ 1 hour 45 min
- ○ 2 hours

Q5 What topics in the curriculum were covered?

_____

_____

_____

_____

_____

Q6 What activities in the curriculum were completed (if applicable)?

_____

_____

_____

_____

_____

Q7 Was anything added to the curriculum (handouts, fact sheets, activities, recipes handouts, recipe tastings, etc.)?

_____

_____

_____

_____

_____

Q8 Was anything in the curriculum (topics, activities, etc.) left out of the class?

_____

_____

_____

_____

_____

APPENDIX D

PARTICIPANT ELIGIBILITY SCREENING FORM

Today's Date *(mm/dd/yyyy)*:

First Name:	**Last Name:**
E-mail Address:	**Phone Number:**
Insurance: ☐ Yes ☐ No	
Date of Birth *(mm/dd/yyyy)*:	**Sex *(check one)*:** ☐ Male ☐ Female ☐ Prefer not to answer
County of Residency:	**Ethnicity *(check one)*:** ☐ Hispanic or Latino ☐ Not Hispanic or Latino
Race *(check all that apply)*:	
☐ American Indian or Alaska Native	☐ Native Hawaiian or Other Pacific Islander
☐ Asian or Asian American	☐ White
☐ Black or African American	
Education: ☐ Some high school ☐ Graduated from high school or got a GED ☐ Some college or technical school ☐ College graduate	
Height: _____ feet _____ inches	**Starting Weight *(weight taken today)*:** _____ pounds

In the past year, have you been told by a doctor or health care provider that you have pre diabetes, elevated blood sugar,

or borderline diabetes? *(check one)*:

☐ Yes ☐ No

If yes, what type of blood test was performed? *(check all that apply)*

☐ Fasting glucose test (blood test where blood was drawn with needle)

☐ Hemoglobin A1c test

☐ Oral Glucose Tolerance Test

☐ There was a blood test, but I don't know / don't remember what kind

If you are a woman, have you ever been told by a health care provider that you had Gestational Diabetes Mellitus (GDM) during pregnancy? *(check one*): ☐ Yes ☐ No

Current Health Questionnaire

In the last year, have you tried to lose weight? ☐ Yes ☐ No If yes, how many times ☐☐

If you have tried to lose weight, what method(s) have you used to try to lose weight?

Would you say that in general your health is:

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

How often do you use nutrition labels to choose foods?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

Are you currently pregnant? ☐ Yes ☐ No
Do you have any of the following health issues now *(check all that apply):* ☐ Kidney Disease ☐ Liver Disease ☐ Cancer ☐ Alzheimer's or other dementia ☐ Congestive Heart Failure ☐ Atrial Fibrillation (A-fib) ☐ Any problems with your body that would keep you from being able to walk
Has your doctor ever told you that you have *(check all that apply):* ☐ High blood pressure ☐ High cholesterol ☐ Heart Disease ☐ Arthritis ☐ Major Depression ☐ Moderate Depression

Physical Activity Readiness Questionnaire

Has your doctor ever said that you have a heart condition and that you should only perform physical activity recommended by a doctor? ☐ Yes ☐ No
Do you feel pain in your chest when you perform physical activity? ☐ Yes ☐ No
In the past month, have you had chest pain when you were not performing any physical activity? ☐ Yes ☐ No
Do you lose your balance because of dizziness or do you ever lose consciousness? ☐Yes ☐ No
Do you have a bone or joint problem that could be made worse by a change in your physical activity? ☐ Yes ☐ No
Is your doctor currently prescribing any medication for your blood pressure or for a heart condition? ☐ Yes ☐ No
Do you know of <u>any</u> other reason why you should not engage in physical activity? ☐ Yes ☐ No

For Lifestyle Coach Use Only

Prediabetes determined by: ☐ Blood test ☐ GDM ☐ Risk Screening Test

BMI (lbs/inches^2) x 703: _____

Assigned Participant ID # _____ Form revised: 10-07-2019

Do you currently have health insurance? ☐ Yes ☐ No

Where do you get your health insurance? If you get health insurance from more than one place, please check all that apply.
☐ No health insurance ☐ My employer/work ☐ My spouse's employer/work
☐ Directly from an insurance company ☐ Health Insurance Marketplace (i.e., Insurance through Affordable Care Act/Obamacare) ☐ Medicare
☐ Medicaid
☐ Other, please explain:
_____

If you get your health insurance through your or your spouse's employer/work, from an insurance company, and/or the Health Insurance Marketplace, what type of plan(s) do you have? This information can usually be found on your health insurance card. If you have more than one type of plan, please check all that apply.
☐ Preferred Provider Organization (PPO) ☐ Point of Service (POS)
☐ Exclusive Provider Organization (EPO) ☐ Health Maintenance Organization (HMO)
☐ High Deductible Health Insurance Plan (HDHP) ☐ Fee-for-service or Indemnity
☐ Other, please explain:
_____
☐ Don't Know

Have you seen your primary care doctor for an annual physical exam (i.e., physical or check-up for preventive care, not for an illness or injury)? ☐ Yes ☐ No

If or when you see your primary care doctor for an annual physical exam (i.e., physical or check-up for preventive care, not for an illness or injury), do you have to pay any money out of pocket for the service (i.e., deductible, coinsurance, and/or copayment)? ☐ Yes ☐ No

Do you have any wellness activities or services offered through your employer/work and/or health insurance plan? These may include things like financial incentives for participating in services or activities to assist you with stopping smoking, losing weight, reducing stress, and exercising, and access to nurses, dietitians, and other counselors or coaches online or over the phone?
☐ No ☐ Yes, and I use these services. ☐ Yes, but I don't use these services.

APPENDIX E

PARTICIPANT SURVEYS

Start of Block: IPAQ Short

The following questionnaires are related to physical activity. Specifically, the questions will ask you about the different types of physical activity you have done recently and your thoughts and feelings related to physical activity. Having a better understanding of UGA students' physical activity levels and how they feel about physical activity will help inform future initiatives that may make it easier for you to be more active if you want to.

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the vigorous activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

During the **last 7 days**, on how many days did you do **vigorous**
physical activities like heavy lifting, digging, aerobics, or fast bicycling?

○ Days per week _____

How much time did you usually spend doing **vigorous** physical activities on one of those days? (Example: 1 hour per day, 30 minutes per day OR 90 minutes per day)

○ Hours per day _____

○ Minutes per day _____

Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

- ○ Days per week _____

How much time did you usually spend doing **moderate** physical activities on one of those days? (Example: 1 hour per day, 30 minutes per day OR 90 minutes per day)

- ○ Hours per day _____
- ○ Minutes per day _____

Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

- ○ Days per week _____

How much time did you usually spend **walking** on one of those days? (Example: 1 hour per day, 30 minutes per day OR 90 minutes per day)

- ○ Hours per day _____
- ○ Minutes per day _____

Think about all the resistance or strength training activities that you did in the last 7 days. Resistance or strength training activities refer to activities that are intended to increase muscular strength or endurance. They can, but do not have to include the use of free weights, machines, or resistance bands.

During the **last 7 days**, on how many days did you perform **resistance or strength training** activities?

- ○ Days per week _____

How much time did you usually spend performing **resistance or strength training** activities on one of those days? (Example: 1 hour per day, 30 minutes per day OR 90 minutes per day)

- ○ Hours per day _____
- ○ Minutes per day _____

The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

During the **last 7 days**, how much time did you spend **sitting** on a week day? (Example: 1 hour per day, 30 minutes per day OR 90 minutes per day)

- ○ Hours per day _____
- ○ Minutes per day _____

End of Block: IPAQ Short

Start of Block: DSQ

Instructions: This first set of questions is about foods you ate or drank during the past month, that is, the past 30 days. When answering, please include meals and snacks at home, at work or school, in restaurants, and anyplace else.

Click on your answer. To change your answer, simply click on your new answer.

During the past month, how often did you eat **hot or cold cereals**? *Select one.*

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, what kind of cereal did you usually eat? *Type cereal below.*

_____

_____

_____

_____

_____

If there was another kind of cereal that you usually ate during the past month, what kind was it? *Type cereal below. If none, leave blank.*

_____

_____

_____

_____

_____

During the past month, how often did you have any **milk** (either to drink or on cereal)? Include regular milks, chocolate or other flavored milks, lactose-free milk, buttermilk. Please do **not** include soy milk, almond milk, or small amounts of milk in coffee or tea. *Select one.*

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2-3 times per day
- ○ 4-5 times per day
- ○ 6 or more times per day

During the past month, what kind of milk did you usually drink. *Select one.*

- ○ Whole or regular milk
- ○ 2% fat or reduced-fat milk
- ○ 1%, 1/2%, or low-fat milk
- ○ Fat-free, skim or nonfat milk
- ○ Soy milk
- ○ Other kind of milk. *Type below.*

_____

During the past month, how often did you drink **regular soda or pop** that contains sugar? Do **not** include diet soda. *Select one.*

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2-3 times per day
- ○ 4-5 times per day
- ○ 6 or more times per day

During the past month, how often did you drink **100% pure fruit juices** such as orange, mango, apple, grape and pineapple juices? Do **not** include fruit-flavored drinks with added sugar or fruit juice you made at home and added sugar to. *Select one.*

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2-3 times per day
- ○ 4-5 times per day
- ○ 6 or more times per day

During the past month, how often did you drink coffee or tea that had **sugar** or **honey** added to it? Include coffee and tea you sweetened yourself and presweetened tea and coffee drinks such as Arizona Iced Tea and Frappuccino. Do **not** include artificially sweetened coffee or diet tea.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2-3 times per day
- ○ 4-5 times per day
- ○ 6 or more times per day

During the past month, how often did you drink **sweetened** fruit drinks, sports or energy drinks, such as Kool-Aid, lemonade, Hi-C, cranberry drink, Gatorade, Red Bull or Vitamin Water?

Include fruit juices you made at home and added sugar to. Do **not** include diet drinks or artificially sweetened drinks.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2-3 times per day
- ○ 4-5 times per day
- ○ 6 or more times per day

During the past month, how often did you eat **fruit**? Include fresh, frozen or canned fruit. Do **not** include juices.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat a green leafy or lettuce **salad**, with or without other vegetables?

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat any kind of **fried potatoes**, including French fries, home fries, or hash brown potatoes?

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat any **other kind of potatoes**, such as baked, boiled, mashed potatoes, sweet potatoes, or potato salad?

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat refried beans, baked beans, beans in soup, pork and beans or any other type of cooked dried beans? Do **not** include green beans.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat **brown rice** or other cooked whole grains, such as bulgur, cracked wheat, or millet? Do **not** include white rice.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, not including what you just told me about (green salads, potatoes, cooked dried beans), how often did you eat **other vegetables**?

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you have Mexican-type **salsa** made with tomato?

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat pizza? Include frozen **pizza**, fast food pizza, and homemade pizza.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you have **tomato sauces** such as with spaghetti or noodles or mixed into foods such as lasagna? Do not include tomato sauce on pizza.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat any kind of **cheese**? Include cheese as a snack, cheese on burgers, sandwiches, and cheese in foods such as lasagna, quesadillas, or casseroles. Do **not** include cheese on pizza.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat **red meat**, such as beef, pork, ham, or sausage? Do **not** include chicken, turkey or seafood. Include red meat you had in sandwiches, lasagna, stew,

and other mixtures. Red meats may also include veal, lamb, and any lunch meats made with these meats.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat any **processed meat**, such as bacon, lunch meats, or hot dogs? Include processed meats you had in sandwiches, soups, pizza, casseroles, and other mixtures.
Processed meats are those preserved by smoking, curing, salting, or by the addition of

preservatives. Examples are: ham, bacon, pastrami, salami, sausages, bratwursts, frankfurters, hot dogs, and spam.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat **whole grain bread** including toast, rolls and in sandwiches? Whole grain breads include whole wheat, rye, oatmeal and pumpernickel. Do **not** include white bread.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat **chocolate** or any other types of candy? Do **not** include sugar-free candy.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat **doughnuts**, sweet rolls, Danish, muffins, pan dulce, or pop-tarts? Do **not** include sugar-free items.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat **cookies, cake, pie or brownies**? Do **not** include sugar-free kinds.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat **ice cream or other frozen desserts**? Do **not** include sugar-free kinds.

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

During the past month, how often did you eat **popcorn**?

- ○ Never
- ○ 1 time last month
- ○ 2-3 times last month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3-4 times per week
- ○ 5-6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

End of Block: DSQ

Start of Block: HRQoL-14

Instructions: This next set of questions is about how you perceive your health to be. Please select and type your answer, when appropriate.

Would you say that in general your health is

- ○ Excellent
- ○ Very good
- ○ Good
- ○ Fair
- ○ Poor
- ○ Don't know/Not sure

Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?

- ○ Number of days: _____
- ○ None
- ○ Don't know/Not sure

Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?

- ○ Number of days: _____
- ○ None
- ○ Don't know/Not sure

During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?

- ○ Number of days: _____
- ○ None
- ○ Don't know/Not sure

Are you LIMITED in any way in any activities because of any impairment or health problem?

- ○ Yes
- ○ No
- ○ Don't know/Not sure

What is the MAJOR impairment or health problem that limits your activities?

- ○ Arthritis/rheumatism
- ○ Back or neck problem
- ○ Fractures, bone/joint injury
- ○ Walking problem
- ○ Lung/breathing problem
- ○ Hearing problem
- ○ Eye/vision problem
- ○ Heart problem
- ○ Stroke problem
- ○ Hypertension/high blood pressure
- ○ Diabetes
- ○ Cancer
- ○ Depression/anxiety/emotional problem
- ○ Other impairment/problem
- ○ Don't know/Not sure

For HOW LONG have your activities been limited because of your major impairment or health problem?

- [ ] Days: _____
- [ ] Weeks: _____
- [ ] Months: _____
- [ ] Years: _____
- [ ] Don't know/Not sure

Because of any impairment or health problem, do you need the help of other persons with your PERSONAL CARE needs, such as eating, bathing, dressing, or getting around the house?

- ○ Yes
- ○ No
- ○ Don't know/Not sure

Because of any impairment or health problem, do you need the help of other persons in handling your ROUTINE needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes?

- ○ Yes
- ○ No
- ○ Don't know/Not sure

During the past 30 days, for about how many days did PAIN make it hard for you to do your usual activities, such as self-care, work, or recreation?

- ○ Number of days: _____
- ○ None
- ○ Don't know/Not sure

During the past 30 days, for about how many days have you felt SAD, BLUE, or DEPRESSED?

- ○ Number of days: _____
- ○ None
- ○ Don't know/Not sure

During the past 30 days, for about how many days have you felt WORRIED, TENSE, or ANXIOUS?

- ○ Number of days: _____
- ○ None
- ○ Don't know/Not sure

During the past 30 days, for about how many days have you felt you did NOT get ENOUGH REST or SLEEP?

- ○ Number of days: _____
- ○ None
- ○ Don't know/Not sure

During the past 30 days, for about how many days have you felt VERY HEALTHY AND FULL OF ENERGY?

- ○ Number of days: _____
- ○ None
- ○ Don't know/Not sure

End of Block: HRQoL-14

Start of Block: Food Security

Instructions: These questions are about the food eaten in your household in the last 12 months, since January of last year, and whether you were able to afford the food you need.

For each statement, please select whether the statement was <u>often</u> true, <u>sometimes</u> true, or <u>never</u> true for you/your household in the last 12 months - that is, since last January.

The food that I/we bought just didn't last, and I/we didn't have money to get more.

- ○ Often true
- ○ Sometimes true
- ○ Never true
- ○ Don't know

I/we couldn't afford to eat balanced meals.

- ○ Often true
- ○ Sometimes true
- ○ Never true
- ○ Don't know

In the last 12 months, since last January, did you/you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?

- ○ Yes
- ○ No
- ○ Don't know

If you answered "Yes" to the last question - How often did this happen - almost every month, some months but not every month, or in only 1 or 2 months?

- ○ Almost every month
- ○ Some months but not every month
- ○ Only 1 or 2 months
- ○ Don't know

In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?

- ○ Yes
- ○ No
- ○ Don't know

In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?

- ○ Yes
- ○ No
- ○ Don't know

End of Block: Food Security

Start of Block: Social Support

Instructions: In this next set of questions, we are interested in how you feel about the following statements. **Reach each statement carefully. Indicate how you feel about each statement.**

	Very Strongly Disagree	Strongly Disagree	Mildly Disagree	Neutral	Mildly Agree	Strongly Agree	Very Strongly Agree
There is a special person who is around when I am in need.	○	○	○	○	○	○	○
There is a special person with whom I can share my joys and sorrows.	○	○	○	○	○	○	○
My family really tries to help me.	○	○	○	○	○	○	○
I get the emotional help and support I need from my family.	○	○	○	○	○	○	○
I have a special person who is a real source of comfort to me.	○	○	○	○	○	○	○

My friends really try to help me.	○	○	○	○	○	○	○
I can count on my friends when things go wrong.	○	○	○	○	○	○	○
I can talk about my problems with my family.	○	○	○	○	○	○	○
I have friends with whom I can share my joys and sorrows.	○	○	○	○	○	○	○
There is a special person in my life who cares about my feelings.	○	○	○	○	○	○	○
My family is willing to help me make decisions.	○	○	○	○	○	○	○

I can talk about my problems with my friends.	○	○	○	○	○	○	○

End of Block: Social Support

Start of Block: Social Support and Eating

Below is a list of things people might do or say to someone who is trying to improve their eating habits. We are interested in high fat and high salt (or high sodium) foods. If you are not trying to make any of these dietary changes, then some of the questions may not apply to you; but please read them and give an answer to every question.

Please notice that the questions repeat themselves. Please consider your family for the first question, and friends for the second. Under family, rate how often anyone living in your household has said or done what is described during the last 3 months. Under friends, rate how often your friends, acquaintances, or coworkers have said or done what is described during the last 3 months.

Read each statement carefully and indicate how you feel about each statement with regards to your FAMILY

	None	Rarely	A Few Times	Often	Very Often	Does Not Apply
Encouraged me not to eat "unhealthy foods" (cake, salted chips) when I'm tempted to do so	○	○	○	○	○	○
Discussed my eating habit. changes with me (asked me how I'm doing with my eating changes)	○	○	○	○	○	○
Reminded me not to eat high fat, high salt foods	○	○	○	○	○	○
Complimented me on changing my eating habits ("Keep it up", "We are proud of you ")	○	○	○	○	○	○
Commented if I went back to my oId eating habits.	○	○	○	○	○	○
Ate high fat or high salt foods in front of me	○	○	○	○	○	○
Refused to eat the same foods I eat	○	○	○	○	○	○

Brought home foods I'm trying not to eat	○	○	○	○	○	○
Got angry when I encouraged them to eat low salt, low fat foods	○	○	○	○	○	○
Offered me food I'm trying not to eat.	○	○	○	○	○	○

Read each statement carefully and indicate how you feel about each statement with regards to your FRIENDS

	None	Rarely	A Few Times	Often	Very Often	Does Not Apply
Encouraged me not to eat "unhealthy foods" (cake, salted chips) when I'm tempted to do so	○	○	○	○	○	○
Discussed my eating habit. changes with me (asked me how I'm doing with my eating changes)	○	○	○	○	○	○
Reminded me not to eat high fat, high salt foods	○	○	○	○	○	○
Complimented me on changing my eating habits ("Keep it up", "We are proud of you ")	○	○	○	○	○	○
Commented if I went back to my oId eating habits.	○	○	○	○	○	○
Ate high fat or high salt foods in front of me	○	○	○	○	○	○
Refused to eat the same foods I eat	○	○	○	○	○	○

Brought home foods I'm trying not to eat	○	○	○	○	○	○
Got angry when I encouraged them to eat low salt, low fat foods	○	○	○	○	○	○
Offered me food I'm trying not to eat.	○	○	○	○	○	○

End of Block: Social Support and Eating

APPENDIX F

PARTICIPANT CONSENT FORM

UNIVERSITY OF GEORGIA
CONSENT FORM
IMPLEMENTATION, HEALTH, AND PHYSICAL FUNCTION OUTCOMES OF A SOCIAL SUPPORT-ENHANCED COOPERATIVE EXTENSION DIABETES PREVENTION PROGRAM

Dear Community Member,

We are asking you to take part in a research study about the UGA Extension delivered Diabetes Prevention Program. The information in this form will help you decide if you want to be in the study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. This form is designed to give you the information about the study so you can decide whether to be in the study or not. Please take the time to read the following information carefully. Please ask the Cooperative Extension Agent or contact the principal investigator using the email or phone number below if there is anything that is not clear or if you need more information. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called "informed consent." A copy of this form will be given to you.

Principal Investigator: *Alison C. Berg, PhD, RDN, LD*
Department of Foods and Nutrition, UGA Cooperative Extension
202 Hoke Smith Annex, 300 Carlton St., Athens, GA 30602
(706) 542-3773, alisoncberg@uga.edu

Purpose of the study
The purpose of this study is to find out:

1) how participation in the Centers for Disease Control and Prevention's (CDC's) Prevent T2 National Diabetes Prevention Program affects weight, eating habits, physical activity, and other health factors, like your ability to move around and participate in normal daily tasks like walking across a room and picking up an object
2) whether individuals who participate in a closed Facebook group as part of the Diabetes Prevention Program make more improvements than those who do not
3) how personal factors like race, education, health insurance status, and support from others may be related to success in the program
4) about your experiences as a participant in the program.

Anyone who is 18 to 70 years of age, has a clinical diagnosis of prediabetes or scores "high risk" on the CDC's Prediabetes Risk Test, and who are not pregnant or have a current diagnosis of

diabetes, chronic kidney disease, liver disease, cancer, Alzheimer's or other dementias, congestive heart failure, or severe physical or cognitive limitations, and agree to participate in the full Prevent T2 Program are eligible to be in this study.

If you are interested in participating in the study, please read the additional information on the following pages, and feel free to ask questions at any point.

Study procedures and time commitment
If you agree to participate in the research, you will be asked to complete several online surveys and participate in some physical tasks. At the beginning of the program, you will be asked basic information about your sex, race, ethnicity, education, and health insurance status.
At the beginning, middle (6 months), and end of the program (12 months), you will be asked to complete online surveys about your eating habits, your health, your financial ability to purchase food, and the social support you receive from people around you. You will also be asked to complete an online interactive questionnaire about the foods you eat and drink for two days at the beginning, middle, and end of the program. You will also be asked to participate in a series of physical tasks to understand how well you can move around, like walking across a room and picking up an object, sitting down on the floor and getting back up, and walking and counting at the same time.

Half way through (6 months) and at end of the program (12 months), you will be invited to participate in a group discussion (focus group) with your fellow program participants to share your experiences about participating in the Diabetes Prevention Program.

These research measures will take place in addition to the group sessions and activities that you will be doing as part of the Diabetes Prevention Program. The online surveys and interactive questionnaire about the foods you eat can be done in between sessions on your own time from your phone or computer or the Extension agent can provide you a computer and space at the Extension office to complete these in between program sessions. The physical tasks will be done during the program sessions. We expect that it will take about 1.5 hours outside of your normal Diabetes Prevention Program time to complete all the surveys at the beginning of the program. However, these surveys do not have to be completed all at one time and can be spread across the first two weeks of the program. You will complete the physical tasks as part of the first few sessions of the program. We expect the same time commitment for these surveys, questionnaires, and physical tasks at the midpoint of the program (6 months) and at the end of the program (12 months). Each focus group (one at 6 months and one at 12 months) will last about one hour and you and your fellow participants will work with the Extension agent to schedule this at a time that is convenient for the group.

The closed Facebook group will be optional and a part of your participation in the Diabetes Prevention Program. The research on the Facebook group will only require you to allow us to use your information (i.e. how often you log in or post) for research purposes and will require no additional time from you. IF you decide to participate in the closed Facebook group, we will ask that you provide the name you use on Facebook so that we may invite you to the group.

Lastly, your participation in the research will also involve sharing information collected as part of the program, like your age, sex, physical activity, and attendance, with the researchers with no additional time on your part.

Risks and discomforts
The risks involved in this research are minimal, and may include feelings of stress, discomfort, guilt, or loss of self-esteem in answering some questions. Risks of participation in some physical activity tasks may include temporary dizziness or mild physical discomfort. These risks may be minimized by skipping any questions you do not feel comfortable answering or physical tasks you do not feel comfortable participating in. All responses and test results will be kept confidential. See section "Privacy/Confidentiality" below.

Benefits
Benefits of participating in this study include a better understanding of your eating habits and any improvements you make in these over the course of the program. You may also learn about how your ability to move or perform the physical tasks improves throughout the time in the program. In addition, participating in this research could improve UGA Extension programs on diabetes prevention, weight loss, and other health-related topics in your community. Better diabetes prevention programs can help lower disease risk and improve the health and well-being of society as a whole.

Incentives for participation
As an incentive for participating in the research study, you will be provided a $15 Walmart gift card after you complete the questionnaires and physical tasks at each time point. You will receive a $15 Walmart gift card after completing the initial research questionnaires and tests at the beginning of the study, a $15 Walmart gift card when you complete them at 6 months, and a $15 Walmart gift card when you complete them at 12 months. Small incentives in the form of items that would help you eat healthy and be physically active (for example, measuring cups and spoons, exercise resistance bands) will also be provided throughout the program. Additional incentives such as parking or bus passes may be provided as needed as well. The value of all incentives available throughout the program is approximately $125.

Confidentiality of records
The information collected from you in the surveys and physical activity task will be kept confidential, and only your FACS Extension Agent lifestyle coach and the researchers in the state Extension office will have access to it. Your name will only be used to identify that you have provided informed consent to participate in this research and if you attend the weekly and monthly group sessions that are part of this study. Once we have documented that you have signed this form and if you participated in more than one session, your name will be removed from your data and replaced with an anonymous code. A master key linking your name, email, and phone number with your anonymous code will be kept in a password-protected computer folder and only be accessible by one of the researchers. All consent forms and data will be kept in a locked cabinet and/or password-protected computer folder in a locked office.

Some data will be collected using the internet. All data from all study participants will be encrypted prior to transmission. Your confidentiality will be maintained to the degree permitted

by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties. However, once the completed survey is received by the researcher, standard confidentiality procedures will be followed.

Physical activity tasks will be conducted during a regular program session and completed in groups with other Diabetes Prevention Program participants. Your results will determined by the researcher at another time and kept confidential. Again, you may choose to skip any tasks that you are uncomfortable performing and/or you may request a separate time to complete these tasks with the Extension agent in private.

If you choose to participate in the closed Facebook group, your name will be visible by Extension agents, the researchers, and your fellow UGA Extension Prevent T2 members throughout the state who are also participating in the closed Facebook group.

The results of the research study may be published, but your name or any identifying information will not be used. In fact, the published results will be presented in summary form only. De-identified data (data from which your name or any personally identifying information has been removed) may be used for future studies. A summary report of results may be shared with Cooperative Extension administrators and agents to help improve the quality of the program. Researchers will not release identifiable results of the study to anyone without your written consent unless required by law.

Research injuries or illnesses
In the event that any research-related activities result in an injury or illness, the sole responsibility of the researchers will be to arrange for your transportation to an appropriate health care facility. If you think that you have suffered a research-related injury, you should seek immediate medical attention and then contact Alison Berg right away at (706) 542-3773. Medical expenses will be your responsibility or that of your third-party payer (insurance). However, you cannot be prevented from seeking to collect compensation for injury related to malpractice, fault, or blame on the part of those involved in the research.

Taking part is voluntary
Your involvement in the study is voluntary, and you may choose to not participate, to skip survey questions or physical tasks, or stop your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision to participate in the research study will not affect your ability to participate in the Diabetes Prevention Program or be offered other services through Cooperative Extension.

Participant rights
The main researcher conducting this study is Alison Berg, an assistant professor and Extension Nutrition and Health Specialist at the University of Georgia. Please ask any questions you have now. If you have questions later, you may contact Alison Berg at alisoncberg@uga.edu or at (706) 542-3773. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at (706) 542-3199 or irb@uga.edu.

Research subject's consent to participate in research
To voluntarily agree to take part in this study, you must sign on the line below. Your signature below indicates that you have read or had read to you this entire consent form, and have had all of your questions answered.

Alison C. Berg	Alison C Berg PHD, RD, LD	**10/14/19**
Name of Researcher	Signature	Date
Name of Participant	Signature	Date

Please keep one copy and return the signed copy to the researcher.

APPENDIX G

CES PROFESSIONAL CONSENT FORM

UNIVERSITY OF GEORGIA
CONSENT FORM: No Signature

Implementation and health outcomes of a social support-enhanced Cooperative Extension Diabetes Prevention Program

Dear Agent:

My name is Hannah Wilson, and I am a graduate student under the supervision of Dr. Alison Berg in the Department of Foods and Nutrition at the University of Georgia. I am inviting you to participate in a research study entitled Implementation and health outcomes of a social support-enhanced Cooperative Extension Diabetes Prevention Program.

The **purpose of this study** is to explore implementation barriers, facilitators, and outcomes of the CDC's Prevent T2 Diabetes Prevention Program (or DPP) within UGA Cooperative Extension, as well as evaluate the effect of a social media enhancement of the DPP on participant health outcomes. To do this, we will be looking at data collected from the DPP, and we would also like to interview you as a UGA FACS Extension faculty member who is implementing the DPP.

Your participation will involve an interview about implementation of the program and your perceptions of and experience with the program so far, and it should take 1.5 - 2 hours. This will be the first of three interviews conducted throughout the study. If you would like to participate in this study, I will contact you again in 6 and 12 months about scheduling the other two interviews. Your **involvement in the study is voluntary**, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. You may also refuse to answer certain questions if desired.

Your responses will be kept confidential. After the interviews are completed and transcripts are made, your name will be removed from the transcripts and replaced with a numeric code. The results of the research study may be published or shared with Extension administration, but your name or any identifying information will not be used. In fact, the published results and any presented to Extension administration will be presented in summary form only.

There are minimal risks associated with this research. They include feelings of stress or discomfort in answering some questions. This risk may be minimized by completing the interviews in the privacy of your office or home. We hope that the study will help advance our knowledge of how to more effectively implement the DPP within Cooperative Extension in the

future. It also may show how the state Extension office can better support you in your implementation of the program in your county in the future.

If you have any questions about this research project, please feel free to call me, Hannah Wilson, at (706) 542-3773 or send an email to hannah.wilson@uga.edu. You may also contact the PI, Alison Berg, also at (706) 542-3773 or send an email to alisoncberg@uga.edu. Questions or concerns about your rights as a research participant should be directed to Institutional Review Board Chairperson at (706) 542-3199 or irb@uga.edu.

By saying "yes," you are agreeing to participate in the above described interviews. Would you like to participate in the research?

[If individual says "yes"] Thank you, we will now proceed with the first interview.

[If individual says "no"] Thank you for your time.

APPENDIX H

SOCIAL MEDIA POST SCHEDULE

Dates	Wk	Session Topic	Post	Content	Post Details
1/27-1/31	1	Introduction to the Program	1	Intro	Intro to the program
			2	Intro	Intro to the researchers
			3	Intro	Goal setting
2/3-2/7	2	Track Your Food	1	Nutrition	Benefits of tracking your food - interesting news/article
			2	Nutrition	Free food tracking apps
			3	Nutrition	How to use MFP (general, printing, inputting exercise)
2/10-2/14	3	Eat Well to Prevent T2	1	Nutrition	Recipe
			2	Nutrition	Nutrition meme
			3	Nutrition	General kcal recommendations
2/17-2/21	4	Get Active to Prevent T2	1	Activity	Benefits of activity for diabetes prevention - interesting news/article
			2	Activity	Importance of *moderate* activity
			3	Activity	I've never been very active - where do I start? (resources for people who are getting active for the first time)
2/24-2/28	5	Track Your Activity	1	Activity	How to make sure you're getting moderate activity
			2	Activity	Free fitness tracking apps
			3	Activity	Should I try to track the kcal I'm burning from exercise?
3/2-3/6	6	Get Support	1	General health	General support
			2	Activity	Walk GA info
			3	Nutrition/ Activity	More about nutrition and exercise experts
3/9-3/13	7	Burn More Calories Than You Take In	1	Nutrition	Easy Ways to Cut 50-100 Calories
			2	Activity	Resources on kcal burned through different exercises by sex/weight (if this exists)?

3/16-3/20	8	Cope with Triggers	3	Nutrition	Food ideas
			1	Nutrition	Recipe
			2	General health	COVID-19 vulnerable populations
			3	Nutrition	Food safety of leftovers
3/23-3/27	9	Find Time for Fitness	1	Activity	Ideas for exercises you can do at home
			2	Activity	Ideas to avoid being sedentary while at home
			3	Activity	Schedule it! (Ideas on ways to schedule activity)
3/30-4/3	10	Take Charge of Your Thoughts	1	Nutrition	List of example at-home exercises
			2	Activity	Grocery shopping during quarantine
			3	Nutrition	Food safety of take-out foods during COVID-19
4/6-4/10	11	Shop and Cook to Prevent T2	1	Activity	Info on example stretching exercises
			2	Nutrition	Healthy Easter ideas
			3	Nutrition	Meme
4/13-4/17	12	Manage Stress	1	Nutrition	Recipe
			2	Nutrition	Avoiding overeating while working from home
			3	Activity	Sitting less
4/20-4/24	13	Eat Well Away from Home	1	Nutrition	Meme
			2	Nutrition	Avoiding cross-contamination
			3	Nutrition	Be careful of "immune-boosting" foods and supplements
4/27-5/1	14	Keep Your Heart Healthy	1	Nutrition	Food safety - cooking temperatures
			2	Discussion	Encouraging post
			3	Nutrition	Coconut oil
5/4-5/8	15	Get More Active	1	Discussion	Poll
			2	Nutrition	Recipe
			3	Nutrition	Shopping and Food Safety
5/11-5/15	16	Stay Motivated	1	Activity	More PA resources
			2	Nutrition	Meme
			3	Nutrition	Recipe
5/18-5/22	17		1	Nutrition	COVID-19 DLL
			2	Nutrition	Tips for a healthy cookout

			3	Nutrition	GIF
5/25-5/29	18	When Weight Loss Stalls	1	Discussion	Meme
			2	Nutrition	Recipe
			3	Nutrition	Meal planning
6/1-6/5	19		1	Nutrition	Sandwich makeover
			2	Nutrition	Meme
			3	Nutrition	Stress eating
6/8-6/12	20	More about Carbs	1	Nutrition	Beware of fad diets
			2	Nutrition	Diabetes plate method
			3	Discussion	Something interactive - poll?
6/15-6/19	21		1	Nutrition	Healthy eating while on vacation
			2	Activity	Move Your Way activity planner
			3	Discussion	GIF
6/22-6/26	22	Take a Fitness Break	1	Nutrition	Recipe
			2	Activity	Move Your Way campaign video
			3	Nutrition	Recipe
6/29-7/3	23		1	Nutrition	Recipe
			2	Nutrition	Nutrition meme
			3	Nutrition	Outdoor food safety
7/6-7/10	24	Get Back on Track	1	Activity	PA on busy days
			2	Nutrition	Body positivity talk around kids
			3	Nutrition	Recipe
7/13-7/17	25		1	Activity	Ideas for physical activity in the summer
			2	Nutrition	Hydration during the summer
			3	Discussion	Meme
7/20-7/24	26		1	Activity	Move Your Way campaign video
			2	Nutrition	Recipe
			3	Nutrition	Tips on seafood intake
7/27-7/31	27		1	Nutrition	Recipe
			2	Activity	GIF
			3	Nutrition	Healthy fats article

8/3-8/7	28	Have Healthy Food You Enjoy	1	Nutrition	Recipe
			2	Activity	Interactive tool to schedule kids' PA
			3	Nutrition	Farmers' market shopping tips
8/10-8/14	29		1	Discussions	GIF
			2	Nutrition	Recipe
			3	Nutrition	Packing lunches
8/17-8/21	30		1	Nutrition	Recipe
			2	Activity	Run GA calendar
			3	Nutrition	Recipe
8/24-8/28	31		1	Discussion	Meme
			2	Nutrition	Eating Well website
			3	General	NIH Body Weight Planner
8/31-9/4	32		1	Nutrition	Poll
			2	Nutrition	Whole Grains Council
			3	Nutrition	Recipe
9/7-9/11	33	Get Enough Sleep	1	Activity/ General	Fall activities in GA
			2	Activity/ General	Traveling in GA during COVID
			3	General	GIF
9/14-9/18	34		1	Nutrition	Recipe
			2	Nutrition	Artificial sweeteners
			3	Activity	Alternative PA log
9/21-9/25	35		1	General	Cholesterol
			2	Activity	Poll
			3	Nutrition	Food talk recipes
9/28-10/2	36		1	Nutrition	Coffee info
			2	General	National Women's Health and Fitness Day
			3	General	GIF
10/5-10/9	37	Stay Active Away from Home	1	Nutrition	Recipe
			2	Nutrition	Discussion
			3	General	Fall activity ideas in GA - continued

10/12 - 10/16	38		1	Nutrition	Recipe
			2	Nutrition	Recipe
			3	General	Fun video
10/19 - 10/23	39		1	General	American Cancer Society breast cancer info
			2	Nutrition	Recipe
			3	General	Halloween tips
10/26 - 10/30	40		1	Nutrition	Recipe
			2	General	Cancer screenings during COVID
			3	General	Coping with stress during COVID
11/2-11/6	41	Stay Active to Prevent T2	1	General	National Diabetes Month announcement
			2	Nutrition	Managing stress eating
			3	General	GIF
11/9-11/13	42		1	Activity	Silver Sneakers
			2	Nutrition	Reinventing Thanksgiving leftovers
			3	Nutrition	Poll
11/16 - 11/20	43		1	Nutrition	Recipe
			2	Nutrition	Thanksgiving food safety
			3	General	GIF
11/23 - 11/27	44		1	Activity	Family exercise ideas
			2	General	GIF
			3	General	Discussion
11/30 -12/4	45		1	Nutrition	Recipe
			2	General	Handwashing
			3	Nutrition	Cookie dough food safety
12/7-12-11	46	Prevent T2 - for Life!	1	General	Daily Wellness podcast link
			2	Activity	How to stay active in cold weather
			3	Nutrition	Recipe
12/14 - 12/18	47		1	Nutrition	Recipe - National Cocoa Day
			2	Nutrition	Recipe - Hanukkah
			3	General	Holiday events in Georgia
	48		1	General	GIF

12/21 - 12/25		2	General	GIF - Merry Christmas
		3	Nutrition	Recipe
12/28 -1/1	49	1	Nutrition	Staying away from fad diets
		2	Nutrition	Recipe - New Years
		3	General	Happy New Year
1/4- 1/8	50	1	Nutrition	Recipe - National Soup Month
		2	Nutrition	Recipe - National Soup Month
		3	Nutrition	2020 DGA video link
1/11- 1/15	51	1	Nutrition	Recipe
		2	Activity	Staying active in cold weather
		3	Nutrition	Recipe
1/18- 1/22	52	1	Activity	Difference between aerobic and anaerobic exercise
		2	Nutrition	Recipe
		3	Nutrition	Recipe
1/25- 1/29	53	1	Activity	Safety tips for exercising outdoors for older adults
		2	General	GIF
		3	Nutrition	Whole grains - National Oatmeal Month
2/1- 2/5	54	1	Nutrition	Recipe
		2	General	GIF
		3	Nutrition	Put a healthy spin on game day article
2/8- 2/12	55	1	Nutrition	Recipe - National Pizza Day
		2	General	Prompt for participants to share recipes
		3	General	Happy Valentine's Day