DIETARY INTAKE OF FRUITS AND VEGETABLES AND BODY MASS INDEX FOR MEXICAN-HERITAGE CHILDREN: EFFECTS OF A BEHAVIORAL NUTRITION PROGRAM IN THE LOWER RIO GRANDE VALLEY OF TEXAS

by

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I. INTRODUCTION

Systemic, structural, and social factors negatively influence Hispanic children through many ways, such as food insecurity and poverty. Hispanic children experiencing food insecurity and poverty are less likely to consume a diet with healthy foods and participate in physical activity. In the US, many children do not eat recommended amounts of fruits and vegetables, especially Latino children. ¡Haz Espacio para Papi! (HEPP, Make Room for Daddy!) program addressed this important need for Mexican-heritage children living in the Lower Rio Grande Valley of Texas. HEPP is a unique nutrition and physical activity program that has a father-focused, family-centered approach and promoted positive behavior changes for fathers, mothers, and children.[1] This thesis project analyzed secondary data to complete an outcome evaluation of HEPP to determine effects on dietary intake of fruits and vegetables and body mass index for Mexican-heritage children.

Role of a Nutritious Diet in Children's Development and Well-Being

Good and adequate nutrition is crucial for helping individuals in the U.S. stay and remain healthy in their lifetime. In children, a healthy diet assists in their growth and development and helps to lower their risk of chronic diseases.[2] The Dietary Guidelines for Americans (DGA), 2020-2025 recommends that a healthy dietary pattern is followed by Americans, which can be achieved by consuming nutrient-dense foods and beverages and limiting saturated fat, sodium, and added sugar.[3] Following the DGA recommendations can benefit an individual by helping to reduce the risk of multiple disease, such as type 2 diabetes, heart disease, and cancer.[3]

Trends in Suboptimal Dietary Quality of Children

While nutrition plays an important role in an individual's health, most children in the U.S. do not consume a healthy diet. In fact, the dietary quality of children in the U.S. has been

declining for some time. While breastfeeding exclusively through 6 months of age is recommended, only 1 in 4 infants are.[2] Additionally, 9 in 10 Americans over the age of 2 have a higher than recommended intake of sodium.[2] Furthermore, 6 in 10 individuals between the age of 2 to 19 consume a sugary drink every day.[2] The Centers of Disease Control and Prevention (CDC) notes that while a healthy diet, together with physical activity and sleep, helps prevent children from becoming overweight/obese, 19% of children aged 2 to 19 are obese.[2]

While the importance of fruit and vegetable consumption is well-known, there are still declining trends for fruits and vegetables consumption in children. National Health and Nutrition Examination Survey (NHANES) is a part of the CDC and National Center for Health Statistics (NCHS) and assesses the nutrition and health status of children and adults in the United States. NHANES provides demographic, socioeconomic, dietary, and health related responses that assist US policy makers in the development of public health policies. Data from 2015-2018 NHANES was used in the NCHS data brief no. 391. This brief reported that consumption of fruits by all children and adolescents in the United States decreases with age during 2015-2018.[4] Fruit intake drops from approximately 90% of children aged 2-5 to 64.3% of adolescents aged 12-19. Fruit juice consumption also decreases with age from 62.1% for children 2-5 years old to 36.4% of adolescents 12-19 years old.[4] Surprisingly, dark green vegetables consumption increased with age from 13.9% of children aged 2-5 to 18.5% of adolescents aged 12-19.[4] Furthermore, more adolescents consumed orange and red vegetables than any other age group (children aged 2-5, children aged 6-11, adolescents aged 12-19). The NCHS data brief no. 391 also notes that family income had an impact on fruit and vegetable consumption on a given day, with families with income below 130% of the federal poverty level (FPL) consuming less than families with incomes above 350% FPL.[4] These trends indicate that as individuals grow older, the amount and

frequency of fruits and vegetables consumed decreases, leading to an increase in certain health risk factors.

The DGA was developed to provide guidance on dietary consumption to promote overall health and prevent diseases. The DGA is used by the Center for Nutrition Policy and Promotion (CNPP) to develop the Healthy Eating Index (HEI). The HEI-2015 determined how well American diets coincide with the 2015-2020 Dietary Guidelines for Americans.[5] The average HEI-2015 score for Americans is 58.7 out of 100, indicating that most Americans do not adhere to the 2015-2020 Dietary Guideline for Americans.[5] Furthermore, children aged 2-17 have an average HEI-2015 score of 53.9, suggesting children have an even lower than average adherence of choosing foods that align with the Dietary Guidelines.[5] The HEI-2015 is divided into 13 sections, which are further divided into two groups: adequacy components and moderation components.[6] Adequacy components depicts dietary elements and food groups that are encouraged, with a higher score representing higher consumption due to consumption of these foods being more desirable.[6] Children aged 2-17 received a 3.6 for total fruit, 2.3 for total vegetables, 1.9 for greens and beans out of 5, and 3.0 for whole grains out of 10 in the adequacy components indicating poor adherence to multiple components of the DGA.[5] Moderation components depicts dietary elements and food groups that should be limited, with higher scores representing lower consumption due to a lower intake being more desirable.[6] Children aged 2-17 scored 4.7 for refined grains, 4.4 for sodium, 6.1 for added sugars, and 5.1 for saturated fats out of 10 in the moderation components, indicating children of this age group are consuming a great deal more of these foods.[5] These reports establish the need for improvement in dietary quality in all Americans, specifically in children.

Just as important as the HEI in determining the nutritional status of Americans, NHANES

provides additional information about the health and nutritional status of U.S. adults and children. NHANES contains multiple components, with What We Eat in American (WWEIA) as the interview component of the dietary intake.[7] The WWEIA, NHANES 2017-2018 reported Hispanic children aged 6-11 years old consume more kcals compared to non-Hispanic white, non-Hispanic black, and non-Hispanic Asian.[8] In fact, Hispanic children between the age of 6-11 have reported consuming 40% of their energy away from home.[9] Much of the food consumed away from home were reported to be in the form of fast food/convenience food, which are typically ultra-processed foods high in saturated fat and sodium. In fact, it was concluded that unprocessed/minimal processed foods are being replaced with ultra-processed foods as a child grows and ages.[10] High consumption of these types of foods can lead to health problems, such as high blood pressure, cardiovascular disease (CVD), heart disease, and weight gain.[11,12] The WWEIA, NHANES 2017-2018 also detailed Hispanic children 6-11 years old consumed 38% of their saturated fat away from home,[9] as well as consuming more saturated fat compared to other race/ethnicity and age.[8] Furthermore, within the subpopulation of Hispanic children, Wang et al. determined that Mexican-American children consumed more saturated fat and had a higher energy intake from saturated fats.[13] Likewise, Mexican-American children had a higher energy intake from saturated fats compared to non-Hispanic Black and other Hispanic children.[13] Additionally, the WWEIA, NHANES 2017-2018 reported that Hispanic children aged 6-11 years old consumed 2908 mg of sodium,[8] well over the current Dietary Guidelines for Americans 2020-2025 recommendation of 1,500 mg/day for 4-8 years old and 1,800 mg/day for 9-13 year olds.[3] Moreover, two-thirds of children who are under the age of five consumed more than the sodium recommendation for their age- and sex-specific recommendation.[13] Furthermore, ultra-processed foods contribute roughly 92% of energy from added sugars.[10] The DGA 2020-2025

suggests limiting added sugar to less than 10% of total daily calories[3] due to the increased risk of heart disease, obesity, and type 2 diabetes. While added sugars should be limited, Neri et al. determined that 92% of all calories consumed between the age of 2-19 come from added sugars.[10] In fact, almost 60% of children examined in Neri et al. consumed more added sugars than the recommended amount.[10] In summary, Hispanic children consume a poorer diet that is high in ultra-processed foods, saturated fat, and added sugar, while having a low consumption of fruits and vegetables, thus increasing their risk of health issues later in life.

Nutritional Benefits and Consequences related to Dietary Intake of Fruits and Vegetables

Eating more fruits and vegetables helps to reduce the risk of some chronic diseases, notably those related to obesity. Obesity, specifically central obesity, is associated with a higher risk for heart attacks later in life.[14] Furthermore, waist circumference is thought to be a more accurate way of measuring cardiovascular (CVD) risk due to central adiposity being more strongly related to visceral fat.[15] Bradlee et al. found that fruit and vegetables intake, combined with grain and dairy consumption, were associated with decreased body fat.[15] This points to the importance of consuming a healthy diet to assist in decreasing body fat and improving quality of life.

Food Insecurity and Dietary Intake of Fruits and Vegetables

There is an association between food insecurity and lower intake of fruits and vegetables in children. Additionally, children with marginal, low, and very low food security are more likely to live in families with lower education, lower incomes, and participating in SNAP.[16] Jun et al. determined 12% of children aged 2-17 live in households with marginal food security, 15% live with low food security, while 7% live with very low food security.[16] Furthermore, Hispanic and non-Hispanic Black adults and children are more likely to have marginal, low, and very low food

security.[16] Potochnick et al. found that the rates of food insecurity for Hispanic/Latino youth (define youth) were almost double the national average and found a significantly higher BMI and CDI score in Hispanic/Latino youth who are experiencing food insecurity.[17]

Along the Texas-Mexico border, Mexican-origin children suffering from food insecurity have been found to not met the recommendations for certain dietary components, like calcium, dietary fiber, and sodium and, in turn, consume higher intakes of total energy from added sugar and fat and at least one-third of Mexican-origin children along the Texas-Mexico border reported having to skip a meal, go hungry, or not eat for the whole day.[18] Food insecurity and dietary quality in underserved populations, such as Hispanic/Latino populations, contribute to the burden of chronic disease, particularly for those who are eligible for federal nutrition assistance programs.[19]

Psychosocial Factors and Dietary Intake of Fruits and Vegetables

Different psychosocial factors such as self-efficacy, knowledge, attitudes, and preferences are influences on nutrition behaviors, such as dietary intake of fruits and vegetables in children. Knowledge and preferences alone have been determined to be significant predictors of fruit and vegetable consumption.[20] When knowledge and confidence about choosing healthy foods are examined together, they are determined to be significant predictors of fruit and vegetable intake, however, confidence alone did not yield a significant change in fruit and vegetable intake.[20] A hallmark study by Krebs-Smith et al. found that an individual's nutrition knowledge was the most important determinant for fruit and vegetable intake and preferences were also a strong predictor of fruit and vegetable intake.[20] A more recent study by Liou et al. found self-efficacy to be the most important determinant for fruit and vegetables intake and was highly related to reducing obesity risks reduction behaviors.[21]

Due to the importance of psychosocial indicators, previous studies have examined the associations of psychosocial factors and healthier eating for different samples of children. Cunningham-Sabo et al., aimed to examine psychosocial factors of self-efficacy, attitudes, and preferences on 4th grade students in the *Cooking With Kids* cooking and tasting (CWK-CT) program, compared to a tasting-only class (CWK-T), and a non-treatment class.[22] The CWK-CT classes had the highest gain in self-efficacy and preferences for fruits and vegetables, and a slight increase in attitudes. Furthermore, preferences for fruits and vegetables in males, as well as self-efficacy in those without prior cooking experience, had a significant increase of 2.5 times. The results of this study demonstrate the need for a cooking component in addition to tasting due there being no change in attitudes for the CWK-T class compared to the CWK-CT class.[22] Both the Krebs-Smith et al. and Cunningham-Sabo et al. studies indicate the importance of improving psychosocial indicators in order to achieve long-term sustainable behavioral change, particularly in children.[20,22]

Data from B'more Healthy Communities for Kids (BHCK) obesity prevention trial focused on psychosocial factors and healthier eating in low-income African American adults and children.[23,24] Specifically, Trude et al. found that increased self-efficacy and behavioral intentions were associated with healthier preparation methods, and increased knowledge was associated with a reduction in the frequency of prepared food venue purchasing.[23] In addition, using data from children, self-efficacy increased vegetable intake by 4%, fruit intake by 7%, and fiber by 10%.[24] Trude et al. found that in children, self-efficacy and "intention" helped predict intake of fruit, vegetable, and fiber,[24] all import psychosocial factors that should be a focus when creating and implementing a nutrition and cooking intervention.

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II. LITERATURE REVIEW

A literature review was completed to provide a foundation for this thesis project. Briefly, PubMed/MEDLINE was searched to identify relevant studies using combinations of cooking [MeSH Terms], health education/methods [MeSH Terms], health promotion [MeSH Terms] in February 2021. The literature review resulted in identifying 25 studies related to this topic, including 22 interventions or programs, and three qualitative studies with focus groups that utilized data from cooking interventions Cooking with Kids and Edible Schoolyard New Orleans. The results are summarized below. **Appendices Table 1 and Table 2** show results from the literature review.

Summary of Experimental Studies (Interventions/Programs)

There were 14 experiential nutrition education interventions conducted with a sample of children and in community-based settings. Prior interventions incorporated cooking, gardening-based, or experiential nutrition interventions.[1-14] Some of these studies included Cooking with Kids,[3,15] LA Sprouts,[4,5,7] and Texas Sprouts.[6] Davis and colleagues have led the Sprouts interventions in California and Texas, including a virtual delivery.

Most of the previous interventions were completed in urban settings in the U.S. (*n*=14),[1,4,5,7-12,15-19] with one study completed in both an urban and rural settings (5 New York counties),[13] and only one completed in a rural setting (5 states of Maine, Nebraska, Tennessee, South Dakota, and West Virginia).[1,4,5,7-12,15-20] with one study completed in both an urban and rural settings (5 New York counties),[13] and only one completed in a rural setting (5 states of Maine, Nebraska, Tennessee, South Dakota, and West Virginia).[20] Studies have been completed in all regions of the US, with most being conducted in urban areas like California.[1,4,5,7,10]

Previous nutrition interventions have recruited children from low or lower-income

communities and households. For example, several studies (n=15) had a majority (50% or more) of children, who were eligible or participating in free or reduced-price lunch programs at school.[1-4,6,7,9,10,12-15,17-19] Regarding the sample and age of the children, most studies (*n*=17) included children from 3-5th grade,[1-7,9,10,12-15,17,18,20,21] while one study focused on younger children in preschool,[19] and four studies focused on older children in 6-8th grade.[8,11,16,22] On average, the sample size was between 1-100 children across all groups (range: *n*=13-1212 children).[1,7,10,11,14,16,21] In some cases, studies had a closely matched male-to-female ratio.[2-8,10,13,15-17,21,22] Regarding other sociodemographic characteristics like racial/ethnic or culture, previous interventions have included children from diverse racial and ethnic backgrounds. For example, the literature review identified ten studies that predominantly sampled (>50% of total sample) Hispanic or Latino/a/x children,[4-7,10-12,17-19] five studies that sampled mostly white children,[2,3,13,20,22] and four studies that sampled mostly African American children.[1,9,14,16] There was limited to no mention of studies included children of parents, who were refugees or immigrants.

Regarding study designs and approaches, prior interventions have utilized quasi-experimental designs with a pretest and posttest design, with or without a comparison group.[1,2,5,9,13,19] Six studies utilized a pre-test and post-test design.[8,11,12,14,18,22] Seven studies were randomized controlled trials.[3,4,6,7,10,17,20] Each intervention included different themes and activities. Generally, studies offered cooking classes along with gardening or nutrition education classes (*n*=14).[1-14] Some interventions also included a meal sharing and conversation[4,5,7,9,10] crafts and games to reinforce concepts learned,[14] a family home activity,[1] and a 90 minute in person presentation.[22] Of the interventions mentioned above, eight studies utilized a cooking class with gardening or nutrition education classes in Latino children.[4-7,10-12,17] Studies have

collected data with interviewer-administered surveys[1,2,4-6,8-11,14,18,20,22] and in some cases, used anthropometry[1,4-7,9,10,12] and plate waste techniques.[19] Most studies evaluated the following variables: liking and preference for fruits and vegetables,[1-12,14,18] self-efficacy,[1,3,4,6,8,10-12,17,18,20] attitudes,[3,4,6,8,10-12,17,18] and other psychosocial indicators related to dietary intake of fruits and vegetables. For most interventions, the primary outcome was dietary intake of fruits and vegetables, measured by survey items or food frequency questionnaires (FFQs) The most commonly used FFQ was the 41-item screener 2007 Block Screener for Ages 2-17.[1,5,7,10,17,20,23] Importantly, no studies have utilized an objective measure of fruits and vegetables intake like a biomarker. Regarding timing, most interventions included an immediate post-test measure to assess effect at the end of the active phase of the intervention, but no interventions/only a limited number included a measure to assess the effect in the maintenance phase.

Generally, studies did not describe considerations to develop culturally relevant interventions for Hispanic/Latino/a/x or African American children. Of the 21 interventions, 9 intentionally focused on children from specific racial, ethnic, and cultural groups.[2,4-7,9,10,12,16] Of those, there were 2 culturally relevant nutrition interventions by Davis et al. and Chen et al. A study conducted by Davis et al.[6] located in a 60-mile radius of Austin, Texas designed a Hispanic culturally-relevant intervention. The intervention focused on containing culturally appropriate recipes, content, and activities with input from Hispanic families and tested to ensure lessons were culturally sensitive and appropriate.[6] Additionally, a study by Chen et al.[2] developed seven cultural food recipes with input from students' parents, as well as Latino and Hmong bicultural/bilingual staff.

Out of the 25 studies identified for this topic, there was three interventions/programs and one observational study (based on a cohort study) that included BMI as the primary outcome.[24-26]

Some of the studies included VALE,[24] and the Standard GOALS[25] and included a nutrition education and physical activity component. One of interventions was completed in both an urban and rural setting, while another was conducted in Northern California.[25] Previous interventions aimed to changing weight variables recruited children from low or lower-income communities and households.[24,25] Regarding sample and age of the children, three of the studies included children between the ages of 4 – 11 years old,[24-26] with one study including older children between the ages of 9 – 17 years old.[27] On average, sample size of these studies was between 60 – 88 children[24,26,27] across all age groups (range *n*= 60 – 241 children) and had a closely matched male to female ratio.[24-27] Two of the intervention studies were predominantly Latino/a/x children,[24,25] one included Latino/a/x children participants,[27] while another was predominantly minority groups.[26]

Regarding study design and approaches for the BMI-focused studies, two prior interventions have utilized a randomized controlled trails,[25,26] one used a pre-test and post-test design,[24] while the other used a prospective cohort study.[27] All four studies offered nutrition education, physical activity education, and behavioral modifications and collected data using anthropometry and had a primary outcome of BMI and/or BMI z-score change.[24-27] Regarding timing, all four interventions included an immediate post-test measure to determine the effect of the active phase of the intervention[24-27] and none of these studies did not utilize a measure to determine the effect in the maintenance phase. Generally, studies did not describe considerations to develop culturally relevant interventions for Hispanic/Latino/a/x children, with the exception of Robinson et al.[25]

Detailed Descriptions of Interventions/Programs

Heerman et al. aimed to expand the Parks and Recreation after school programing experiential teaching kitchens for low-income, minority children in large urban settings.[8] Heerman et al. determined that mean cooking attitudes, fruit and vegetable preferences, intention, self-efficacy, and willingness to try new foods increased. It is noted that the intervention was not randomized and was self-reported based on child report. Demographic data at an individual level was also not available.[8]

Jarpe-Ratner et al. utilized an intervention that focused on African American students and hypothesized a school-based nutrition and cooking classes with trained chef-instructors will increase students nutrition knowledge, fruit and vegetable preferences and cooking self-efficacy.[9] Jarpe-Ratner et al. found that nutrition knowledge and consumption of fruits and vegetables increased. The intervention utilized in this study expanded students' nutrition knowledge and fruit and vegetable intake.[9] It was noted that staff at the participating schools selected the participants, which could lead to a bias. The results of this study might not be generalizable to 3-8th grade students who have higher socioeconomic status due to sample size consisting of students from low socioeconomic status.[9]

Wolfe et al. examines Choose Health: Food, Fun, and Fitness (CHFFF) a cooking curriculum intervention that utilizes food preparation, active games, and family newsletters to lower childhood obesity and risk of chronic disease.[13] Fruits, vegetables, sugar sweetened beverages/fast food, and overall dietary intake significantly increased after CHFFF participation compared to the control period. Trying new food also significantly increased after the CHFFF period compared to the control period.[13] Wolfe et al. noted that data was self-reported, which could lead to social desirability bias. It was also difficult to tightly control aspects of the study

due to the delivery method. Furthermore, assessing behaviors that prevent obesity is not validated in this age group (grade 3rd-6th).[13]

Overcash et al. determine the influence of Cooking Matters for Families had on child and parent psychosocial measures, liking of and variety of vegetables consumed, and the availability of vegetables at home.[11] Children and parents reported increasing the number of vegetables they were willing to try. Additionally, parents stated their confidence preparing the food taught to them in the intervention (avocados, peas, zucchini, bean sprouts, and root vegetables) increased. Parents also described their confidence increasing when using poaching, stir-frying, stewing/braising, and roasting.[11] Overcash et al. notes that self-selection bias was probable due to those interested in cooking may have more motivation to enroll. Reporting bias was also possible due to data being self- reported. Furthermore, determinants of eating behavior were only reported, which could lead to a need to study longer-term effects of eating behavior.[11]

Melnick et al. describes a study that determines what affect Culture of Wellness in Preschools Nutrition Education (COWP-NE) had on the willingness to try fruits and vegetables in preschool children.[19] Intake of cauliflower, edamame, and red peppers displayed the highest increase between the intervention group and control group when analyzed over time. Furthermore, one year of COWP-NE increased preschool children's willingness to try vegetables. In this study, there is a possibly lack of generalizability due to lack of randomization of intervention participants.[19] Furthermore, the number of African American children and children who qualify for free or reduced lunches were higher in the intervention group compared to the control group, thus possibly affecting the study's findings. Lastly, time 1 plate waste was measured at different times for the intervention and control group.[19]

Santarossa et al. analyzed data from Kinect-Ed to determine if the objective of the use of

an informational presentation to motivate 6th-8th grade students to assist with meal preparation was met.[22] At the end of the informational presentation, self-efficacy, food preparation techniques, food preparation frequency increased. Kinect-Ed resulted in an increase in family dinners 6-7 days/week and a decrease in family dinners 0-2 days/week.[22] Santarossa et al. noted that the study was not randomized and was a sample of convenience with a small range of ethnicity and socioeconomic status. Moreover, the socioeconomic status of the parents and the young adult participants were not recorded. The results were strictly related to family dinner meals and not all meals.[22]

Ehrenberg et al. analyzed data from Mini-Chef increased preferences for targeted fruit and vegetables (apples, broccoli, cantaloupe, cucumbers, grapes, green bell peppers, nectarines, tomatoes, and snap peas) after repeated taste tests in lower-income children.[14] Preferences for target foods (bell peppers, cantaloupe, nectarines, and tomatoes) increased from pre-test to post-test. Children's preferences also increased after being repeatedly exposed to target foods via hands-on cooking. Ehrenberg et al. notes the small sample size is a weakness.[14]

Virtual Sprouts was a unique pilot study that employed a tablet-based educational game to teach nutrition and gardening knowledge.[1] Children who participated in the Virtual Sprouts intervention increased their self-efficacy to garden, cook, and eat fruits and vegetables significantly increased compared to children in the control group. While this study showed remarkable improvements on specific determinants of dietary intake in the 3-week time frame, the short length of time was a weakness.[1] The students were not blinded at consent, which could be responsible for the imbalance in sample size (n=116 vs. n=64). The sample size was also comprised of Hispanic and African American participants, possibly making the results not generalizable to nonurban and nonminority youth.[1]

Cunningham-Sabe et al. examined CWK, a food education program that teaches elementary school children about fresh, affordable foods through cooking and tasting lessons.[3] The CWK program resulted in a significantly increased self-efficacy for cooking and vegetable preference, increasing more than three times. Attitudes towards cooking significantly increased for the intervention students, regardless of gender and cooking experiences.[3] Fruit preferences were also improved at follow-up for participants in the intervention group. Cunningham-Sabe et al. state that the study did not evaluate the home environment.[3] Lohse et al. also examined data from CWK to determine the validity and reliability of the fruit and vegetable preference measures, as well as attitudes and self-efficacy towards cooking.[18] Lohse et al. found the study displayed psychometric value for evaluating attitudes and self-efficacy for cooking, and preferences for featured fruits and vegetables.[18]

Sharma et al. examined a pilot school-based co-op program, called Brighter Bites, that aims to increase the demand and consumption of fruits and vegetables in low-income children and their families by nutrition education and supplying fresh fruit and vegetables to participants, particularly in Hispanic children.[12] Brighter Bites was found to increase self-efficacy for fruit intake as a snack instead of candy, as well as children playing outside instead of watching television. Likewise, parents stated the percentage of children who assisted in food preparation for the evening meal increased at post-intervention. Sharma et al. note that a lack of a control group and low response rates from parents were weaknesses in this study.[12]

Texas Sprouts was an intervention that was developed specifically for Hispanic children that was one school year long intervention program that taught nutrition, cooking, and gardening classes to students and parents.[6] After this intervention, Davis et al. found that vegetable consumption increased, however, fruit or sugar sweetened beverage (SSB) consumption did not

differ. Blood pressure and obesity parameters were also not found to have a decrease at the end of intervention.[6] The results of Texas Sprouts may not be generalizable to other race/ethnicities and income levels due to study sample being comprised of mainly Hispanic and low-income individuals.[6]

LA Sprouts was a culturally relevant intervention designed in Los Angeles that focused on Hispanic individuals.[4,5,7,10] Martinez et al. outlines the methodology used for the LA Sprouts intervention.[10] LA Sprouts is a culturally tailored program developed to lower obesity in overweight Latino children based on off previous BMI lowering research with overweight Latino youth. LA Sprouts evaluation tools were specifically established to measure mediators and moderators to limit obesity nutrition and gardening knowledge and cooking and gardening attitudes.[10] While LA Sprouts has been shown to improve nutrition knowledge and improved dietary intake, it was delivered through an after-school program that not all students at the school attended. The long-term sustainability of the education program, along with the garden, was not determined. The dietary screener and bioelectrical impedance measurements were difficult for the study participants.[10] Davis et al. (2016), examined LA Sprouts, a 12-week nutrition, cooking, and gardening intervention.[4] The aim of this study was to determine the effect LA Sprouts had on dietary behavior in Hispanic/Latino 3rd-5th grad students. LA Sprouts intervention students improved their nutrition and gardening knowledge, increased their identification of vegetables, and expanded the number of students gardening at home.[4] The LA Sprouts intervention, however, did not display any significant increase in self-efficacy, preferences, or willingness to try fruit and vegetables. Davis et al. (2016) state the intervention needs to be longer to assess the long-term effects on determinants of dietary behavior.[4] The results of this study may not be generalizable to the general population due to be conducted in low-income, mostly

Hispanic/Latino children.[4] Davis et al. (2011) also examine the intervention LA Sprouts.[5] The aim of Davis et al. (2011) was to determine the effects of LA Sprouts on blood pressure, dietary consumption, and obesity parameters in 4th and 5th grade Latino students in Los Angles.[5] LA Sprouts was found to increase students' fiber consumption by 22% compared to the 12% decline in control group students. LA Sprout students lowered their diastolic blood pressure by 5% compared to the 3% decrease in controls.[5] Overweight students participating in LA Sprouts did not display a change in dietary fiber consumption compared to the 29% reduction in overweight control students and gained 1% less than the 4% increase in overweight control students. Overweight students participating in LA Sprouts also decreased their BMI by 1% vs a 1% increase in overweight control students. LA Sprouts demonstrated an improvement in dietary consumption and lowered blood pressure.[5] Furthermore, the intervention demonstrated an improvement in BMI and weight gain in Latino overweight students. Davis et al. (2011) noted the intervention sample was small and not randomized and intervention length was short.[5] Additionally, the food frequency questionnaire screener relied on participant recall to determine dietary intake for the prior 24 hours and is considered less sensitive as the 24-hour dietary recall. LA Sprouts did not incorporate a family or parent program, which could be beneficial to long-lasting healthy benefits.[5] Gatto et al. hypothesized that participants in LA Sprouts will have a reduction in metabolic risk factors and adiposity and increase the consumption of fruits, vegetables, and dietary fiber.[7] It was determined that LA Sprouts students had a more significant increase in reductions in BMI scores. Additionally, after the LA Sprouts intervention, the number of participants who suffered from metabolic syndrome was reduced. Students in LA Sprouts increased their whole grain, green beans, peas, and dietary fiber intake compared to the control students.[7] Furthermore, Gatto et al. determined LA Sprouts was able to decrease the risk of

obesity for Hispanic/Latino elementary school aged children. It was noted that staff were not blinded to anthropometric data and questionaries. There was also small sample size for blood measures, which would lower the statistical power.[7] An extensive review of all the literature displays the importance and need of implementing a cooking/nutrition program rooted in the intention to change psychosocial indictors in order to bring about a long-lasting change in fruit and vegetable consumption in Hispanic children.

Lastly, Chen et al.[2] was a mixed methods study that was designed for Latino and Hmong children where focus groups were used as part of the evaluation. Chen et al. utilized a short term pilot intervention to determine if the 5-8 year old students participating and their family members' attitudes, behaviors, and knowledge regarding the featured produce (asparagus, bell pepper, black beans, butternut squash, jicama, napa cabbage, and snap peas) were impacted.[2] The intervention employed in this study was developed using culturally relevant strategies to develop seven cultural/ethnic food recipes, via students' parents and Latino and Hmong bilingual/bicultural staff to represent Latino, Hmong, and mainstream American cultures.[2] Quantitative results displayed a significant increase at the end of the intervention for five of the featured vegetables, with familiarity also increasing for napa cabbage and bell pepper, although not significantly. Students' preferences for all featured vegetables increased significantly post intervention.[2] Parents also reported the frequency of students consuming the seven featured vegetables increased from pre intervention period to post. Food preparation at home with child involvement, parents' knowledge of cultural produce and local produce, as well as parents' encouraging to try new foods significantly increased at the end of the intervention.[2] Parents included in the intervention relayed a higher increase in child involvement in food preparation at home compared to the control parents. Qualitative analysis revealed four main themes comprised

of *Children playing an active role in home cooking activities, Parents and children appreciating new foods/recipes, Improved knowledge, attitudes, and behaviors regarding healthy eating, and Potential long-term impact on healthy eating*.[2] These results suggest the knowledge and food preparation skills learned by participants are applied to their daily lives, possibly leading to an increase in fruit and vegetables intake at home.[2] Weaknesses of the Chen et al. study include the short intervention time, data collected by self-report, and a control and intervention group not strictly matching regarding ethnicity.[2]

Observational (Qualitative) Studies

To date, there have been three relevant qualitative studies (led by Lukas et al., Knapp et al., Olfert et al.), with focus groups, related to this topic.[15,16,21] Two of these studies utilized data from cooking interventions (Cooking with Kids (CWK)[15] and Edible Schoolyard New Orleans (ESYNOLA)).[16] The ESYNOLA intervention was developed using culturally relevant strategies, specifically for African American students.[16]

Lukas et al. conducted multiple focus groups to determine what the experience of CWK was in the classroom, the perceived effects of CWK by the participants, and determine how the students experiences cooking with family compared to cooking with friends.[15] A total of 22 focus groups, with 10 focus groups conducted in cooking schools, 8 focus groups in tasting schools, and 4 focus groups in comparison schools.[15] Students were asked questions about home versus school (location) and family versus friends (others). Their analyses identified four broad themes, such as: (1) Perceptions of cooking at home and with family, (2) Cooking with friends and classmates, (3) Teaching approaches: Integration into curriculum topics and hands-on learning, and (4) Other food experiences in the classroom.[15] Strengths of this study included deliberately choosing students from all research conditions and participating schools for their

sample. Lukas et al. also included weaknesses such as challenges of administering interviews in classrooms, conforming to school schedules and available facilities resulting in unequal distribution of students into groups, and numerous moderators were needed to complete all focus groups during available time.[15]

Knapp et al. explored the perceptions of students, parents, and teachers in the ESYNOLA program, determine the characteristics of the program that are most highly appreciated, and identify the perceived influence of the program on the students.[16] Qualitative data was collected through 10 semi-structured focus group discussions of 7 randomly selected 5th-8th grade students. Parents were selected by being assigned a number and numbers randomly selected and teachers were recruited from two schools by flyers put in teacher's mailbox. Analyses of qualitative data from the students, parents, and teachers lead to the emergence of four primary themes: (1) Development of life skills, (2) Food and health, (3) Family and community, and (4) Experiential and participatory learning environment.[16] Knapp et al. determined that at an individual level, students, parents, and teachers noted an improvement in student's self-efficacy, knowledge, and skills due to participating in ESYNOLA. Students assisting in growing and cooking lead to a willingness to try more fruits and vegetables.[16] Furthermore, students and parents stated the knowledge, skills, and self-efficacy learned at school influenced behavior at home. Some limitations were noted, such as recruitment being difficult, resulting in low parent and teacher participation, with no fathers participating.[16]

Olfert et al. examined children's preparation cognitions and behaviors qualitatively in 6–11-year-old students and their parents in order to determine recommendations that can be incorporated into cooking programs for families who have school-age children.[21] Four focus groups each were held in New Jersey, West Virginia, and Florida, with participants evenly

distributed across locations. Two children's focus groups were conducted, determined by age, to ensure small focus groups to ensure everyone could participate.[21] Four separate themes were developed based off of the child focus groups and 3 themes were determined from the parent focus group. The child focus group themes consisted of: (1) Children's perceptions of their food preparation skills, (2) Children's involvement in family meal preparation, (3) Children's perceptions of the importance of knowing how to prepare foods, and (4) Children's suggestion for getting kids involved in making meals.[21] While the parent focus group themes included: (1) Parents' attitudes toward children participating in food preparation, (2) Parent reports of children's food preparation activities, and (3) Parents concern about children's food preparation activities.[21] Knapp et al. noted the results display that both children and parents thought it was important for children to be involved in meal preparation in order to develop cooking skills. Weaknesses of this study include small sample size, with mostly mothers being recruited.[21] The small sample size also made it difficult to determine age, sex, and ethnic differences. Furthermore, due to the study being conducted in only 3 geographic locations and could reflect regional characteristics.[21]

Conclusion

In summary, previous interventions have been completed in mostly urban areas with children from varied racial/ethnic backgrounds, and with a large proportion of children, who were eligible or participating in free and reduced-price lunch programs at school. There have been no interventions that were family- or father-focused that focused only on children who lived in rural areas, specifically along the Texas-Mexico border, or included a follow-up or maintenance measure to assess sustained effects, that included children of parents, who were refugees or immigrants, and no studies reported the use of promotoras (community health

workers) or utilized an objective measure of fruit and vegetables intake, like a biomarker. A critical need for community-based experiential nutrition education programs located in rural and border communities that emphasize the inclusion of male caregivers, while encouraging the use of promotoras and using an objective measure of fruit and vegetables intake is important due to the increasing growth of the Latino population.[28,29] Providing community-based experiential nutrition education helps to improve access, education, and resources to those of low socioeconomic status and/or racially diverse populations, which could assist in reducing health inequities and disparities, while promoting health equity for all.

Purpose and Aim

The goal of this thesis is to contribute evidence for a community-based experiential nutrition education and skill building program to promote nutrition for Mexican-heritage children. Upon completion, this thesis study aims to:

- Examine the immediate post-program effects of HEPP participation on dietary intake of fruits and vegetables and weight status. This analysis will be completed using descriptive and inferential statistics to determine the program effects for Mexican-heritage children.

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II. NUTRITION EFFECTS OF A FAMILY-CENTERED HEALTH PROMOTION PROGRAM FOR MEXICAN-HERITAGE CHILDEN IN THE LOWER RIO GRANDE VALLEY OF TEXAS

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Introduction

Systemic, structural, and social factors, like poverty and food insecurity, negatively influence nutrition for Latino/a children living in border communities.[1-4] Sharkey et al. determined that only 28% of the children residing in colonias in the Lower Rio Grande Valley of Texas along the Mexico border consumed the recommended amount of calcium, 10% for dietary fiber, 6% for sodium, while none of the children met the recommendation for vitamin D and potassium.[1] Additionally, children with very low food-security status consumed higher total energy, calcium, and percentage of calories from added sugar.

There is an opportunity for health promotion to support nutrition and physical activity for Latino/a children living in limited-resource households and rural communities, including Texas–Mexico border communities, but few nutrition interventions or programs have been designed,

implemented, or evaluated for this population. Exemplar interventions for Latino/a children include Crespo et al., Davis et al., and Barragan et al.[5-7] Prior research has documented the importance of strengths-based and culturally relevant approaches for experiential nutrition education interventions or programs.[8] Diaz et al. stated that culturally appropriate information, along with consideration of healthy traditional behaviors and the importance of peers' opinions, must be considered when developing an intervention to improve health promotion.[9] Lukas et al. stated that, when done through a culturally meaningful way, hands-on cooking classes that highlight learning among peers, could be effective.[10] Additionally, there is growing literature emphasizing the potential of family-centered approaches, within child obesity research, targeting the family as a system,[11] the home environment or family dynamics between family members.

To date, there have been no family-centered behavioral nutrition programs for Latino/a children living in border communities. The ¡Haz Espacio para Papi! (HEPP, Make Room for Daddy!) program was a novel and theory-based program for Mexican-heritage families living in border communities in the Lower Rio Grande Valley of Texas.[12-14] Specifically, HEPP was a father-focused, family-centered program to support nutrition and physical activity,[13] and based on the knowledge of the authors, the first program of its kind. The purpose of this manuscript is to examine the effects of the HEPP program for Mexican-heritage children on (1) dietary intake of fruits and vegetables evaluated with the instant skin carotenoid score via the Veggie Meter® and (2) body mass index (BMI) evaluated with age- and sex-adjusted BMI percentiles and BMI z-scores. Findings from this study are an important step in designing culturally relevant and sustainable programs for Mexican-heritage children living in border communities.

Materials & Methods

Overview, Study Design, and Context

This manuscript reports on an outcome evaluation of the six-week HEPP (Haz Espacio para Papi | Make Room for Daddy!) program. HEPP utilized a pre-test/post-test (or "pre-post") design, specifically a modified stepped-wedge design with a comparison wait-listed control or delayed intervention group (Figure 1). The ¡Haz Espacio para Papi! (HEPP, Make Room for Daddy!) nutrition program was conducted between July 2019 and February 2020 in the Lower Rio Grande Valley of Texas.[12-14] Participants were Mexican-heritage fathers, mothers, and children. Outcomes were assessed at transition, pre-test (baseline), post-test, and maintenance (short-term follow-up). A transition measure was key for the modified stepped-wedge study design and defined the control/comparison group (see Figure 1 for the modified stepped-wedge study design). Promotoras completed the pre-test within two weeks of the program start, completed post-test within two weeks of the program conclusion, and the maintenance about three to four months after post-test. During this time, the COVID-19 pandemic occurred and there were disruptions to program implementation and evaluation. The HEPP program was developed by an inter-disciplinary and multi-institutional team. The team consisted of academic-based public health researchers, who had experience and training in nutrition, behavioral and social health, and physical activity, a licensed family psychologist who had expertise in working with Latino family systems, and promotoras that received training and had experience in education, research, and social work. Promotoras played a critical role in the design, implementation, and evaluation,[12,13] as part of community-based participatory research.[15,16] The program was created in both English and Spanish and included an iterative process of development and review. A separate article describes the rationale and design for the HEPP

nutrition program in detail.[12]

Participants

Prior to recruitment, all materials were approved by the Institutional Review Board (IRB) at Texas A&M. Additionally, collaborating institutions reviewed and approved applications for data analyses. The proposed analyses were submitted and approved by the Texas State University IRB on 27 August 2021 (IRB Protocol #7973). The HEPP program purposefully recruited Latino fathers and mothers. Promotoras and community partners helped to recruit families through flyers, word of mouth, and going door to door. As recommended by Panter-Brick et al. and others, the promotoras verbally highlighted the uniqueness of the HEPP program and the importance of it to fathers and the whole family.[17-22]

Eligible parents had to self-identify as Mexican-heritage (self, parent, or grandparent, who was born in Mexico) and be 21 years old or older. Parents also needed to live with their spouse/partner and child (aged 9 to 11 years old), be willing to complete in-person measurement visits at their home for both the pre- and post-test measurements and commit to participate for the full six weeks. Parents and children were excluded from participating if they disclosed having a severe food allergy or physical activity restrictions.[3,23,24]

The HEPP program recruited 10 to 12 families from each cluster of colonias (neighborhoods), which were geographically defined within the study area in the Lower Rio Grande Valley of Texas. Program groups were defined based on the neighborhood clusters, and this program recruited from five clusters of colonias (five groups). One group of 10–12 families participated in the program at a time. Each family had one child participating in the program. Random assignment was used to determine which group would start as the intervention (treatment) group and as the wait-listed control.

Development of the informed consent process was done in collaboration with the research team, the promotoras, and literature. A Spanish and English informed consent form was developed at or below a fifth-grade reading level with visual aids and graphics to help participants understand the program commitment, research activities, potential risks, and potential benefits. After parental consent, eligible children were asked for their assent to participate in the program. Fathers, mothers, and children received $100 for pre-program visits, $200 for post-program visits, up to $200 for attending all six sessions ($500 per family/household), and a kitchen (food preparation and cooking) kit worth $100.

Program Design

A separate article describes the theoretical foundation and provides a conceptual framework for the HEPP program.[12] Briefly, the Family-centered Action Model of Intervention Layout and Implementation approach (FAMILI),[11] Family Ecological Model (FEM),[25] the Family Systems Theory (FST),[26] and Social Cognitive Theory (SCT)[27] were used to develop a unique theory of action and support multi-level behavior changes at the home or household environment, family system, and individual levels. In addition, formative work informed program development. A field-based research team identified, mapped, and ground-truthed geographic clusters or areas to prepare for the program. Fathers, mothers, and children engaged in independent activities in focus groups, participant-driven photo-elicitation interviews, dyadic interviews, and household elicitation surveys. A separate article describes the formative work in detail.[13]

Intervention Structure, Components, and Curriculum

HEPP was a six-week program that consisted of three intervention components: weekly in-person group sessions, check-ins (home visits and phone calls), and at-home activities that

occurred between the group sessions.[12] The program's overall theme was embracing existing health-promoting traditions while encouraging new healthy traditions with families. Promotoras led in-person group sessions that included a food and beverage tasting for participants with a "mini" nutrition education lesson, an interactive lesson for participants to gain knowledge and skills related to nutrition and family functioning, child-focused cooking lesson, and eating together lesson. Promotoras also led weekly check-ins (home visits and phone calls). The nutrition curriculum focused on embracing traditional and cultural foods and food preparations while learning new ways to enjoy beverages, snacks, sides, and main dishes. Every week, a new "spotlight" fruit or vegetable was featured, which included garbanzo bean (chickpea), jicama, cabbage, spinach, sweet potato, and avocado. Most recipes required no animal proteins and were plant-based or vegetarian preparations.[12] A separate article reports on the physical activity curriculum.[14]

Data Collection

A team of promotoras collected all data simultaneously in person at the homes of participating families.[12,13] Different promotoras collected data privately from each family member during the visit. They (promotoras) collected data using several techniques: inter-viewer-administered surveys (sociodemographic data including food security), accelerometry (activity behaviors, including sedentary and physical activity), anthropometry (measured height and weight), and reflection spectroscopy with the Veggie Meter® to obtain instant skin carotenoid score, which is a biomarker for dietary fruit and vegetable intake.

This study was affected by the COVID-19 pandemic. Originally, the study planned assessments at transition (key for modified stepped-wedge study design), baseline or pre-test (within two weeks of program start), post-test (within two weeks after program completion), and

maintenance (three to four months after post-test) for all groups (see Figure 1 for the study design). However, the HEPP program stopped in February of 2020 due to the pandemic (and restrictions on in-person contact) and participants in each group did not complete the same set of assessments. This meant that the study canceled group 4 maintenance measures (maintenance measures completed only for groups 1, 2, and 3) and group 5 did not complete the program or any measures after the pre-test. Group 5 completed transition and pre-tests measures only. Program outcomes were assessed at each time point: transition (for groups 2–5), pre-test (all groups, 1–5), post-test (for groups 1–4), and maintenance (for groups 1–3). Table 5 presents data on program completion.

Measures

Food Insecurity

According to the U.S. Department of Agriculture, food insecurity is defined as limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways.[28] The promotoras collected data about food insecurity in an interviewer-administered survey administered pre-test and post-test. Food insecurity was assessed based on the validated Hunger Vital Sign two-item food insecurity screener by Hager et al.[29]

Instant Skin Carotenoid Score

The Veggie Meter® is a portable, non-invasive instrument that obtains an objective measure of dietary intake of fruits and vegetables by assessing skin carotenoid levels.[30] The device works through a validated reflection spectroscopy (RS) approach, allowing for carotenoid concentrations in the skin to be objectively measured.[30] The device includes a RS device and a laptop. A Veggie Meter® score has been suggested to reflect fruit and vegetable intake over at

least two months (eight weeks) prior.[30] Several validation studies have provided evidence for using the Veggie Meter®. Skin carotenoid levels measured by an RS device are an accurate and validated way to measure plasma carotenoid concentrations in children and adults.[31-34] Jilcott Pitts et al. examined the validity of the RS device between skin and plasma carotenoid concentrations in four different racial and ethnic groups and found a correlation of 0.71.[35] Furthermore, skin carotenoid concentrations were associated with plasma carotenoid concentrations when adjusted for age, sex, racial/ethnic group, and BMI.[35] Similarly, Jahns et al. found a strong correlation at baseline and moderately strong correlation for skin and plasma carotenoid concentrations across the year.[31] Evidence has shown that the Veggie Meter® is promising for use with individuals across a range of skin tones, and the device automatically adjusts for differences in melanin.[30,32]

For this study, the team acquired two Veggie Meter® devices in the summer of 2018 and started training, withs limited information on best practices for Veggie Meter® use. Instructions outlined the importance of calibration with dark and white reference sticks before use, recalibration at least every two hours during continuous use (not needed for this study, because measures were done with one family per visit), handwashing before assessment, and completing a triple scan on the same finger to obtain an average instant skin carotenoid score. Given the nature of data collection in semi-rural communities like the colonias, the promotoras traveled with a portable table for the RS device and laptop, sanitizing wipes, and paper towels to complete the Veggie Meter® assessments. Promotoras using the Veggie Meter® followed a study protocol that included traveling with a fully charged Veggie Meter® laptop, calibration before each home visit, setting up the device on a portable table, and ensuring that participants washed hands before assessment. Handwashing helped to remove residual staining from any

highly pigmented foods or remnant splotches from colored markers or paint.[29] The promotoras used the average setting (versus relying on a single scan), which meant that each child completed three consecutive scans of the same finger to improve reliability.[32] Promotoras completed Veggie Meter® scans at each time point (pre-test, transition, post-test, and maintenance) and documented which finger was scanned and any comments regarding protocol deviations. Table 6 reports protocol deviations with the Veggie Meter®, out-of-range scores, and the range of scores at each measurement visit.

Children's Body Mass Index (BMI)

Body Mass Index (BMI) was assessed using age- and sex-adjusted BMI percentile and BMI z-scores based on the 2000 CDC (Centers for Disease Control and Prevention) BMI-for-Age Growth Charts.[36] The CDC recommends using age-adjusted BMI for children, since their height and weight change as they grow, and they also recommend sex-adjustment since body composition varies for boys and girls. The BMI percentile can be interpreted as the relative position of a child's BMI to children of the same sex and age from the reference population.[36] Promotoras obtained measured height (in inches) and weight (in pounds) with a portable stadiometer and digital scale at each time point (pre-test, transition, post-test, and maintenance). They followed a recommended protocol for obtaining height and weight measures and completed three consecutive measurements of height and weight to improve reliability.[37] Average weight was calculated from the multiple weight measurements, and the same procedure was used for height. Children's body mass index (BMI) was calculated based on the SAS Program macro for the 2000 CDC BMI-for-Age Growth Charts.[36] Data on sex, age (in months), weight (in kg), and height (in cm) were used to calculate children's age- and sex-adjusted BMI percentiles and z-scores.[36]

Data Analysis and Interpretation

Given that the HEPP nutrition program was a pilot study, there was no a priori sample size calculation to determine the minimum number of children in the treatment (or intervention) group. This manuscript used all available data from the children who participated in the HEPP program. Of the 59 children enrolled, promotoras completed measures at pre-test for 57 children, post-test for 42 children, and maintenance for 24 children. Like prior studies, analyses focused on determining within-person changes in instant skin carotenoid score and BMI outcomes overall, by group and examining group differences.[38] To determine within-person changes in outcomes during the intervention period, changes from pre- to post-test ($change_{post}$ = post–pre) and from post-test to the end of the maintenance period ($change_{maintenance}$ = maintenance–post) were calculated. To determine with-in-person changes in outcomes during the control period, changes from the transition period to pre-test were calculated ($change_{control}$ = transition–pre). When each group underwent the intervention, the subsequent group served as the preceding group's control. For example, when group 2 underwent the intervention, group 3 served as the control for group 2. Changes in group 2 skin carotenoid scores between pre- and the post-test were compared to changes in group 3 skin carotenoid scores between transition and pre-test. Figure 1 presents the sequence of the measures in the modified stepped-wedge study de-sign.

All data were analyzed using SAS (SAS Institute Inc., SAS Statistical Software: version 9.4. Cary, NC: SAS Institute Inc.) and Stata (StataCorp. Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC). Unadjusted descriptive analyses were used to determine overall, and group means for child age in years, instant skin carotenoid score, BMI z-score, BMI percentiles and group distributions by sex, BMI percentile categories and food insecurity status at pre-test measure. Fisher's exact tests were used to deter-mine differences in the distributions

of categorical variables and analysis of variance (ANOVA) was used to test differences in means of continuous variables. To obtain mean pre- to post-test and maintenance to post-test changes for each outcome, six unadjusted ANOVAs were conducted with each within-person change outcome as the dependent variable and group as the independent variable. To determine whether mean with-in-person changes in each outcome differed by group, three separate ANOVAs were conducted with each within-person change outcome as the dependent variable and an interaction of data collection time point and group as the independent term (time x group). These analyses compared changes in outcomes from pre- to post-test for intervention groups to the changes from transition to pretest for the control groups. Additionally, changes in outcomes from post-test to maintenance for intervention groups were compared to the changes at post-test measures for the control groups. Stata's margins command was used to obtain unadjusted mean within-person changes in instant skin carotenoid scores, BMI z-scores and BMI percentiles overall and by group from each ANOVA. Linear mixed-effects models were used to determine the overall intervention effects on changes in instant skin carotenoid scores, BMI z-scores and BMI percentiles. Mixed models account for the hierarchical structure of the data, are recommended for use with a stepped-wedge study design,[39,40] and allow for the analysis of partial datasets with dropouts or missing study visits. Each model included a fixed effect for child: age in months, sex, month of pre-test data collection, number of intervention sessions attended and baseline instant skin carotenoid score (when change in instant skin carotenoid score was the outcome), baseline BMI z-score (when change in BMI z-score was the outcome), or baseline BMI percentile (when change in BMI percentile was the outcome). Random effects for the assigned study group were included in the model to account for nonindependence of members in the same intervention group as either a random intercept or random slope. Results were considered

statistically significant at $p < 0.05$. Prior studies were used to interpret results from analyses.

Results

Sample Characteristics

Promotoras screened 308 families for eligibility in the HEPP program, and 61 families met eligibility requirements. Families were recruited from five geographic clusters of neighborhoods (colonias). Two families dropped out before pre-test measures and the program enrolled 59 families or 59 children. Figure 2 shows the flow of children from recruitment and enrollment through program completion and evaluation. This figure was based on the CONSORT (Consolidated Standards of Reporting Trials) flowchart.[41]

Table 1 presents characteristics for the analytic sample of children who completed pre-test measures (n = 57). All children were of Mexican heritage (average age 10 years old). Individual and household characteristics were similar across groups. Overall, the sex distribution was 52.6% female and 47.4% male children; however, the distribution varied between some groups. For example, groups 1 and 2 were mostly female children (58.3% and 70.0%, respectively) while group 3 was mostly male children (75.0%). Most children reported household food insecurity at baseline (68.4%).

The program dose delivered was 900 h for the child (six sessions at 2.5 h per session). The mean number of sessions attended was highest for group 1 (5.6 sessions); on average other groups had between 4.7 and 5.4 sessions (Tables 2 and 3). Unfortunately, the COVID-19 pandemic negatively affected the HEPP program. Program completion is shown in Table 5. Before the pandemic, groups 1–3 completed the program and all measures (pre-test, post-test, and maintenance). However, because of the timing of the pandemic on-set in the U.S., group 4 did not complete maintenance measures. Group 5 started the pro-gram (first two sessions), but

participants did not finish the six-week program (Figure 2). Given the timing of the COVID-19 pandemic, 31 out of 59 children (52.5%) completed all six sessions (Table 5). Excluding group 5 (n = 12), 66.0% (31 out of 47 children) completed all six sessions and 74.5% (35 out of 47 children) completed most sessions (data not shown). Retention varied by group. For example, group 1 retained 58.3% of children through session 6 (attended all six sessions). Group 2 had the lowest retention (50%). Group 3 retained proportionally more children than groups 1 or 2 but less than group 3 (69.2% completed all six sessions). Group 4 had the highest retention (83.3%) (Table 5).

Within-Person Change for Instant Skin Carotenoid Scores and BMI for Children at Post-Test and Maintenance

Table 2 presents the unadjusted within-person changes for instant skin carotenoid scores and BMI outcomes for children at post-test overall and by group. Skin carotenoid scores varied widely (range: 17 to 498 across all measurement visits and all children, see Table 6). The only statistically significant difference between groups was for dose, given group 5 stopped the program early due to the COVID-19 pandemic. Overall, the average change for instant skin carotenoid score was −15.3 ± 6.2 (total for all intervention groups), which meant that the instant skin carotenoid score decreased between pre- and post-test for groups 1 through 4. There was no post-test data for group 5 because of the timing of the COVID-19 pandemic. The overall average change for control groups was −5.5 ± 4.2. Notably, group 1 had a 14.8 ± 23.8 score increase between pre- and post-test, while decreases in scores between pre/post-test were observed for groups 2 (−18.2 ± 23.8), 3 (−30.5 ± 21.6), and 4 (−21.7 ± 20.6). Group 3 had the most noticeable change in instant skin carotenoid score (intervention: −30.5 ± 21.6 versus control: −13.4 ± 20.6).

Regarding BMI outcomes at post-test, the average BMI percentile change was −0.34 ±

0.4 (total for all groups), which meant that BMI percentile decreased between pre- and post-test. The overall average change for control groups was an increase of 0.44 ± 0.41 for BMI percentile. Group 3 had the most noticeable decrease in BMI percentile (intervention: −3.3 ± 1.6 versus control: −0.58 ± 1.5) at post-test. A similar pattern was seen for BMI z-score.

Table 3 presents the within-person change for instant skin carotenoid scores and BMI outcomes for children at maintenance. Overall, the average instant skin carotenoid change was −2.0 ± 7.3 (total—groups 1, 2, and 3) for all groups, which meant that the instant skin carotenoid score decreased between post-test and maintenance. There was no maintenance data for groups 4 and 5 because of the timing of the COVID-19 pandemic. Group 1 reported an average score change of −3.4 ± 12.7 at maintenance. Group 2 had an average score change of −18.9 ± 13.6. Group 3 had an average score change of 12.2 ± 12.0 and was the only group with an increase in instant skin carotenoid score between post-test and maintenance.

Regarding BMI outcomes at maintenance, the average BMI percentile change was −1.6 ± 0.37 (total for all groups), which meant that BMI percentile decreased between post-test and maintenance. Group 2 had the most noticeable decrease in BMI percentile (−2.5 ± 0.68) at maintenance. Groups 1–3 reported reductions in BMI at maintenance (three to four months later). A similar pattern was seen for BMI z-score.

Program effects on Instant Skin Carotenoid Scores and BMI for Children at Post-Test

Table 4 presents the overall change for instant skin carotenoid score and BMI outcomes for children at post-test. In the unadjusted models, the program decreased the instant skin carotenoid score (−14.7l, 95% CI: −30.9, 1.6) and decreased BMI percentile (−0.2, 95% CI: −2.2, 1.8) for children at post-test. A similar pattern was seen for BMI z-score. In adjusted models, the change in skin carotenoid score was strengthened and significant (−15.14; 95% CI:

−24.95, −5.33). Unadjusted and adjusted estimates were similar for BMI outcomes.

Discussion

This study examined the effects of the HEPP program on instant skin carotenoid score, as a biomarker of fruit and vegetable intake, and age- and sex-adjusted body mass index (BMI) at post-test and maintenance. Overall, the results showed that the HEPP program had no statistically significant effects on instant skin carotenoid score or BMI for Mexican-heritage children at post-test, based on unadjusted and adjusted models. In addition, there were no statistically significant within-person changes by groups aside from dose for group 5. However, for some groups, associations were in the hypothesized direction, and there were greater effects for the program (intervention) group compared to the control group for BMI outcomes, which provides some evidence for program effectiveness.

Preliminary evidence from this program is promising. In the U.S., systemic, structural, and social factors, like poverty and food insecurity, disproportionately affect Latino communities, which means that Latino households have not had resources or opportunities to support adequate nutrition. For example, based on the U.S. Department of Agriculture's (USDA) most recent report, food insecurity prevalence was 10.8% in Hispanic households with children compared to 3.6% in non-Hispanic white households with children in 2021.[28] Although the sample was not nationally representative, our data showed that 68.4% of participants lived in households considered food insecure. Previous research documents how food insecurity limits access to health-promoting foods.[42] Studies with national samples of Latino/a children have reported racial/ethnic disparities in fruit and vegetable (FV) intake and body mass index (BMI)).[28] Overall, this program showed a null effect on a biomarker of FV intake (instant skin carotenoid status), and a reduction in BMI for children. However, given the need to support

nutrition among Latino/a children, this manuscript makes an important contribution.

Findings highlighted interesting patterns between groups, likely related to group variations in program retention and timing of delivery. For example, group 3 consistently reported greater changes in outcomes compared to the other groups at post-test and maintenance. One reason for the larger effect sizes may have been gains in confidence or skill of the promotora group leaders/interventionists over time. Another reason may have been peer learning or social support that participants experienced in this group 3.[9,10]

Results also generated important insights related to school lunch programs. Group 1 was the only group that started and finished the program during the summer and the only group with an increase in Veggie Meter® scores at post-test (and an increase relative to control group). When school was not in session, children may have had limited access to school lunch programs and benefited more from this program. When school was in session, children likely had greater access to school lunch programs, through the Community Eligibility Provision,[43] and increased dietary intake of fruits and vegetables, resulting in an increase in Veggie Meter® score. School lunch programs have been shown to increase the selection and dietary intake of fruits and vegetables[44] in children participating in the program by up to 16 to 23%.[45] Furthermore, children between the ages of 9 to 12 years old have been found to consume over half of their daily fruit and vegetable intake while at school.[46] We expected a larger increase in Veggie Meter® score for children in groups 2, 3, and 4, who participated in the HEPP program during the school year and may have had access to school lunch programs. Yet, our results showed reductions in Veggie Meter® scores for some groups, which suggests that children's access to fruits and vegetables through school lunch meals program may have been insufficient to affect instant skin carotenoid score.

A couple of points warrant additional discussion. First, the program evaluated its primary outcome of dietary intake of fruits and vegetables with the Veggie Meter®, which was a relatively new device at the time. Available evidence from Veggie Meter® studies now indicates that the exposure period is about eight weeks.[32] However, this pro-gram lasted six weeks, and the relatively short duration may have made it more difficult to observe a change in instant skin carotenoid score. There was also tremendous variation in data from the Veggie Meter®. The promotoras documented numerous issues with residual food staining, which initiated a protocol deviation or changing the finger for assessment. Anecdotally, when the promotoras scanned a different finger, the score was quite different. The small sample size and large variation in Veggie Meter® scores likely made it difficult to determine effect size. To date, though, there has been limited published research on using Veggie Meter® with Latino children or adults[47,48] and a few studies have assessed skin carotenoids among Latino/a children.[49,50] However, based on the authors' knowledge, there have been no published studies using the Veggie Meter® with Latino/a children living in border communities and only one study that obtained Veggie Meter® scans at more than one time point for a subsample of Latino/a children.[51]

Based on the team's experience, there are several practical benefits to using the Veggie Meter® in community-based research. First, the Veggie Meter® is a rapid assessment, and assessments only take a couple of minutes. There is no additional data entry and sources of error are reduced. Second, the Veggie Meter® is a small and lightweight device and easy to transport. Third, the non-invasive nature of the assessment reduced the burden and increased the acceptability of the program, which was grounded in community-engaged research. This allowed for inadequate fruit and vegetable intake to be identified and to evaluate the success rates of intervention programs that aim at increasing fruit and vegetable intake in study participants.[30]

Anecdotally, the promotoras shared that the Veggie Meter® was quick and easy to use for them, and accepted by families, especially for children.

Second, this program evaluated BMI in growing children. Findings showed that the program resulted in a decrease in body mass index (BMI) outcomes at post-test and maintenance. Program effects may be attributed to the family functioning, nutrition, or the physical activity components of the program.[12-14] There may have been other factors affecting children's BMI, which were unmeasured and not considered in analyses. In addition, while some programs have reported similar effects among Latino/a children, successful programs had longer durations or samples from varied racial and ethnic back-grounds, which could lead to different results.[52,53] For example, Gallo et al. examined the 10-week program Vidas Activas y Familas Saludables (VALE) and found statistically significant decreases in child BMI for age z-scores, waist circumference, and percent body fat.[52] Robinson et al. evaluated a three-year intervention program in Latino/a children and found children gained an average ~0.25 kg.m2 less than those in control group over the three-year period.[53] The effects at maintenance of a decrease of −0.05 in BMI z-score (−0.20 to −0.25 BMI z-score change) were insufficient for clinical significance for BMI outcomes in children;[54,55] however, the smaller sample size and imprecision of estimates made it somewhat difficult to determine effect size.

Limitations and Strengths

This study is not without limitations. First, the sample size was relatively small (59 children enrolled and 41 children with pre- and post-test data). The design, implementation, and evaluation required tremendous resources, which limited the number of families that were able to participate. Prior studies, family-based nutrition interventions, have included samples of between nine and 356 children.[46,56-59] A larger sample size would have improved precision of estimates

and may have provided sufficient power to detect statistically significant effects. The program was relatively shorter than other programs (duration six weeks to 16 weeks),[3,7,59-62] but more comprehensive and intensive. For example, the program included family functioning, nutrition, and physical activity and was intense, with a greater dose (900 min or 15 h) compared to previous programs with a similar focus (range for dose: 10.5 to 20 h) over a shorter six-week duration (range: 6 to 12 weeks).[12] Additional research will be needed to balance resource demands of the program with efficacy. Second, the COVID-19 pandemic negatively impacted this program and resulted in missing data at post-test for all of group 5 and missing data at maintenance for groups 4 and 5. Limited data may have biased the results for within-person and between group differences. Imputation, such as baseline observation carried forward, was not considered for this analysis because of the risk of bias associated with single imputation.[63] Multiple imputation was not considered because of the relatively small sample and limited data available for multiple imputation. Third, as with all intervention programs, it is not possible to account for and measure all the factors that might impact the program or outcomes. This study attempted to minimize threats to internal validity by including a comparison or control group, using more objective measures for outcomes, and defining outcome variables with a change score. For example, in analyses, the use of within-person change to define outcomes captures time-invariant inherent immeasurable factors associated with the outcomes and reduces between-person variability.[64] However, future research is needed to fully understand and minimize confounding bias. Fourth, relatively early adoption of a new device like the Veggie Meter® meant that there was not a standard research protocol for how to use the Veggie Meter® in evaluation available at the time of the program (design or implementation). The research team overcame this barrier by developing a protocol (described in the methods) that outlined con-

ducting scans on the right index finger for all children, unless there was a reason to use the left hand due to residual staining or "out of range" scores. However, recommendations published in 2022 suggested that scans use the non-dominant ring finger, which was not done in this study. Because of the timing, and recommended protocol being unavailable,[32] findings for the instant skin carotenoid score must be interpreted carefully.

At the same time, use of the Veggie Meter®, as an objective measure of dietary intake, was a strength and sets this program apart. Validation studies have shown a high correlation between Veggie Meter® scores and serum carotenoids, which is a more reliable way to measure fruit and vegetable intake compared to self-reported dietary recalls and food records, which are prone to inherent bias and inaccurate estimates.[32,35,65] Additional strengths were using anthropometry versus self-report to obtain height and weight.[64] This study included a maintenance measure, which is another strength. Originally, the program intended to collect maintenance measurements for all groups to determine short-term impacts at 3–4 months. Generally, programs have not collected data for maintenance and assessing outcomes at maintenance contributes valuable evidence. The need for additional research on long-term impacts has been documented in the literature to determine the sustainability of intervention effects and strengthen and improve intervention strategies.[66-69] Importantly, the strength of this program is attributed to the community-engaged approach with a promotora model, use of theory, and targeting family functioning to engage fathers, mothers, and children as a family system.[12,13] Additionally, this program uniquely investigated individual measures within the context of family and community systems, which underscores the value of this research.

Implications

Findings offer implications for practice, research, and policy. First, the Veggie Meter® was a relatively easy assessment for promotoras and acceptable to the Mexican-heritage children. The device provided a rapid, non-invasive, and portable way to obtain an objective measure of dietary intake[32] and may be valuable in community-based office or clinical settings. However, the relatively high cost of a Veggie Meter® may make it difficult for community-based organizations or researchers to acquire. Using the Veggie Meter® for research offered several advantages, including using an objective measure to evaluate the program, portability, and minimizing sources of error in data entry. However, future research is needed to create standardized protocols or best practices for research with the Veggie Meter® and create a data repository of Veggie Meter® scores for different subpopulations, including children from different racial and ethnic backgrounds, ages, and genders. Protocols will support validity and reliability of findings and a data repository will help with data interpretation, especially for special populations, including children. Given that the Veggie Meter® reflects a reference period of about eight weeks,[32] this assessment may be better suited for programs with a longer duration (eight weeks or longer). Second, the promising results were likely related to the community-engaged approach with a promotora model and theory-based design.[12,13] The approach led to an effective program that may have been culturally meaningful to families and individual children. Future research is needed to understand which components of the program were efficacious, and specifically, a process evaluation is required before considering replication or adaptation. Because this family-centered program targeted family functioning, data were collected on family functioning with a validated scale.[12] Additional analysis may provide important insights into effects on family functioning or how family functioning related to outcomes, if at all. Future

research is needed to test this program with a larger sample. Lastly, findings have policy relevance and novel approaches that may support nutrition security. The USDA has defined nutrition security as having consistent and equitable access to healthy, safe, affordable foods essential to optimal health and well-being.[70] There may be a need to strengthen school meal programs, and emphasize carotenoid-rich fruit and vegetable intake, especially for communities with limited access.

Conclusions

This study applied an inclusive approach to behavioral nutrition and targeted family functioning for Mexican-heritage families living in the Lower Rio Grande Valley of Texas. While the program was not a weight-centered program, there were promising results for body mass index (BMI) at post-test for Mexican-heritage children (six weeks after baseline or program start) and somewhat sustained effects on BMI at maintenance (three to four months after program completion). However, the promotoras documented numerous issues with residual food staining that affected the consistency of the Veggie Meter® scans, and results showed that the program did not have a positive effect on instant skin carotenoid score at post-test or maintenance for children across groups. Additional research can help establish protocols for collecting and interpreting Veggie Meter® data with Latino/a children.[48] Our findings provide evidence for strengths-based approaches in behavioral nutrition and strengthening federal nutrition and food assistance programs, like the National School Lunch Program, which have been shown to increase fruit and vegetable in-take among children and support food security for their families.[68,69]

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III. CONCLUSION

Systemic and structural factors play a role in fruit and vegetable intake for Hispanic and Latino/a children. The ¡Haz Espacio para Papi! (HEPP, Make Room for Daddy!) program sought to address this critical need and provided community-based experiential nutrition education that increased and improved access, education, and resources to low socioeconomic status Mexican-heritage children and assisted in promoting healthy equity for families.

Within Latino families, there is a strong sense of "family togetherness" and an importance of spending time together as a family,[1] leading to the need to address not only individual factors, but also factors at the family level. This led to a unique theoretical model that drew on multiple theories and focused on multi-level determinants at the individual and family level to support nutrition and physical activity in Mexican American families living in border communities.[2] These theories were chosen due to the emphasis they place on the importance of family interactions within the home environment and were used to influence the activities conducted within the program.[2] Program activities, including co-participation in cooking lessons, targeted cognitive factors like attitudes, knowledge, and self-efficacy at the individual level, and environmental factors like family functioning, family norms, and family support at the family level.[2] A family systems approach to behavioral programs is supported by the National Institute for Minority Health and Health Disparities research framework to advance and achieve health equity.[3] The family systems approach may have been related to the larger group effects seen for some groups in their instant skin carotenoid score, particularly for groups that participated in the program during the school year, where the consistent access to fruits and vegetables through the school meal programs may have helped to increase the effects of targeting the family system. Future process evaluations of the HEPP program are needed in order to provide important

insights into the effects on family functioning on program outcomes, like instant skin carotenoid score, and to understand which components of the program were efficacious and how.

This research also adds to the growing literature of established protocols for collecting and interpreting Veggie Meter® data with Hispanic and Latino/a children. As reported by the HEPP program, the use of a Veggie Meter® in a research setting was relatively quick, non-invasive, and provided easy assessment for use. Additionally, the Veggie Meter® was acceptable to Mexican-heritage children. However, a few things warrant additional consideration. First, there were many issues with residual food staining that affected the consistency of the Veggie Meter® scans and resulted in finger usage protocol deviations. When a different finger was used for the skin carotenoid score, there were large discrepancies between the scores. While a protocol paper was published a year after this program was completed and recommends the use of the non-dominant ring finger,[4] additional research is needed to confirm the use of the non-dominant ring finger in the use of the Vegie Meter® and best practices for ensuring accurate, reliable assessment with Latino/a children and community-based data collection.

Second, it is unknown how accurately the Veggie Meter® device can measure all types of carotenoids, specifically lycopene.[5] Lycopene is a type of carotenoid that is predominantly found in tomato and tomato-based products and has been a reportedly difficult carotenoid for the Veggie Meter® to measure.[6-14] Considering how tomatoes and tomato-based products are an important part of dietary patterns for Mexican-heritage populations, future research might investigate how well the Veggie Meter® can detect all types of carotenoids, including lycopene.

Third, there has been discussion on the sensitivity of the Veggie Meter® and its sensitivity to change, that is how accurately it can measure changes in intakes of carotenoid-rich fruits and vegetables. Casperson et al. has found that an increase of approximately 0.8 cups of

high-carotenoid vegetable juice per day for 3 weeks increased skin carotenoid scores from baseline, while an increase of 1 cup of additional carotenoids were detected within one week.[7] Additional research is needed to understand Veggie Meter® sensitivity.

Lastly, there has been some discussion over how, if at all, seasonality of fruits and vegetables affect instant skin carotenoid scores, assessed by the Veggie Meter®. A systematic review by Hasnin et al. examining skin carotenoid scores across different racial and ethnic groups to identify potential non-dietary factors affect skin carotenoid scores and summarize the validity and reliability of skin carotenoid scores. [15] Hasnin et al. found four studies reporting seasonality changes in skin carotenoid scores relating to lower skin carotenoid in the winter months.[16-19] While current research is being done to confirm the accuracy and validity of the Veggie Meter® in all racial and ethnic groups, more research is needed regarding the use of the Veggie Meter® in community-based experiential nutrition education programs in different seasons and with different samples.

The challenges that Mexican American individuals face while living in the colonias along the south Texas-Mexico border emphasize the importance of programs grounded in community-based participatory research (CBPR) practices, like those found in the HEPP program. Community based participatory research emphasizes a collaborative approach that fosters co-learning and capacity building,[20] among community and research partners,[21,22] which is especially important in rural communities and communities of color. It is an approach that emphasizes current community assets, knowledge, and resources that can strengthen community capacity.[20] Community-capacity building is an important way of shifting power in ways that benefit marginalized communities to promote equitable knowledge and expertise sharing to build capacity and system changes to improve health outcomes.[23] The use of community based

participatory research, particularly for programs with multi-level interventions, allows all stakeholders to be involved and to develop programs that are more culturally appropriate and acceptable.[24] As part of capacity building, extensive formative work for the creation of the HEPP program included an iterative process of development and review. This all-encompassing formative work may have led to the success seen in certain components of the program and further outcome and process evaluations are needed before large replication and translation of this program can be conducted on a larger scale with varied population groups.

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Table 1. Baseline characteristics of full sample of Mexican-heritage children in the HEPP program

BMI: Body mass index; CDC: Centers for Disease Control and Prevention; SD: Standard Deviation.

Data for 57 children excluding 2 children with missing pre-test measures. Promotoras collected baseline data at the pre-test measure. P-values are for chi^2 tests of the unadjusted percentage distributions of categorical covariates and uncorrected overall p-value for analysis of variance (ANOVA) for means of continuous covariates. Differences were considered statistically significant at $p<0.05$.

Characteristics	Total	Group 1	Group 2	Group 3	Group 4	Group 5	*p-value*
Number of children, n	57	12	10	12	12	11	
Child							
Mexican-heritage ethnicity	57 (100%)	9 (100%)	10 (100%)	12 (100%)	12 (100%)	11 (100%)	
Age	10.21±0.94	10.26±0.27	10.36±0.3	10.1±0.27	10.52±0.27	9.8±0.28	0.4391
Sex							0.203
Male	27 (47.37%)	5 (41.67%)	3 (30%)	9 (75%)	4 (33.33%)	6 (54.55%)	
Female	30 (52.63%)	7 (58.33%)	7 (70%)	3 (25%)	8 (66.67%)	5 (45.45%)	
Instant skin carotenoid score (biomarker for dietary intake of fruits and vegetables)	213.54±61.57	242.63±17.77	208.7±19.46	213.79±17.77	194.46±17.77	206.77±18.56	0.4124
BMI z-score	1.14±1.15	0.9±0.34	1.05±0.37	1.2±0.34	1.35±0.34	1.21±0.36	0.9122
BMI percentile	77.57±27.89	69.04±8.21	74.26±8.99	81.24±8.21	82.84±8.21	80.12±8.57	0.7506
BMI categories							0.997
$< 85^{th}$ percentile	22 (38.6%)	6 (50%)	4 (40%)	4 (33.33%)	4 (33.33%)	4 (36.36%)	
85^{th} to $< 95^{th}$ percentile	11 (19.3%)	2 (16.67%)	2 (20%)	2 (16.67%)	3 (25%)	2 (18.18%)	
$\geq 95^{th}$ percentile	24 (42.11%)	4 (33.33%)	4 (40%)	6 (50%)	5 (45.45%)	5 (45.45%)	
Household food insecurity							
Food Secure	18 (31.58%)	3 (25%)	5 (50%)	2 (16.67%)	2 (16.67%)	6 (54.55%)	0.154
Food Insecure	39 (68.42%)	9 (75%)	5 (50%)	10 (83.33%)	10 (83.33%)	5 (45.45%)	

Table 2. Descriptive statistics for within-person change in child nutrition outcomes at post-test for Mexican-heritage children

BMI: Body mass index; CDC: Centers for Disease Control and Prevention; SD Standard Deviation.

Data for 55 children excluding 4 children with missing outcome data at all four data collection time points. This table presents changes in outcomes between the pre-test (baseline) and post-test measures for intervention groups. Promotoras completed post-test measures six weeks after baseline. P-values are for uncorrected overall p-value for analysis of variance (ANOVA) for differences in mean changes between intervention and control groups. *Statistically significant difference between group 5 and all other groups based on p-values <0.05 for group differences generated from Tukey test to control Type 1 error rate.

Characteristics	Total	Group 1	Group 2	Group 3	Group 4	Group 5	*p*-value
Number of children, n	55	9	10	13	12	11	
Program period							
Program dose, mean number of sessions (SD)	4.72 (2.15)	5.59 (0.94)	4.69 (2.19)	4.94 (2.12)	5.42 (1.69)	1.27* (0.79)	<0.001
Dietary intake of fruits and vegetables							
Within-person change in instant skin carotenoid score	-15.3 (6.2)	14.8 (23.8)	-18.2 (23.8)	-30.5 (21.6)	-21.7 (20.6)	-	
BMI							
Within-person change in BMI percentile	-0.34 (0.4)	1.79 (1.74)	1.43 (1.74)	-3.27 (1.57)	-0.56 (1.51)	-	
Within-person change in BMI z-score	-0.03 (0.02)	0.07 (0.07)	0.04 (0.07)	-0.15 (0.06)	-0.03 (0.06)	-	
Control period							
Dietary intake of fruits and vegetables							
Within-person change in instant skin carotenoid score	-5.5 (4.2)	4.9 (22.6)	-6 (20.6)	-13.4 (20.6)	-6 (21.6)	-	0.695
BMI							
Within-person change in BMI percentile	0.44 (0.41)	0.66 (1.65)	1.33 (1.51)	-0.58 (1.51)	0.4 (1.57)	-	0.787
Within-person change in BMI z-score	0.03 (0.02)	0.02 (0.07)	0.08 (0.06)	-0.01 (0.06)	0.01 (0.06)	-	0.561

Table 3 Descriptive statistics for within-person change in child nutrition outcomes at maintenance for Mexican-heritage children

BMI: Body mass index; CDC: Centers for Disease Control and Prevention; SD Standard Deviation.
Data for 24 children with fruit and vegetable intake and BMI outcome data at maintenance. This table presents changes in outcomes between the post-test and maintenance measures. Promotoras completed maintenance measures three to four months after the post-test. P-values are for uncorrected overall p-value for analysis of variance (ANOVA) for differences in mean changes between intervention and control groups. Differences were considered statistically significant at $p<0.05$.

Characteristics	Total	Group 1	Group 2	Group 3	Group 4	Group 5	*p*-value
Number of children, n	24	8	7	9	0	0	
Program dose, mean number of sessions (SD)	4.72 (2.15)	5.59 (0.94)	4.69 (2.19)	4.94 (2.12)	-	-	<0.001
Dietary intake of fruits and vegetables							
Within-person change in instant skin carotenoid score	-2.00 (7.3)	-3.38 (12.71)	-18.86 (13.59)	12.22 (11.98)	-	-	0.233
BMI							
Within-person change in BMI percentile	-1.6 (0.37)	-0.48 (0.64)	-2.45 (0.68)	-1.93 (0.6)	-	-	0.0925
Within-person change in BMI z-score	-0.05 (0.01)	-0.01 (0.03)	-0.07 (0.03)	-0.06 (0.02)			0.2133

Table 4 Program effects on instant skin carotenoid score and BMI for Mexican-heritage children

BMI: Body mass index; CDC: Centers for Disease Control and Prevention; CI: Confidence Interval.
This table presents model estimates and 95% confidence intervals (95% CI) for fruit and vegetable intake or BMI outcomes, based on change scores between pre- and post-test. Data for 41 children excluding 18 children missing pre- or post-test data. Estimates are mean within-person changes in outcomes obtained using Stata's margins command. The adjusted models controlled for age, sex, month of baseline data collection, intervention/program dose (number of sessions attended), and baseline value of outcome.

Outcome	Unadjusted Estimate	(95% CI)	Adjusted Estimate	(95% CI)
Dietary intake of fruits and vegetables				
Change in instant skin carotenoid score	-14.67	(-30.9, 1.56)	-15.14	(-24.95, -5.33)
BMI				
Change in BMI percentile	-0.18	(-2.16, 1.79)	-0.2	(-0.89, 0.49)
Change in BMI z-score	-0.02	(-0.1, 0.06)	-0.02	(-0.05, 0.00)

Table 5 Program completion by group

This table presents counts and proportions for program completion. The program had six weekly sessions. Children in groups 1 through 4 completed a maximum of six sessions. Due to the timing of the COVID-19 pandemic in winter of 2020, group 5 stopped at session 2. Children in group 5 completed a maximum of two sessions.

	Total (n = 59)	**Group 1** (n = 12)	**Group 2** (n = 10)	**Group 3** (n = 13)	**Group 4** (n = 12)	**Group 5** (n = 12)
All, 6 sessions, n (%)	52.5% (31)	58.3% (7)	50% (5)	69.2% (9)	83.3% (10)	0
Most, 4 or 5 sessions, n (%)	6.8% (4)	8.3% (1)	20% (2)	0	8.3% (1)	0
Half, 3 sessions, n (%)	3.4% (2)	8.3% (1)	0	7.7% (1)	0	0
Some, 1 or 2 sessions, n (%)	22.0% (13)	16.7% (2)	10% (1)	7.7% (1)	0	75%) (9)
None, no sessions, n (%)	15.3% (9)	8.3% (1)	20% (2)	15.4% (2)	8.3% (1)	25% (3)

Table 6 Protocol deviations, out of range scores, and range of Veggie Meter® scores by measurement visit

Protocol deviations were documented for the following reasons: error that score was" out of range" or promotoras observations that child had residual staining from foods or cuts on finger. In some cases, a promotora was not able to obtain a reading on the first attempt or second attempt (even after recalibrating), and after a failed second attempt, they obtained a score on the other finger and documented that score. Promotoras noted when which finger was used for the scan and when there were multiple attempts to obtain a score.

	Transition A or B	**Pre-test A or B**	**Post-test A or B**	**Maintenance**
Number of protocol deviations	6	7	14	0
Number of out-of-range Veggie Meter® scores	5	4	8	1
Number of out-of-range scores where scores were missing (No Veggie Meter® score)	1	2	3	0
Minimum – maximum Score	52 - 341	17- 409	24 - 498	34 - 428
Number of scores below 100	4	7	10	1
Example comments from promotora	"Used left index finger because the right index finger had hot Cheetos residue and reading was showing out of range."	"Child had been eating Cheetos and had to use other hand."	"When measurement for right index finger was conducted reading was out of range. Second try on left index finger reading was also out of range"	"Out of range twice, switched to the left index finger."

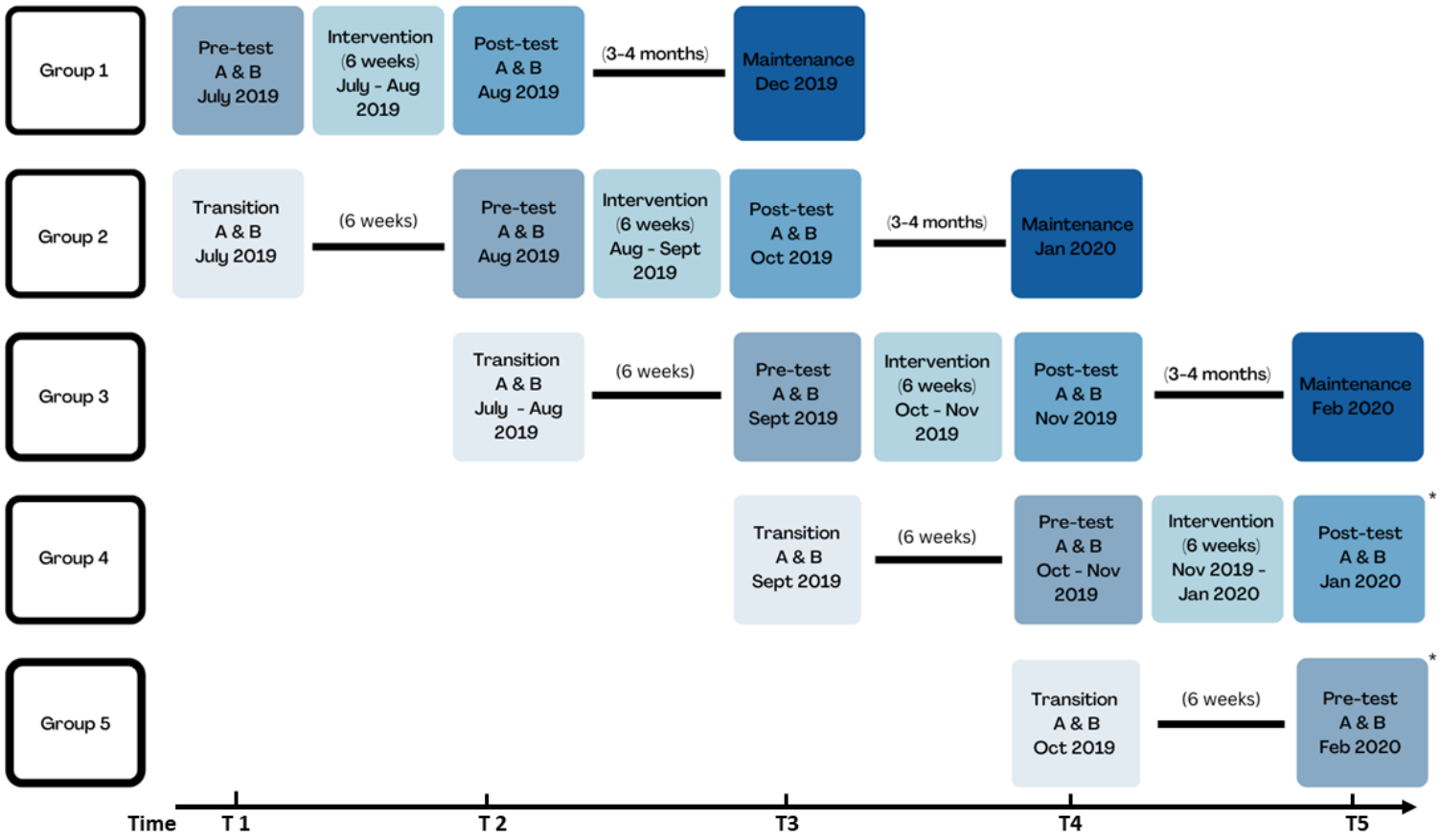

Figure 1. Modified stepped-wedge study design for HEPP program

This figure shows the modified stepped-wedge study design with data collection time points T1 through T5. The time between post-test and maintenance is not shown to scale. The transition measure was critical for the delayed intervention (or wait listed control) group. Due to the COVID-19 pandemic in early 2020, Group 4 did not complete a maintenance measure (last measure was post-test). Group 5 did not complete the program and had no post-test or maintenance measure (last measure was pre-test).

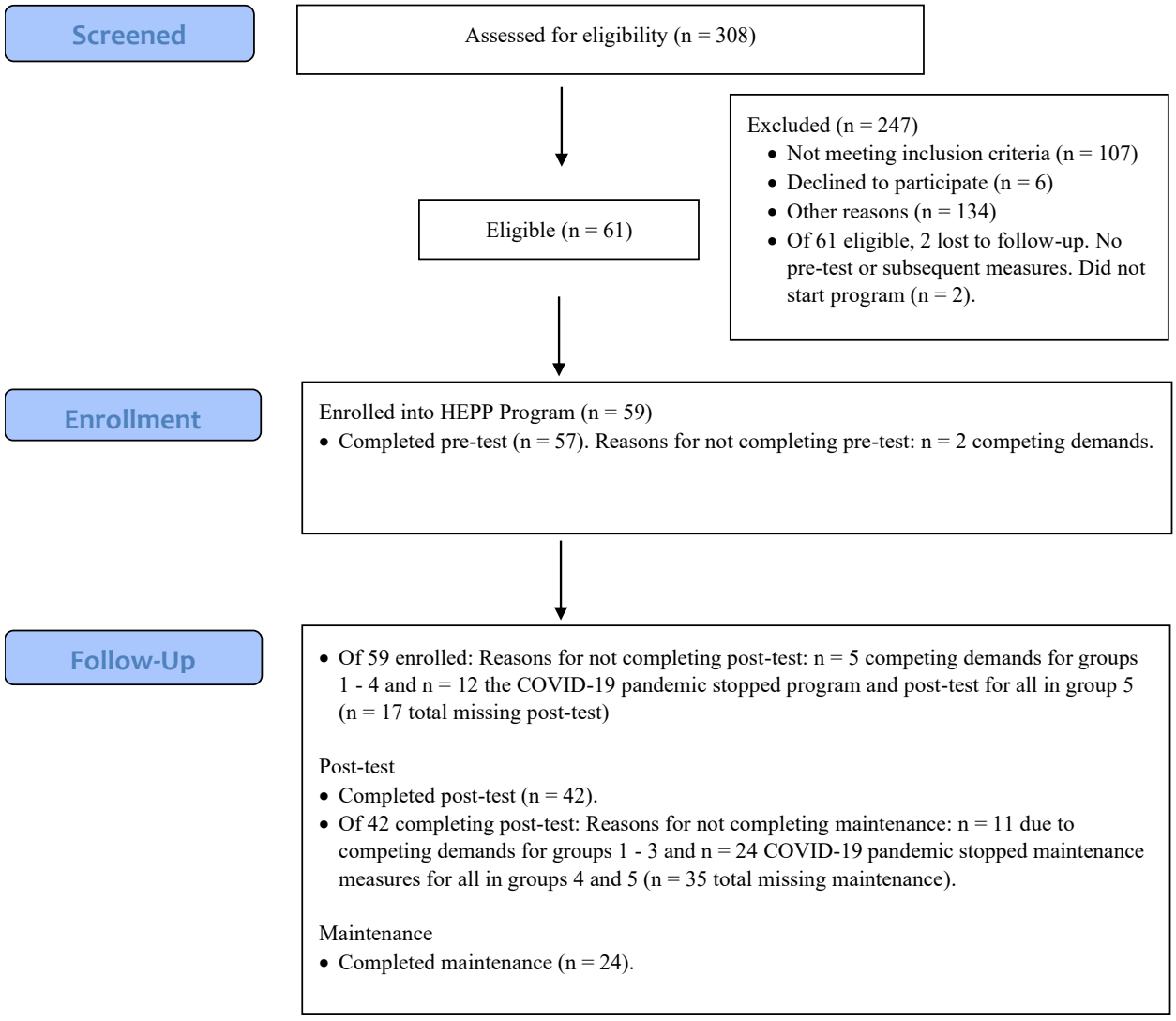

Figure 2. Participant recruitment and enrollment for HEPP program
Figure shows flow of participants from recruitment through enrollment and follow-up (post-test and maintenance measures.

APPENDIX SECTION

Table 1. Sample and study characteristics of included studies

Citation/Title/Year	Approach/Study Design	Setting & Sample	Ethnicity/Socioeconomic status
Bell, B.; Martinez, L.; Gotsis, M.; Lane, CH.; Davis, JN.; Antunez-Castillo, L.; Ragusa, G.; Spruijt-Metz, D. *Virtual Sprouts: A virtual gardening pilot intervention increases self-efficacy to cook and eat fruits and vegetables in minority youth* 2018	Quantitative w/a quasi- experimental pre/post-test with comparison group study design.	Urban (Los Angeles, CA). 3-5th grade. Intervention: 60 (51.7%) males. Control: 24 (37.5%) males.	Intervention: 11 (9.5%) Latino. 73 (63%) Black. 1 (0.9%) Native American. 30 (25.9%) Mixed race. Control: 7 (11.3%) Latino. 1 (1.6) white. 36 (58.1%) Black. 18 (29%) mixed race. 107 (92.2)% eligible for free lunch (intervention).
Chen, Q.; Goto, K.; Wolff, C.; Bianco-Simeral, S.; Gruneisen, K.; Gray, K. *Cooking up diversity. Impact of a multicomponent, multicultural, experiential intervention on food and cooking behaviors among elementary-school students from low-income ethnically diverse families* 2014	Quantitative w/a quasi- experimental pre/post-test with comparison group study design. Mixed methods	NR (Northern California). 5-8 years old. 604 students. (270 males. 270 females. 189 male student survey pre-post matched students; 188 female.)	42% white. 32% Hispanics/Latino. 9% Asian. 16% other ethnic groups 80% of students qualify for free or reduced price lunch.
Cunningham-Sabo, L.; Lohse, B. *Cooking with kids positively affects fourth graders' vegetable preferences and attitudes and self-efficacy for food and cooking* 2013	RCT. Pre and post test	NR (Northern Colorado school district.) 4th graders. 257 students. (118 boys. 139 girls.)	75% white. 18-28% of students qualifying for free or reduced-priced lunch by school.
Davis, J. N.; Martinez, L. C.; Spruijt-Metz, D.; Gatto, N. M.	RCT. Pre and post test	Urban (Los Angeles, CA). 3-5th grade.	Intervention: 119 (88.8%) Hispanic. 2 (1.5%) Asian. 2 (1.5%) Non-Hispanic White.

Citation/Title/Year	Approach/Study Design	Setting & Sample	Ethnicity/Socioeconomic status
LA Sprouts: A 12-week gardening, nutrition, and cooking randomized control trial improves determinants of dietary behaviors 2016		372 students (204 intervention. 171 control.) Intervention: 69 (50.4%) male. 68 (49.6%) female. Control: 78 (46.7) male. 89 (53.3%) female.	11 (8.2%) Other. Control: 148 (88.6%) Hispanic. 1 (0.6%) Asian. 4 (2.4%) Non-Hispanic Black. 2 (1.2%) Non-Hispanic white. 12 (7.2%) Other. Schools eligible if ≥75% Hispanic/Latino, ≥75% on free or reduced lunch, within 10 miles of USC campus, & willing to participate
Davis, J. N.; Ventura, E. E.; Cook, L. T.; Gyllenhammer, L. E.; Gatto, N. M. *LA Sprouts: a gardening, nutrition, and cooking intervention for Latino youth improves diet and reduces obesity* 2011	Quantitative w/a quasi- experimental pre/post-test with comparison group study design	Urban (Los Angeles, CA). 4-5th grade. 104 participants. (Intervention: 13 boys & 21 girls. Control: 41 boys & 29 girls.)	Intervention: 97% Latino. 3% Asian. Control: 93% Latino 4% white, 3% Asian. Measured by asking if family uses a computer at home and if mom had own car. Intervention: 64.7% mothers had their own car. 82.4% had computer at home. Control: 54.6% mothers had their own car. 66.7% had computer at home.
Davis, J. N.; Perez, A.; Asigbee, F. M. Landry, M. J.; Vandyousefi, S.; Ghaddar, R.; Hoover, A.; Jeans, M.; Nikah, K.; Fischer, B.; Pont, S. J.; Richards, D.; Hoelscher, D. M.; Van Den Berg, A. E. *School-based gardening, cooking and nutrition intervention increased vegetable intake but did not reduce BMI: Texas sprouts - a cluster randomized controlled trial* 2021	Cluster RCT. 16 elementary schools. Texas Sprouts Intervention (n=8 schools) or control (n=8. Delayed intervention). Implemented in 3 waves over 3 yrs. Wave 1 & 2: 6 schools (3 intervention and 3 control). Wave 3: 4 school (2 intervention and 2 control).	NR (60 miles of central Austin). 3-5th grade. Intervention: n=1212 students. Delayed Intervention: n=1509 students. 47% male	64% Hispanic. 69% of children received free and reduced breakfast/lunch.
Ehrenberg, S.; Leone, L. A.; Sharpe, B.; Reardon, K.; Anzman-	Pre and Post test	NR (Summer camp in Buffalo, NY).	94.1% Black. 5.9% Latino

Citation/Title/Year	Approach/Study Design	Setting & Sample	Ethnicity/Socioeconomic status
Frasca, S. *Using repeated exposure through hands-on cooking to increase children's preferences for fruits and vegetables* 2019		6-8 years old. 76.5% girls. 17 participants.	To be eligible for summer camp, families had to qualify for free or reduced price school meals.
Ford, A. D.; Colby, S. E.; McElrone, M.; Franzen-Castle, L..; Olfert, M. D.; Kattelmann, K. K.; White, A. A. *Cooking frequency associated with dietary quality in iCook-4H youth participants at baseline* 2019	RCT.	Rural (Children lived in Main, Nebraska, Tennesse, South Dakota, and West Virginia.) 9-10 years old 228 children. 56% female (n=124). 44% male (n=97).	67% white (n=142). 33% non-white (n= 69). 41% participated in government assistance programs (n=83).
Gatto, N.M.; Martinez, L. C.; Spruijt-Metz, D.; Davis, J. N. *LA sprouts randomized controlled nutrition, cooking and gardening programme reduces obesity and metabolic risk in Hispanic/Latino youth* 2017	RCT. Pre and post test	Urban (Los Angeles, CA). 3-5th grade. Male: 82.	Hispanic: 153 (89%) School ID as eligible: $\geq$75% of students participating in free lunch program, study body $\geq$75% Latino, had after school program, within 10 miles of USC, was interested in school garden/hosting garden program, make admin commitment. N=172 48 no English spoke at home. 42 no computer at home. 39 no interent at home. 57 mothers don't own a car. 152 eligible for free lunch at school.
Heerman, W. J.; Elsakary, Y.; Sommer, E. C.; Escarfuller, J.; Barkin, S. L. *Assessing the scale and spread of an experiential teaching kitchen in after-school programming among school-age children*	Pre and post test	Urban (Nashville, TN.). 25 Parks & Rec centers. 6-14 years old 369 participants. (8-20 participants/group. 53.7% identified as girl.)	Predominantly low income, minority children (most households had annual incomes below fed poverty level).

Citation/Title/Year	Approach/Study Design	Setting & Sample	Ethnicity/Socioeconomic status
2020			
Jarpe-Ratner, E.; Folkens, S.; Sharma, S.; Edens, N. K. *An experiential cooking and nutrition education program increases cooking self-efficacy and vegetable consumption in children in grades 3-8* 2016	Quantitative w/a quasi- experimental pre/post-test with comparison group study design	Urban (Chicago (17 elementary schools & 1 middle school.)) 3-8th grade. 271 students.	49% African American. 42% Hispanic 94% eligible for free or reduced-price lunch.
Knapp, M. B.; Hall, M. T.; Mundorf, A. R., Partridge, K. L.; Johnson, C. C. *Perceptions of school-based kitchen garden programs in low-income, African American communities* 2019	Qualitative approach with focus groups.	Urban (New Orleans, LA). 5-8th grade (10-14 years old) 53.9% male, 46.1% female students. 100% female parents. 82.4% female teachers. 27 students, 17 parents, 2 with teachers in focus groups.	Predominantly African American schools. 100% African American students. 66.7% African American parents. 23.5% African American teachers. 84% students qualify for SNAP and Medicaid benefits.
Lukas, C.; Cunningham-Sabo, L. *Qualitative investigation of the Cooking with Kids program: focus group interviews with fourth-grade students, teachers, and food educators* 2011	Qualitative	Urban (Santa Fe, NM) 4th grade. 178 participants. (86 girls. 92 boys.)	~half of Sante Fe residents identify as Hispanic or Latino. 107 (92.2)% eligible for free lunch (intervention). 45 (72.6%) control.
Lohse, B.; Cunningham-Sabo, L.; Walters, L. M.; Stacey, J. E. *Valid and reliable measures of cognitive behaviors toward fruit and vegetables for children aged 9 to 11 years*	Pre and post test	Urban (Santa Fe, NM). 4-5th grade. (14 classrooms in 6 schools). Intervention: 344 participants. (183 males (53.8%)).	Intervention: 245 Hispanic (72.9%) 64 white (19%) 20 American Indian (6) 5 Asian (1.5%) 2 Black (2%) Schools were eligible if they had 50% or more students who qualify for free or reduced-price school meals

Citation/Title/Year	Approach/Study Design	Setting & Sample	Ethnicity/Socioeconomic status
2011			
Martinez, L.; Gatto, N.; Spruijt-Metz, D.; Davis, J. *Design and methodology of the LA Sprouts nutrition, cooking and gardening program for Latino youth: A randomized controlled intervention* 2015	RCT. Pre and post test	Urban (Los Angeles, CA). (Schools with an afterschool program within Los Angeles Unified School District (LAUSD)) 3-5th grade. Intervention: 94 males (47.5%) Control: 79 males (47.6%)	Intervention: 175 Latino (88.4%). Control: 142 Latino (87.7%) Schools were eligible if they had a student body ≥75% Latino, ≥75% of students participated in free lunch program, offered after-school program, within 10 miles of USC Health Science Campus, and expressed interest and could make admin commitment.
Melnick, E. M.; Thomas, K.; Farewell, C.; Quinlan, D. L.; Brogden, S. S.; Puma, J. E. ***Impact of a nutrition education programme on preschool children's willingness to consume fruits and vegetables*** 2020	Quasi-experimental. Pre and post surveys.	Urban (Denver metro) 3-6 years old. 308 children intervention group. 215 comparison group.	54.1% Hispanic/Latino 22.9% Non-Hispanic white. 14.4% non-Hispanic black. 96% free & reduced lunch
Olfert, M. D.; Hagedorn, R. L.; Leary, M. P.; Eck, K.; Shelnutt, K. P.; Byrd-Bredbenner, C. *Parent and school-age children's food preparation cognitions and behaviors guide recommendations for future interventions* 2019	Qualitative approach with focus groups.	NR (Children & parents lived in Florida, West Virginia, or New Jersey.) (13 in NJ, 12 in WV, & 12 in FL) 6-11 years old 37 children. 51% males	NR
Overcash, F.; Ritter, A.; Mann, T.; Mykerezi, E.; Redden, J.; Rendahl, A.; Vickers, Z.; Reicks, M. *Impacts of a vegetable cooking skills program*	Pre and post test	Urban (Minneapolis-St. Paul, MN). 9-12 years old. 89 participants. 63% female	43% Hispanic Family had to qualify for public assistance

Citation/Title/Year	Approach/Study Design	Setting & Sample	Ethnicity/Socioeconomic status
among low-income parents and children 2018			
Santarossa, S.; Ciccone, J.; Woodruff, S. J. *An evaluation of the Kinect-Ed presentation, a motivating nutrition and cooking intervention for young adolescents in grades 6-8* 2015	Pre and post test	NR (Ontario, Canada). 6-8th grade. 219 participants. 54% males. 46% female.	88% white. 12% Black, Chinese, Arabic, South Asian, Aboriginal.
Sharma, S.; Helfman, L.; Albus, K.; Pomeroy, M.; Chuang, R. J.; Markham, C. *Feasibility and acceptability of brighter bites: A food Co-Op in schools to increase access, continuity and education of fruits and vegetables among low-income populations* 2015	Pre and post test	Urban (Houston, TX). 3rd grade. 60% boys	94.1% Hispanic 91% free or reduced price school lunch
Wolfe, W. S.; Dollahite, J. *Evaluation of the choose health: Food, fun, and fitness 3rd- to 6th-grade curriculum: Changes in obesity-related behaviors* 2021	Quantitative w/a quasi- experimental pre/post-test with comparison group study design	Rural and Urban. (5 New York counties. 15 school classrooms were rural (population <10,000). 8 after school were rural. 4 school classrooms were large town/small city (population 10-50,000). 14 after school larger town/small city. 9 school classrooms were urban (>8M). 5 after school was urban.) 3-6th grade. 561 students. (48% female (school classrooms). 49% female (After	58% white. 25% black. 16% Hispanic. 17% Other. Schools had to have at least 50% of students eligible for free/reduced price lunch & after school programs had to be in schools or draw mostly low-income youth.

Citation/Title/Year	Approach/Study Design	Setting & Sample	Ethnicity/Socioeconomic status
		school).) 27 after school & 28 in school groups.	

Table 2. Intervention characteristics of included studies

Citation/Title/ Year	Intervention format (Individual, dyads, or group)	Dose & Delivery	Nutr/Gardening class	Intervention Training & Roles	Strategies for Developing Culturally Relevant Intervention
Bell, B.; Martinez, L.; Gotsis, M.; Lane, CH.; Davis, JN.; Antunez-Castillo, L.; Ragusa, G.; Spruijt-Metz, D. *Virtual Sprouts: A virtual gardening pilot intervention increases self-efficacy to cook and eat fruits and vegetables in minority youth* 2018	Individual	3 wk intervention. Played Virtual Sprouts on tablets for one hr/wk. One family home activity a wk that usually spanned over a course of 3 days. **Online	Yes- virtually	Nutr educator who taught classroom teachers	NR
Chen, Q.; Goto, K.; Wolff, C.; Bianco-Simeral, S.; Gruneisen, K.; Gray, K. *Cooking up diversity. Impact of a multicomponent, multicultural, experiential intervention on food and cooking behaviors among elementary-school students from low-income ethnically diverse families* 2014	Dyad. Parent and child	20 min cooking class. **IN person	Nutr class	Nutr educator taught teachers. Teachers facilitated food demonstrations and tasting activities.	Seven cultural/ethnic food recipes were developed with input from interventions students' parents and Latino and Hmong bilingual/bicultural staff and represented Latino, Hmong, and mainstream American cultures.

Cunningham-Sabo, L.; Lohse, B. *Cooking with kids positively affects fourth graders' vegetable preferences and attitudes and self-efficacy for food and cooking* 2013	Group	6 lessons over 10 weeks. **IN person	Tasting class	Food educator (graduate nutrition student with 30 hrs of training) led cooking class with help from classroom teacher and another trained graduate student. Tasting class led by second trained graduate student with help from classroom teacher.	NR
Davis, J. N.; Martinez, L. C.; Spruijt-Metz, D.; Gatto, N. M. *LA Sprouts: A 12-week gardening, nutrition, and cooking randomized control trial improves determinants of dietary behaviors* 2016	Group	12 wks 90min/wk lesson. 45 min cooking/nutr edu. 45 min gardening **In person	Nutr class: eaten in "family style" manner Gardening class	Nutr educators with strong background in cooking and nutrition Garden educators with strong background in gardening.	Focused on Hispanic students
Davis, J. N.; Ventura, E. E.; Cook, L. T.; Gyllenhammer, L. E.; Gatto, N. M. *LA Sprouts: a gardening, nutrition, and cooking*	Group	12 wks. 90 min/wk. 45 min cooking & nutr edu. 45 min gardening lesson	Nutr class: eaten in "family style" manner Gardening class	Cooking & nutr edu taught by study staff member or nutr graduate student & supervised by RD. Gardening taught by	Focused on Hispanic students

intervention for Latino youth improves diet and reduces obesity 2011		** In person		Latina Master Gardener from UC.	
Davis, J. N.; Perez, A.; Asigbee, F. M. Landry, M. J.; Vandyousefi, S.; Ghaddar, R.; Hoover, A.; Jeans, M.; Nikah, K.; Fischer, B.; Pont, S. J.; Richards, D.; Hoelscher, D. M.; Van Den Berg, A. E. *School-based gardening, cooking and nutrition intervention increased vegetable intake but did not reduce BMI: Texas sprouts - a cluster randomized controlled trial* 2021	Dyad (child/parent)	18 one-hour Texas Sprouts lessons separately to each 3-5th grade class throughout the school yr as part of their school day. Every lesson had either a garden taste-test (7 lessons) or cooking activity (11 lessons). ***In person	Nutr class Gardening class	Taught by college graduates in either horticultural, nutrition, or public health and at least 3 yrs of teaching nutr and gardening lessons to children.	Designed to be culturally customized to Hispanics. Contained appropriate recipes, content and activities. Designed with input from Hispanic families and tested to ensure lessons were culturally sensitive and appropriate.
Ehrenberg, S.; Leone, L. A.; Sharpe, B.; Reardon, K.; Anzman-Frasca, S. *Using repeated exposure through hands-on cooking to increase children's preferences for fruits and vegetables*	Group	6 wks (biweekly) **** IN person	Games & activities	Unknown- just says study staff	NR

2019					
Ford, A. D.; Colby, S. E.; McElrone, M. Franzen-Castle, L..; Olfert, M. D.; Kattelmann, K. K.; White, A. A. *Cooking frequency associated with dietary quality in iCook-4H youth participants at baseline* 2019	Dyad- parent and child	2 year out-of-school program intervention ***In person	NR	NR	NR
Gatto, N.M.; Martinez, L. C.; Spruijt-Metz, D.; Davis, J. N. *LA sprouts randomized controlled nutrition, cooking and gardening programme reduces obesity and metabolic risk in Hispanic/Latino youth* 2017	Group	Once a week for 12 wks. 45 min cooking/nutr lesson. 45 min gardening lessons *** In person	Nutr class: eaten in "family style" manner Gardening class	Nutr & gardening educator with nutrition or gardening background	Focused on Hispanic students
Heerman, W. J.; Elsakary, Y.; Sommer, E. C.; Escarfuller, J.; Barkin, S. L. *Assessing the scale and spread of an experiential teaching kitchen in after-school programming among school-*	Group	4 month long, 2x/month, for 30 min. ****IN person	Nutr class	Teaching kitchen sessions were delivered by staff of the Parks and Recreation department. No previous training	NR

age children 2020					
Jarpe-Ratner, E.; Folkens, S.; Sharma, S.; Edens, N. K. *An experiential cooking and nutrition education program increases cooking self-efficacy and vegetable consumption in children in grades 3-8* 2016	Dyad. Parent and child	10wk after school cooking/nutr edu course. 30 min lecture/discussion of nutr principles & cultural awareness. 75 min culinary skill & cooking. 15 min meal sharing/conversation 10 wk 2 hour/wk. **In person	Nutr class w meal sharing	Professional chef-instructors (supported by Common Threads program manager).	Focused on African American students
Knapp, M. B.; Hall, M. T.; Mundorf, A. R., Partridge, K. L.; Johnson, C. C. *Perceptions of school-based kitchen garden programs in low-income, African American communities* 2019	Dyads. Parents, child, & teacher	10 45min focus groups across 4 middle schools (4 w students, 4 with parents, 2 with teachers) **In person	NR	Focus group facilitator had master's degree in nutr sci, qualitative research experience & training.	Focused on African American students
Lukas, C.; Cunningham-Sabo, L. *Qualitative investigation of the Cooking with Kids program: focus group interviews with fourth-grade students, teachers, and food educators* 2011		2 hr cooking class and 1 hr F&V tasting class Assigned to either cooking & tasting (5 cooking, 5 tasting), tasting-only intervention (5 tasting), or comparison condition. **IN person	NR	Classroom teachers	NR

Lohse, B.; Cunningham-Sabo, L.; Walters, L. M.; Stacey, J. E. *Valid and reliable measures of cognitive behaviors toward fruit and vegetables for children aged 9 to 11 years* 2011	Group	2 surveys administered 9, 10, or 13 days apart. Survey lasted 20-30 minutes. ** IN person	No nutr education occurred between testing times	Classroom teachers reading instructions	NR
Martinez, L.; Gatto, N.; Spruijt-Metz, D.; Davis, J. *Design and methodology of the LA Sprouts nutrition, cooking and gardening program for Latino youth: A randomized controlled intervention* 2015	Group	12 weekly lessons, 90 min long (45 min nutr edu/cooking. 45 min gardening) **IN person	Nutr class: eaten in "family style" manner Gardening class	Nutr educator with strong background in cooking & nutr. Gardening educator (UCCE Common Ground certified Master Gardeners)	Focused on Hispanic students
Melnick, E. M.; Thomas, K.; Farewell, C.; Quinlan, D. L.; Brogden, S. S.; Puma, J. E. ***Impact of a nutrition education programme on preschool children's willingness to consume fruits and vegetables*** 2020	Group	12 classroom-based nutr edu (COWP-NE) lasting 30-45 min 12 lessons during 2015-16 school yr. *****IN person	NR	Preschool teachers	NR
Olfert, M. D.;	Dyad- parent	60 min focus	NR (not reported)	Focus groups	NR

Hagedorn, R. L.; Leary, M. P.; Eck, K.; Shelnutt, K. P.; Byrd-Bredbenner, C. *Parent and school-age children's food preparation cognitions and behaviors guide recommendations for future interventions* 2019	and child	group **IN person		were conducted by a team of 2 researchers, 1 of whom moderated the group; the other served as a notetaker. All researchers completed formal training and practice sessions to standardize data collection across researchers and focus group sites.	
Overcash, F.; Ritter, A.; Mann, T.; Mykerezi, E.; Redden, J.; Rendahl, A.; Vickers, Z.; Reicks, M. *Impacts of a vegetable cooking skills program among low-income parents and children* 2018	Dyad. Parent and child	Six 2-hour cooking skills & nutr education sessions. **In person	Nutr classes	Nutr educators and chefs.	NR
Santarossa, S.; Ciccone, J.; Woodruff, S. J. *An evaluation of the Kinect-Ed presentation, a motivating nutrition and cooking intervention for young adolescents in grades 6-8*	Group	90 min presentation **In person	NR	Sandi Richard (Kinect-Ed was developed by Sandi Richard, a Food Network Host and International Best Selling author, and Dr. Sarah Woodruff, a professor at	NR

2015				the University of Windsor)	
Sharma, S.; Helfman, L.; Albus, K.; Pomeroy, M.; Chuang, R. J.; Markham, C. *Feasibility and acceptability of brighter bites: A food Co-Op in schools to increase access, continuity and education of fruits and vegetables among low-income populations* 2015	Dyad. Parent and child	16 wk **In person	Nutr class	Teachers	Focused on Hispanic students
Wolfe, W. S.; Dollahite, J. *Evaluation of the choose health: Food, fun, and fitness 3rd- to 6th-grade curriculum: Changes in obesity-related behaviors* 2021	Group	6 lessons 45 min long. (2 recipes/lesson) 6 lessons- 3 in after-school setting & 3 in school classroom ***IN person	Nutr class EFNEP para-professional nutr educators & their nutr professional supervisors	Local supervisors	NR

Table 3. Comparison of study designs, primary and secondary outcomes, and analytic plans for previous community-based programs

***Program focused on Latino and African American children.

NR: Not reported

Abbreviated Citation	Program Name	Study Design	Primary Outcomes	Secondary Outcomes	Analysis
Hannon et al. 2019	Abriendo Caminos Program	RCT	Prevent excess weight gain in children, improve dietary habits, and family routines, compared with control group.	Nutrition-related outcomes include change in servings/week of food groups like fruits, vegetables, and SSBs.	Mixed-effects model with a random intercept and slope to determine change in repeated measures of outcomes (p. 1217)
Sharma et al. 2015	Brighter Bites	Single group with pre- and post-test (Feasibility study)	Provide access to fresh FV & nutrition education	Increase demand & intake of FV	Pearson's Chi square test, Fisher's exact test (if cell size was <5), or a paired t
Cunningham-Sabo et al. 2013	Cooking with Kids	RCT. Pre-and post-test with comparison group.	Assess the effect of CWK in a different study sample (e.g., mostly non-Hispanic white)	Determine whether CWK had greater effect with a sample that had no previous CWK exposure.	General linear models (p. 2)

Abbreviated Citation	Program Name	Study Design	Primary Outcomes	Secondary Outcomes	Analysis
Schmied et al. 2015; Horton et al. 2013	Entre Familia: Reflejos de Salud	RCT with a delayed-treatment control condition	Provide a comprehensive description of the process evaluation measures used; Describe development, implementation, and immediate post-intervention effects on child-reported dietary intake, specifically fruits and vegetables, fast food, and SSB consumption.	Assess intervention fidelity	Regression analyses (pg. 4, Schmied et al. 2015). Generalized linear models (pg. 5, Horton et al. 2013)
Po'e et al. 2013	Growing Right Onto Wellness (GROW)	Parallel-group RCT***	Evaluate efficacy of intervention to prevent pediatric obesity (i.e., BMI trajectory) among children ages 3–5.	Compare effect in children who made significant changes in their dietary and/or physical activity behaviors to the effect in children who	Quadratic mixed model (pg. 12)

Abbreviated Citation	Program Name	Study Design	Primary Outcomes	Secondary Outcomes	Analysis
				did not.	
Morgan et al. 2011; Morgan et al. 2014	Healthy Dads, Healthy Kids	RCT with wait-list control (Feasibility study)	Body weight of fathers (kg and percentage) at 6-month follow-up; Implement and evaluate the HDHK intervention, when delivered by trained local facilitators in a community setting.	BMI, waist circumference, blood pressure & resting heart rate, physical activity, & dietary intake of fathers and children	Linear mixed model (pg. 5, Morgan et al. 2011) (pg. 3, Morgan et al. 2014)
Ford et al. 2019; Kattelmann et al. 2019	iCook 4-H Study	RCT	Determine cooking self-efficacy and frequency of 9- to 10-year-old youth at baseline of a 2-year intervention study program	NR	Independent-sample t-tests (pg. 3, Ford et al. 2019) Linear mixed models (pg. 5, Kattelmann et al. 2019)

Abbreviated Citation	Program Name	Study Design	Primary Outcomes	Secondary Outcomes	Analysis
			and the associations of those factors with dietary quality and body mass index (BMI); Report physical activity and sedentary time outcomes of youth.		
Davis et al. 2011; Davis et al. 2016; Gatto et al., 2017	LA Sprouts	RCT. Pre-and post-test with comparison group.	Dietary intake of FV (Davis et al., 2011; Gatto et al., 2017); Obesity parameters (i.e., body mass index [BMI], waist circumference, percent body fat), and blood pressure (Davis et al., 2011);	Preference for FV, willingness to try FV, identification of FV, self-efficacy to garden, eat and cook FV, motivation to garden, eat, and cook FV, attitudes towards FV, nutrition and gardening knowledge; and gardening at home habits (Davis et al., 2016) Reductions in adiposity and metabolic risk factors (Gatto	Generalized weighted linear mixed models (GLMM). Generalized weighted linear mixed models (GLMM). (p. 6, Davis et al., 2011) (p. 5, Gatto et al., 2017)

Abbreviated Citation	Program Name	Study Design	Primary Outcomes	Secondary Outcomes	Analysis
				et al., 2017)	
Zhang et al. 2019	Padres Preparados, Jóvenes Saludables	One-group, pre-test/post-test, quasi-experimental design with a small convenience sample	Dietary intake, physical activity, and screen time among early adolescents and their parents.	Latino parents' parenting styles and food- and activity-related parenting practices.	Paired sample t-tests (pg. 11)
Davis et al. 2021	TX Sprouts	Cluster RCT. Pre-and post-test with comparison group.	Dietary intake of FV; Obesity outcomes; Blood pressure.	Psychosocial variables (gardening and nutrition knowledge, self-efficacy and attitudes toward gardening and cooking FV, willingness to try and preferences for FV, food security)	Generalized weighted linear mixed models (GLMM). (p. 6)

Abbreviated Citation	Program Name	Study Design	Primary Outcomes	Secondary Outcomes	Analysis
Bell et al. 2018	Virtual Sprouts	Quantitative w/a quasi-experimental pre/post-test with comparison group study design.	Dietary intake of FV.	Gardening knowledge; preference for and motivation to eat FV; self-efficacy to cook and eat FV.	Mixed models (p. 4)

Table 4. Measures and timing of data collection for the entire HEPP program

This table shows measures to evaluate the program. The pre- and post-test measures were collected before and after the program. Data were collected at two-time points A and B to collect dietary intake and physical activity data over a 7-day period. Data collection techniques included interviewer-administered surveys, more objective techniques like reflection spectroscopy with the VeggieMeter for fruits and vegetable intake, accelerometry for physical and sedentary activity, anthropometry for height and weight), and subjective techniques like semi-structured interviews (qualitative data) for the process evaluation. The nutrition survey included questions to assess psychosocial indicators related to nutrition, eating behaviors, and food practices, and there was a similar survey for physical activity. Semi-structured interviews were used to learn more about participants' experiences in the program as part of the process evaluation. All measures were collected for all individuals: fathers, children, and mothers.

	Pre-test		Post-test		Short-term maintenance (3-4 months after program)	
	A	**B**	**A**	**B**	**A**	**B**
Interviewer-administered nutrition survey	X		X		X	
Family functioning survey		X		X		
Physical activity survey		X		X	X	
Demographic survey	X					
Food security survey	X		X			
Reflection spectroscopy (Veggie Meter ® for instant skin carotenoid score)	X	X	X	X	X	
Accelerometry (Physical activity behaviors)	X	X	X	X	X	X
Anthropometry (Height and weight for calculating body mass index)	X	X	X	X	X	
Semi-structured interviews						X

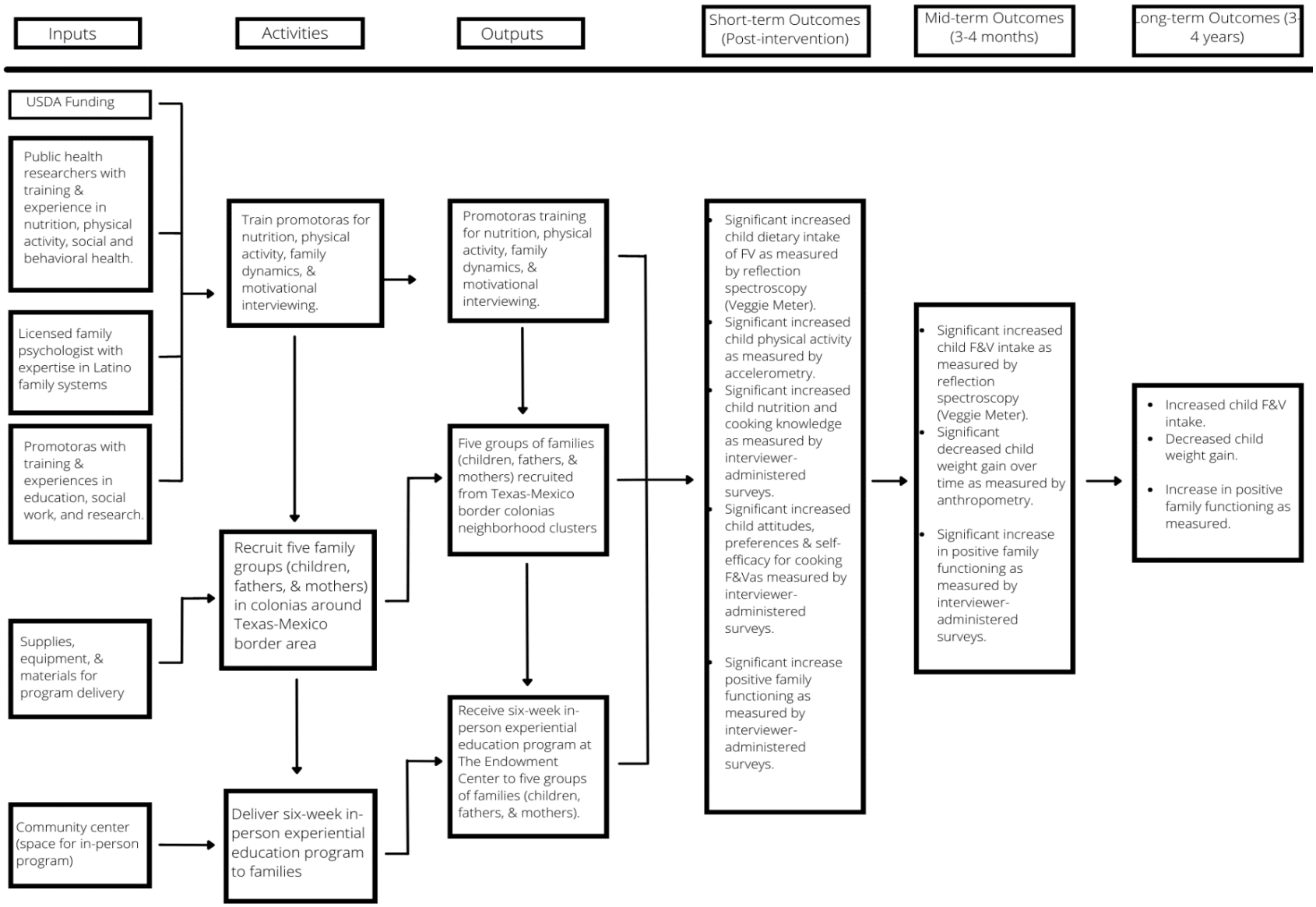

Figure 1. Logic model for HEPP program to inform thesis proposal