

ENAHORA, BASHEERAH R. Ph.D. Engaging Low-Income African American Adolescents in a Virtual Avatar-Based Nutrition Education Program. (2022)  
Directed by Dr. Jared McGuirt. 133 pp.

Childhood obesity is a serious public health concern, with minority, low-income adolescents disproportionately affected and at the greatest risk. In addition, as adolescents gain independence, dietary quality declines with youth eating more energy-dense foods away from home, increasing the risk of overweight and obesity, and other adverse health conditions. Studies have demonstrated that African American adolescents consume more added sugar, fried foods, sweetened beverages, and snack foods than non-Hispanic White adolescents.

Effective, culturally tailored interventions to improve African American adolescents' dietary intake are limited. In addition, implementing in-person community-based nutrition programs often requires significant labor and financial resources. However, compared with traditional face-to-face nutrition education, youth have reported a preference for digital health promotion programs.

The use of digital technology and media is pervasive among youth, with low-income adolescents using digital devices roughly two hours more per day than adolescents of higher income. Adolescents communicate via digital technology and view it as a source of entertainment, socialization, and active learning. Youth avidly use avatars, or digital characters, to engage with digital media and strongly identify with avatars as extensions of themselves.

Thus, this research examines the use of a technology-based virtual reality (VR) avatar-led health promotion program among adolescents. The specific objectives of this research are to (1) assess the appeal of a VR avatar-based nutrition education program among African American adolescents and their parents and, identify necessary modifications to impact dietary behaviors, (2) identify factors associated with the adoption and dissemination of a VR avatar-based nutrition education program among community agency partners and (3a) quantitatively

assess the acceptability of the VR avatar-based nutrition education program among African American youth and (3b) explore if interaction with the avatar impact's dietary responses.

This research utilized a mixed-method approach, consisting of formative research, a cross-sectional survey, and a quantitative formative process evaluation to address these objectives. Focus groups and in-depth interviews with predominantly (84.6%) low-income African American adolescents age  $12.38 \pm 1.02$  ( $n=37$ ) and parents ( $n=11$ ) revealed positive interest in the VR avatar-based nutrition education program. Adolescents found the use of avatars to provide health guidance appealing. Most youth and parents agreed that the program would impact their dietary behaviors. Adolescents also suggested a theme-based storyline, a points-based reward system, challenges, music customization, and avatar customization to increase and sustain program engagement. Parents desired exploration of cultural foods, cooking skills development, and for youth to see themselves reflected in the program to foster cultural identity.

For the cross-sectional survey, one hundred community agency partners who served families in all one hundred counties in North Carolina responded. The majority of community partners were affiliated with hospital systems (27%), school systems (27%), or health departments (16%). Overall perceptions of the VR avatar nutrition education program were favorable among community partners. Community partners who perceived the VR avatar nutrition program as a relative advantage to current programs ( $p < 0.05$ ) and compatible ( $p < 0.001$ ) with organizational and personal values had significantly higher future use intention. There were no statistically significant differences in future use intention observed by agency type, the age range of youth served, current use of digital tools to teach nutrition education (NE), early adopter status, organizational support for technology, or role in the adoption of new nutrition programs.

Finally, we conducted a quantitative formative process evaluation with thirty-nine low-income youth, who were majority African American (79.5%), and an average age of  $11.06 \pm$

1.79 years old. Findings revealed that overall program appeal and usability were favorable, with the majority of youth reporting the VR avatar program was fun to use (84.6%), overall easy to use (92.3%), would be useful in daily life (79.4%), would use the program often if it becomes available (71.8%), intend to use when it becomes available (66.7%), and would recommend the VR avatar program to a friend (92.3%). Significantly more youth with smartphones agreed the VR avatar program would increase confidence to eat healthy ( $p=0.013$ ,  $d=0.322$ ), would be useful in daily life ( $p=0.020$ ,  $d=0.298$ ), and intend to regularly use the program when it becomes available ( $p=0.002$ ,  $d=0.415$ ), compared to youth without smartphones. There was a weak positive statistically significant association between VR avatar program fruit servings and the FV screener fruit servings ( $r = 0.363$ ,  $p = 0.023$ ), indicating the VR avatar program does not appear to impact responses regarding fruit intake among low-income youth.

These findings demonstrate the appeal of the VR avatar nutrition education program among African American adolescents and the potentiality of the program to impact dietary behaviors. Community organizations also view the VR avatar nutrition education program as an advantage compared to current programs and as compatible with organizational and personal values. Utilizing these findings can help guide the development of a culturally tailored-avatar-led digital nutrition program, as well as future nutrition education and health promotion research and programming. Furthermore, considering the factors identified in this study will help the adoption and dissemination of digital nutrition education programs among community partners who serve low-income families.

ENGAGING LOW-INCOME AFRICAN AMERICAN ADOLESCENTS IN A VIRTUAL AVATAR-  
BASED NUTRITION EDUCATION PROGRAM

by

Basheerah R. Enahora

A Dissertation

Submitted to

the Faculty of The Graduate School at  
The University of North Carolina at Greensboro

in Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

Greensboro

2022

Approved by

---

Dr. Jared McGuirt  
Committee Chair

© 2022 Basheerah R Enahora

APPROVAL PAGE

This dissertation written by Basheerah R. Enahora has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair

\_\_\_\_\_  
Dr. Jared McGuirt

Committee Members

\_\_\_\_\_  
Dr. Lenka Shriver

\_\_\_\_\_  
Dr. Lauren Haldeman

\_\_\_\_\_  
Dr. Gina Tripicchio

May 26, 2022

Date of Acceptance by Committee

May 26, 2022

Date of Final Oral Examination

## ACKNOWLEDGEMENTS

I would like to thank my committee chair and mentor, Dr. Jared McGuirt, for his guidance and support throughout my doctoral degree program. Thank you to the members of my committee, Dr. Laruen Haldeman, Dr. Lenka Shriver, and Dr. Gina Tripicchio, for their continued support in helping shape this research. I would also like to thank the students, faculty, and staff of the Nutrition Department for creating a collegial and supportive academic environment, especially Dr. Perrin and Dr. Dharod, two of my greatest supporters and mentors throughout my graduate studies.

I am grateful to the community partners who invest daily to improve the health and lives of low-income children and families. These partners supported this study's validation and recruitment processes, and I cannot thank them enough for their time and support.

The Behavioral Intervention Scholars grant from the Department of Health and Human Services Office of Planning Research and Evaluation funded this research. Receiving this grant award was such a proud moment and my greatest accomplishment and honor during my doctoral journey.

My success would not be possible without my parents, who instilled in me the desire to never stop learning. Thank you for showing me that all things are possible when we work hard and put God first. Finally, thank you to my sister, brothers, and close friends for your constant support and encouragement. You were always there with the right words to lift me when I needed them most.

## TABLE OF CONTENTS

LIST OF TABLES .....	viii
LIST OF FIGURES .....	x
CHAPTER I: INTRODUCTION.....	1
CHAPTER II: REVIEW OF THE LITERATURE.....	7
Adolescent Obesity.....	7
Dietary Intake Practices During Adolescence .....	7
Adolescent Development, Peers, and Use of Technology .....	8
Community-Based Nutrition Education.....	9
Virtual Reality in Nutrition Education .....	10
Adoption of Virtual Reality .....	12
Virtual Avatar Digital Nutrition Education Program Early Pilot Testing.....	12
Virtual Avatar Digital Nutrition Education Program Description.....	13
Theoretical Underpinning of the VR Avatar Nutrition Education Program.....	14
CHAPTER III: EXAMINING A VIRTUAL REALITY AVATAR-BASED NUTRITION EDUCATION PROGRAM AMONG LOW-INCOME AFRICAN AMERICAN ADOLESCENTS .....	18
Abstract .....	18
Introduction.....	19
Methods.....	21
Participants and Recruitment.....	21
Procedures .....	22
Adolescent Focus Groups .....	23
Parent Focus Groups and In-Depth Interviews.....	23
Data Analysis.....	24
Results.....	24
Avatar Familiarity and Acceptance .....	25
Usability and Dietary Impact.....	27
Program Customization .....	28
Life Skills Development .....	30
Parental Involvement.....	31
Parental Concerns .....	31
Community Connection and Culture.....	32



Discussion .....	32
Conclusions and Future Implications.....	35
<b>CHAPTER IV: ASSESSING ADOPTION AND DISSEMINATION OF A VIRTUAL AVATAR-BASED NUTRITION EDUCATION PROGRAM AMONG COMMUNITY PARTNERS.....</b>	<b>36</b>
Abstract .....	36
Introduction.....	37
Methods.....	39
Survey Recruitment .....	39
Measures .....	40
Statistical Analysis .....	42
Results.....	43
Participant Characteristics .....	43
Adoption of the VR Avatar Nutrition Education Program (DOIT).....	47
Discussion .....	52
Conclusion and Future Implications .....	54
<b>CHAPTER V: ACCEPTANCE AND USABILITY OF A VIRTUAL REALITY AVATAR-BASED NUTRITION EDUCATION PROGRAM AMONG LOW-INCOME YOUTH .....</b>	<b>55</b>
Abstract .....	55
Introduction.....	56
Methods.....	59
Participant Recruitment .....	59
Procedures .....	60
Measures .....	61
Dietary Intake.....	61
Program Acceptance and Usability.....	61
Skin Carotenoids Measurements.....	62
Statistical Analysis .....	63
Results.....	64
Participant Characteristics .....	64
Program Acceptability and Usability .....	65
Measuring Fruit and Vegetable Intake.....	69
Discussion .....	71
Conclusions and Future Implications.....	74
<b>CHAPTER VI: EPILOGUE.....</b>	<b>76</b>

Summary of Findings.....	76
Difficulties Encountered and Lessons Learned .....	78
Future Areas of Interest.....	79
WORKS CITED .....	81
APPENDIX A: VR AVATAR PROGRAM CONCEPTUAL MODEL.....	91
APPENDIX B: DISSERTATION CONCEPTUAL MODEL .....	94
APPENDIX C: FOCUS GROUP AND IN-DEPTH INTERVIEW DISCUSSION GUIDES .....	95
APPENDIX D: COMMUNITY AGENCY SURVEY CONCEPTUAL MODEL .....	99
APPENDIX E: COMMUNITY AGENCY ADOPTION QUESTIONNAIRE .....	101
APPENDIX F: VR AVATAR PROGRAM ACCEPTABILITY AND USABILITY SURVEY .....	111
APPENDIX G: FOCUS GROUP AND IN-DEPTH INTERVIEWS YOUTH ASSENT AND ADULT CONSENT FORMS .....	114
APPENDIX H: FORMATIVE PROCESS EVALUATION ASSENT AND CONSENT FORMS..	122
APPENDIX I: RECRUITMENT FLYERS AND SCRIPTS .....	127
APPENDIX J: FORMATIVE PROCESS EVALUATION STUDY PROTOCOL.....	131

LIST OF TABLES

Table 1. Parent and adolescent participant characteristics ..... 24

Table 2. Focus group and interview themes..... 26

Table 3. Community agency characteristics (n = 100) ..... 44

Table 4. Future use intention by participant characteristics ..... 46

Table 5. Participant perceptions of the VR avatar nutrition education program Likert scale responses ..... 48

Table 6. Logistic Regression model predicting intention to use the VR avatar program in the future ..... 49

Table 7. Open-ended participant responses regarding why they would use or would not use the VR avatar program in the future. .... 50

Table 8. Participant characteristics..... 64

Table 9. Servings of fruits and vegetables measured in the Avatar program, 24-hour Recalls, and brief FV screener ..... 65

Table 10. Overall program acceptance and useability ..... 65

Table 11. Program acceptance and usability by age ..... 66

Table 12. Program acceptance and useability by gender ..... 67

Table 13. Program acceptance and usability by Race ..... 67

Table 14. Program acceptance and usability by smartphone ownership ..... 68

Table 15. Program acceptance and usability by home computer access ..... 69

Table 16. Correlations between VR avatar fruit servings and FV screener fruit servings and 24-hr recall fruit servings .....	70
Table 17. Correlations between VR avatar vegetable servings and FV screener vegetable servings and 24-hr recall vegetable servings .....	70
Table 18. Veggie Meter Scores by dietary intake collection method.....	70
Table 19. Veggie Meter® scores by VR avatar fruit serving categories.....	71
Table 20. Veggie Meter® scores by VR avatar vegetable serving categories .....	71

LIST OF FIGURES

Figure 1. Conceptual model of the VR avatar nutrition education program experience ..... 16

Figure 2. Dissertation research conceptual model ..... 17

Figure 3. Conceptual framework based on diffusion of innovation theory..... 42

Figure 4. Community agency current use of digital tools to teach nutrition education ..... 45

Figure 5. North Carolina counties served by community agency partners..... 45

Figure 6. Community agency perceptions of less used resources with the VR Avatar program 46

Figure 7. Potential VR Avatar promotion methods among participants with high future use intentions ..... 49

Figure 8. VR avatar program screens showing how fruits and vegetable servings are selected in the program ..... 58

Figure 9. Formative Process Evaluation Study Flow Diagram ..... 60

## CHAPTER I: INTRODUCTION

While current trends indicate that childhood obesity overall may have leveled in recent years, rates of obesity among adolescents have continued to rise steadily.<sup>1</sup> Over 19% of US adolescents (12-19 years old) are obese, which is higher than among school-aged children (6-11 years, 18.4%) and preschool-age children (2-5 years, 13.9%).<sup>1</sup> These trends in adolescent obesity are of serious public health concern, as nearly 80% of obese adolescents are at risk of remaining obese into adulthood, with a greater risk of hypertension, hyperlipidemia, type 2 diabetes, sleep apnea, poor self-esteem, and depression.<sup>2-5</sup> Recent trends also demonstrate disparities in adolescent obesity by race and socioeconomic status, with African American adolescents disproportionately affected and at greater risk of obesity and severe obesity, disparities which worsened during the COVID-19 pandemic.<sup>5-8</sup>

Adolescence is a critical time marked by dramatic biological, psychological, and social changes.<sup>9</sup> As the personal identity and a unique value system develop, adolescents seek increased independence and decision making, separate from their parents and other family members. Dramatic shifts in behavior, including dietary behavior, are often seen during adolescence.<sup>10,11</sup> Therefore, the early adolescent period (ages 12-14 years old) is an ideal intervention target, as youth's self-concepts are malleable as their identity and value system develop.<sup>11</sup> Among low-income African American adolescents, mothers and grandmothers still appear to influence dietary habits.<sup>12</sup> However, as adolescents spend more time away from home and gain autonomy in decision-making, studies show snacking increases. African American youth, in particular, frequently purchase and consume high-energy, nutrient-poor foods, such as chips, candy, sugar-sweetened beverages, caffeinated beverages, and fast food.<sup>12-16</sup> Consumption of fruits and vegetables declines as adolescents consume more energy-dense foods.<sup>14</sup> These poor dietary habits, coupled with parental obesity and environmental factors, increase the risk of overweight and obesity in adolescence, particularly among African

American youth.<sup>12,16,17</sup> The Social Cognitive Theory and the Social-Ecological Model provide an integrated framework to characterize the influential factors on adolescent eating behaviors.<sup>10</sup>

The levels of dietary influence include individual (intrapersonal), social environmental (interpersonal), and physical environmental (community settings, mass media).<sup>10</sup>

Social and physical environments play a critical role during adolescence. As social influences begin to shift, peers exert a greater, potentially positive or negative, impact on the consumption of energy-dense foods.<sup>12,18</sup> Peer-led interventions show promise to impact the social environment, improve knowledge and attitudes, increase self-efficacy, and change behaviors, such as increasing fruit and vegetable intake.<sup>13,19–22</sup> Much of the peer interaction during adolescence occurs through online social networks and mobile devices. Most US teens spend four or more hours on social media sites per day, with low-income adolescents spending eight hours or more online per day.<sup>23,24</sup>

To date, few studies have been culturally tailored to meet the needs of African American adolescents.<sup>25–27</sup> Cultural-specific health-related considerations unique to African Americans include cultural foods and practices (i.e., soul food and Sunday dinners), cultural values and traditions, family structure (matriarchal centrality and extended family), spirituality, body image (preference for larger body sizes), and collectivism (kinship, collective survival, and advancement).<sup>27–29</sup> Previous research also indicates that low-income, minority children receive inadequate exposure to nutrition education.<sup>18,30,31</sup> Lack of transportation, child care, inconvenience of meeting times and locations, low rapport with research staff, and lack of individual and community acceptance have been identified as barriers to participation in nutrition interventions among urban minority adolescents and their parents.<sup>32</sup> In addition, as most nutrition interventions targeting adolescents have been conducted in school-based settings, teachers delivering the information and lack of classroom resources and time also present a significant barrier.<sup>33–37</sup>

Given the significant resources required to implement community-based nutrition interventions and the multitude of barriers preventing participation by low-income individuals, particularly African Americans, technology-based health promotion programs have emerged as a promising and viable option to help provide greater access to nutrition education and facilitate health behavior change.<sup>25,37,38</sup> Virtual Reality (VR) is an interactive technology experience that takes place in a simulated environment and can be accessed via a computer, with or without a head-mounted display.<sup>25,39</sup> An immersive VR experience is often created utilizing 3-dimensional figures or avatars. Digital nutrition interventions have the potential to increase knowledge and address the factors that influence dietary behaviors in an enticing manner for both youth and parents.<sup>33,40</sup> However, our scoping review of the use of virtual and extended reality technologies found that few digital health-focused interventions have been conducted with adolescents or African Americans.<sup>25</sup>

The McGuirt lab developed and beta tested a VR avatar-led nutrition education program among children ages five to ten years old and their parents.<sup>41</sup> The program leverages key tenants of the Socioecological Model, Social Cognitive Theory, and Self-Determination Theory to promote dynamic and reciprocal learning in a social context to increase youth self-efficacy, knowledge, and motivation. Children and parents can access the current version of the program on the internet on a WIFI-enabled computer. An avatar, designed to look like youth, provides both child and adult with evidenced-based nutrition and physical activity guidance interactively with short 7-minute-long modules discussing and demonstrating healthy snacking and exercising. For example, in the snacking module, the avatar asks the child what types of snacks they like to consume and shows examples of snacks to select from. Based on the child's favorite snack selections, the avatar provides feedback. If the child selected snacks such as fruits, vegetables, string cheese, nuts, and low-fat yogurt, the avatar encourages the child to continue eating healthy snacks. If the child selected less healthy snacks, such as potato chips, cookies, and cupcakes, the avatar provides examples of healthy snacks and encourages the



child to consume healthy snacks more often. Additional avatar interaction includes the child choosing ingredients to build their own smoothie, selecting when and where snacking occurs, what food outlets they typically obtain snacks from and how they feel about their weight. After interacting with the child, the parent interacts with the avatar. The program shares with parents the selections the child made while interacting with the avatar and provides guidance to parents about modeling healthy behaviors. In addition, at the start of the program, the child inputs their home address (if willing). The VR avatar nutrition education program also integrates geographical information systems (GIS) and SMS text messaging, designed to help youth and parents navigate the physical environment to make healthy choices and reinforce healthy behaviors. The avatar provides a healthy social experience for youth and parents and creates an opportunity for parents to continuously have an interpersonal influence on their child's behaviors. At the environmental level, the avatar can make suggestions to improve the home food environment and help youth navigate the neighborhood food environment. While the current version of the program demonstrates promise, further research is required to explore the use of VR nutrition education programming to address diet-related behaviors among adolescents.

The adoption, dissemination, and implementation of VR nutrition education programs among community agency stakeholders are also critical to extending program reach and engaging adolescents to impact health behaviors. As most nutrition interventions conducted in adolescent populations are conducted in school-based settings, there is currently a dearth of research evaluating the factors affecting agency adoption and dissemination of technology-based nutrition interventions, including VR.<sup>31,42,43</sup> The Diffusion of Innovation Theory (DOIT) postulates that the adoption and spread of innovation (i.e., the VR avatar nutrition program) rely heavily on the perceptions of the innovation among users and decision-makers.<sup>44</sup> Perceptions that have been shown to be important in the adoption of new technologies include the innovation's relative advantage over current practices, compatibility with the user's and

organization's needs and values, and perceived complexity or ease of use of the new technology. Further research is needed to assess if DOIT constructs help predict community agency adoption and dissemination of technology-based nutrition education programs, particularly among agencies that serve African American adolescents and families.

As few digital nutrition interventions have targeted African American adolescents, assessing program acceptance is essential. Given the complexity of environmental context on behavior, it is unclear if providing information to help navigate the neighborhood food environment in the digital world translates into real-world experiences. As adolescents gain independence and spend more time away from home, the neighborhood food environment may profoundly influence eating behaviors and weight status, particularly in disadvantaged areas.<sup>45-</sup>  
<sup>48</sup> Story et al. (2002) demonstrate that as adolescents gain autonomy, they are more likely to purchase snacks and food nearby their school and home.<sup>10</sup> The association between the availability of full-service supermarkets and healthier weight status among adolescents and adults has also been established.<sup>45,46,49</sup> However, there is often a high concentration of fast-food restaurants and convenience stores in low-income neighborhoods, and these outlets typically stock few healthy options.<sup>46,49-51</sup> Powell et al. (2014) also suggest that sugar-sweetened beverages and fast-food-related advertising disproportionately target African American adolescents and low-income households compared to white adolescents.<sup>52</sup> Given these factors, acknowledging the influence of the neighborhood food environment among adolescents in nutrition education programs is essential. However, to what extent the VR nutrition education program will be acceptable among African American youth and to what extent they perceive it as a helpful tool to navigate the neighborhood food environment warrants further investigation.

The VR nutrition education program asks youth about their current dietary behaviors and provides several response options. The current program collects cross-sectional data on fruit consumed yesterday in servings and vegetables consumed yesterday in servings. Assessing if interaction with an avatar influences dietary responses in a digital program is a critical step

before deploying a fully powered study to evaluate efficacy. As avatars often represent idealized versions of oneself, it is unknown if avatar interaction may influence how a child responds to probes about daily dietary intake.<sup>42,53</sup>

This research aims to fill the existing gaps in the literature by assessing the appeal of a virtual reality avatar-based nutrition education program among African American adolescents and identifying necessary modifications to the program. In addition, factors affecting the adoption and dissemination of the virtual reality avatar-based nutrition education program among community agency partners who serve low-income African American adolescents will also be identified. Finally, a quantitative assessment of program acceptance and usability and the potential influence of an avatar on dietary responses will be explored. The long-term goal of this project is to aid in developing targeted interventions for this high-risk population, which will extend the reach and access of preventative services for medically vulnerable families.

## CHAPTER II: REVIEW OF THE LITERATURE

### **Adolescent Obesity**

Childhood or pediatric overweight and obesity, defined as a body mass index (BMI)-for-age at the 85<sup>th</sup> and 95<sup>th</sup> percentiles, is a serious public health concern.<sup>1</sup> From 2017 to 2018, the rate of childhood obesity was 19.3%, with prevalence among adolescents the highest of all age groups at 21.2%.<sup>1</sup> With rates of obesity as high as 21% among African American adolescents, compared to 13% among non-Hispanic whites, low-income, minority adolescents are at disproportionately greater risk of obesity.<sup>8</sup> Also, while rates of obesity are similar among African American adolescent girls (21%) and boys (21.1%), the prevalence of overweight among African American adolescent girls (19.8%) is significantly higher than in boys (13.3%).<sup>8</sup> Severe obesity, defined as at or above the 125% of BMI-for-age at the 125<sup>th</sup> percentile or higher, was also highest in adolescents at 8.4% compared to school-age children at 4.8%.<sup>1</sup> Compared to non-Hispanic white adolescents, severe obesity prevalence was also significantly higher among African American adolescents.<sup>1</sup> While the development of childhood obesity is complex and multifaceted, poor dietary intake and physical inactivity are commonly associated with its development.<sup>5</sup> These unhealthy behaviors tend to track from adolescence into adulthood, increasing the risk of many health complications later in life, such as hypertension and type 2 diabetes.<sup>2,4</sup>

### **Dietary Intake Practices During Adolescence**

Few adolescents consume a diet that aligns with the current 2020-2025 US Dietary Guidelines for Americans, engaging in poor dietary behaviors such as eating few fruits and vegetables, increased snacking on energy-dense foods, and skipping meals.<sup>16,54,55</sup> Specifically, among low-income African American adolescents, studies have found youth with high total energy intakes, excessive consumption of added sugar, fried foods, sweetened beverages, and snack foods compared to non-Hispanic white adolescents.<sup>15,56</sup> Among participants in the 2015-

2016 National Health and Nutrition Examination Survey (NHANES), African American adolescents reported consuming 0.04 servings/d of fruit, compared to the recommended 3 servings/day and 0.45 servings/d of vegetables, compared to the recommended 5 servings/day.<sup>56</sup> Also, African American adolescents report high intakes of sugar-sweetened beverages (SSBs), drinking a little more than two servings of SSBs per day.<sup>56</sup> Energy drink and caffeine consumption have remained relatively high and stable among adolescents, as top contributors of total daily energy intake, particularly among adolescent males.<sup>57</sup> Furthermore, in a nationally-representative sample of US adolescents (n=1570, 16.4% African American), Williams et al. (2017) found a significant positive association between energy drink consumption and increased intakes of high-sugar foods and fried foods, especially fried chicken, fried potatoes, frozen desserts, and chips.<sup>58</sup> These deleterious dietary behaviors may be related to a high concentration of fast-food restaurants and convenience stores in low-income, minority communities and targeted advertising of sugar-sweetened beverages, fast food, and candy in television programs and online to African American youth.<sup>46-52</sup>

### **Adolescent Development, Peers, and Use of Technology**

Adolescence is a critical time period of growth and development in which adolescents experience increased velocity of growth, including sexual maturation and changes in body shape.<sup>9</sup> The intake of nutritious foods is critical during this time to support proper growth, development, and weight management. During this time, adolescents also develop a clearer sense of personal identity, gain cognitive and abstract thinking skills and seek increased independence and decision making.<sup>9</sup> As adolescents seek to define themselves and spend more time away from home, time spent with peers takes precedence over spending time with family. Regarding the influence of peers among low-income African American adolescents, Steeves et al. (2016) found that peers positively influenced exercise behaviors but negatively influenced dietary intake.<sup>12</sup> African American adolescents reported that peers influenced their food choices before, during, and after school.<sup>12</sup> Youth acquired and shared unhealthy foods with

friends, such as chips, cookies, candy, and soda.<sup>12</sup> Additionally, peer interaction through online social networks and mobile devices has increased in recent years.<sup>59</sup> The use of cell phones among US adolescents is nearly ubiquitous regardless of socioeconomic status, and almost half of all teens report they are constantly online.<sup>23,24,59,60</sup> While teens and parents have mixed views on the frequent use of mobile devices and social media, those who view regular use as positive support the use of social media as a means of easier social connection and interaction with others and faster access to news, information and entertainment.<sup>23,59,61</sup>

### **Community-Based Nutrition Education**

Most nutrition education programs are implemented in school settings.<sup>19,20,26,30,62</sup> However, lack of classroom resources and limited instruction time are significant barriers to increasing youth nutrition knowledge.<sup>26,62</sup> Less than half the schools in many US cities include nutrition education in the standard curriculum, with urban minority areas receiving the least exposure.<sup>63</sup> Of those who receive nutrition education, as little as five hours of class time per academic year is devoted to nutrition.<sup>63</sup> To date, few of the nutrition intervention programs that target adolescents are culturally tailored for African American youth.<sup>26,28,62</sup> Cultural values and identity play a role in food consumption.<sup>28,64,65</sup> In addition, culturally tailored interventions may promote the recruitment and retention of participants.<sup>28,65</sup> Research suggests programs tailored for African Americans should consider spirituality, orality (oral stories, spoken word), family structure (matriarchal centrality and extended family), body image (preference for larger body sizes), and collectivism (kinship, collective survival, and advancement).<sup>29,66</sup> In a drug prevention program among African American youth, fostering a strong, positive ethnic identity facilitated higher self-esteem and less engagement in risky health behaviors, such as sex and drugs.<sup>66</sup> Strategies used to foster ethnic identity in the health promotion program included exploring the culture and history of African countries, Kwanzaa celebrations, spoken-word poetry, and hip-hop dance lessons.<sup>66</sup> Additionally, effective interventions among African American adolescents have addressed individual-level psychosocial factors (cultural identity, knowledge, self-efficacy) and

physical-environmental factors (increased access to healthy foods and pricing), and building community capacity among numerous partners (churches, health departments, parks & rec centers, retail stores).<sup>50,67</sup>

### **Virtual Reality in Nutrition Education**

Technology has become an integral part of teaching and instructing learners. However, the current delivery of nutrition education lags far behind in using technology as an educational modality.<sup>25,68</sup> Nutrition educators face numerous delivery challenges, particularly in rural, low-income areas, such as lack of dependable transportation, lack of participant interest, time/schedule conflicts, and other social barriers. However, resource-constrained learners report interest in using the internet and technology-based learning solutions with compelling nutrition-related information.<sup>68</sup> Casazza and Ciccazzo (2007) also demonstrated that adolescents preferred computer-based delivery of nutrition education over traditional materials and lectures.<sup>69</sup> Thus, innovative computer-software technologies like virtual reality are poised to provide nutrition education to limited-resource learners in a dynamic yet cost-effective manner.

Virtual reality (VR) is a computer-generated environment where people can immerse themselves and interact with the environment. VR is commonly accessed with a head-mounted display or without a head-mounted display on a computer (i.e., a 3-dimensional model or avatar), video game, or mobile phone. VR environments provide a real-time exploration of a user's current physical environment or an illusionary environment. The ability of VR to modulate subjective experience lends itself to use in health behavior change interventions, such as childhood obesity prevention programming. VR is particularly appealing to adolescents, as a study of US adolescents ages 11 to 15 years old found that 73% of adolescents were somewhat to extremely interested in VR.<sup>70</sup> Yet, there is a dearth of literature examining adolescent-specific health outcomes related to VR use.

The McGuirt lab conducted a scoping review regarding the use of virtual and extended technologies for nutrition education and health behavior change. Our scoping review identified

92 articles published between January 2009 and December 2018, increasing focus on VR in more recent years.<sup>25</sup> The majority of studies were observational ( $n = 31$ ) or randomized controlled trials ( $n = 19$ ) and focused on adults ( $n = 41$ ).<sup>25</sup> Few studies focused on children and adolescents ( $n = 7$ ) or African Americans ( $n = 10$ ).<sup>25</sup> Computers were the most used device ( $n = 34$ ), followed by mobile apps ( $n = 25$ ) and head-mounted devices ( $n = 17$ ).<sup>25</sup> The common research focus was behavior change ( $n = 50$ ), with the top focus areas including food purchase/selection ( $n = 9$ ) in virtual settings (i.e., supermarkets, buffets), food/beverage consumption ( $n = 8$ ), changing cravings ( $n = 6$ ), and weight loss ( $n = 4$ ).<sup>25</sup> Thus, our scoping review highlights the rise in VR nutrition interventions targeting health behavior change. However, there is a need for more VR nutrition interventions focused on adolescents. Adolescents are particularly interested in VR as a form of infotainment and may be more receptive to nutrition education and behavior change approaches which utilize this technology.<sup>40,70</sup> Previous research found that obese adolescents were interested in an avatar-led VR approach for lifestyle modification, as it provided on-ongoing motivation, aligned with their busy schedules, and reinforced healthy behaviors.<sup>40</sup>

Rodriguez-Rocha and Kim (2019) also conducted a systematic review consisting of 19 studies, mostly RCTs ( $n = 17$ ), assessing the effectiveness of eHealth interventions to increase fruit and vegetable intake among healthy populations.<sup>37</sup> eHealth was defined as the use of technology as a proxy for the practitioner in intervention delivery, including mobile devices, internet-based programs, computer-based programs (non-internet), and video games. Few studies were conducted in children ( $n = 4$ ) or adolescents ( $n = 4$ ), with the most common setting in schools ( $n = 8$ ).<sup>37</sup> All studies showed a positive effect on fruit vegetable intake (FVI), particularly tailored interventions.<sup>37</sup> Overall, studies conducted among adolescents ( $n = 4$ ) showed a small positive effect size (ES) of 0.35 (SE = 0.10, 95% CI [0.16, 0.55],  $p < .001$ ), with computer-based interventions demonstrating the largest positive effect, closely followed by SMS interventions and internet-based interventions.<sup>37</sup> These findings further support the promising



use of innovative technologies in behavior change interventions with adolescents to increase FVI. Increasing FVI is of particular interest, given the low prevalence of adolescents who meet the recommended dietary guidelines for these food groups.<sup>54</sup> However, congruent with our lab's findings, few studies focused on adolescents or African Americans. Additionally, this systematic review did not assess VR specifically or the use of avatars as health promotion agents.

### **Adoption of Virtual Reality**

While new technologies, such as VR, hold promise to promote health behavior change among adolescents, little is known about the adoption of VR among community partners who serve a critical role in providing nutrition education programs to youth. The Diffusion of Innovation Theory can provide a framework to examine the factors influencing the adoption and dissemination of virtual reality-based nutrition education programs among community partners. The Diffusion of Innovation Theory seeks to explain how new ideas or innovations are adopted. Rogers (2003) characterizes user perceptions according to five domains that influence the rate of innovation adoption, including the innovation's relative advantage to current programs; the compatibility of the innovation with the user's or organization's values, experiences, or settings; complexity or ease of use; the innovation's trialability, or degree to which it can be experienced before implementation; and the observability or capacity to observe the innovation's results.<sup>44</sup> Rogers also describes the process of innovation adoption by individuals as a normal, bell-shaped distribution, with five adopter categories: (1) innovators, (2) early adopters, (3) early majority adopters, (4) late majority adopters, and (5) laggards.<sup>71,72</sup> Greenhalgh et al. (2004) have used these categories to predict new technology adoption along with other factors, such as organizational readiness and support.<sup>71</sup>

### **Virtual Avatar Digital Nutrition Education Program Early Pilot Testing**

In 2019 the McGuirt lab conducted a mixed-methods study examining the usability and acceptability of a VR, avatar-led nutrition education program with low-income adult-child dyads (children ages 5 to 10 years old).<sup>41</sup> A total of 15 African American child-adult dyads (*n* = 30 total

*participants*) completed the pilot study, with children an average age of 9 years old and a nearly even distribution of boys and girls.<sup>41</sup> Engaging with the VR nutrition education program generated considerable excitement among participants, as children and adults enjoyed interacting with the avatar, being provided with tailored advice, and being acknowledged personally by the avatar.<sup>41</sup> In-depth interviews and structured observations revealed that the program served as a vehicle for discussion between the adult and child around dietary habits, as adults learned more about their child's food preferences and made plans based on this discovery, such as buying new fruits and vegetables (FVs) or making smoothies together.<sup>41</sup> Participants also reported increased knowledge about healthy dietary/snacking recommendations, distinguishing between healthier versus less healthy foods, and new food preparation methods. Almost all children and adults thought the program had the potential to positively impact their eating behaviors, such as eating more FVs, and were interested in using the program again.<sup>41</sup> Following pilot testing, the VR avatar nutrition education program was redesigned utilizing the Unity software platform (Unity Technologies, San Francisco, CA) and a physical activity module was added.

### **Virtual Avatar Digital Nutrition Education Program Description**

The VR avatar nutrition education program is an internet-based program that can be accessed via a computer (desktop or laptop). The program is designed for a child and parent to engage together to learn about nutrition and health. The VR avatar nutrition education program provides positive, optimized social interactions in a digital environment. The program utilizes an avatar to present evidenced-based nutrition education guidance for children ages five to ten years old based on the Health Resources and Services Administration sponsored Bright Futures in Practice clinical guidance manual. Ideally, the child and parent interact with the program together via a computer.

The current version of the program consists of two roughly 7-minute-long modules, or lessons, on healthy snacking and physical activity. The program format remains the same with

children and parents interacting with the program together. The first part of the module (usually five minutes long) is designed for the child to engage with the avatar. The second part of the module (usually two minutes long) is designed for the parent to engage with the avatar. Thus, the avatar can discuss child responses with the parent.

In the snacking module, the child interacts with the avatar to learn about fruit and vegetable servings, identify healthy snacks, learn how often snacks should be consumed, understand how to find healthy snacks at food outlets in their neighborhood, and discuss weight and maturation for children ages five to ten years old. Children also interact with the avatar to select ingredients to make a healthy smoothie. The avatar asks youth about their current dietary behaviors and provides several response options. The program collects cross-sectional data on fruit consumed yesterday in servings and vegetables consumed yesterday in servings. The child section is then followed by a parent section. The avatar provides the parent with the information collected on the child's dietary habits and provides parents with tips to model healthy dietary behaviors.

In the physical activity (PA) module, the avatar discusses the child's favorite physical activities, and places available in the child's neighborhood to play, then leads the child through a warm-up, followed by several exercises, including one leg hops, frog jumps, push-ups, and jumping jacks. The avatar also discusses the child's snacking and physical activity habits with parents and provides parents with guidance on how to model healthy behaviors for their child.

Finally, after interacting with the child and parent, the avatar can send SMS text messages to the child or parent to reinforce program lessons. We aim to assess the appeal of receiving text messages in this research.

### **Theoretical Underpinning of the VR Avatar Nutrition Education Program**

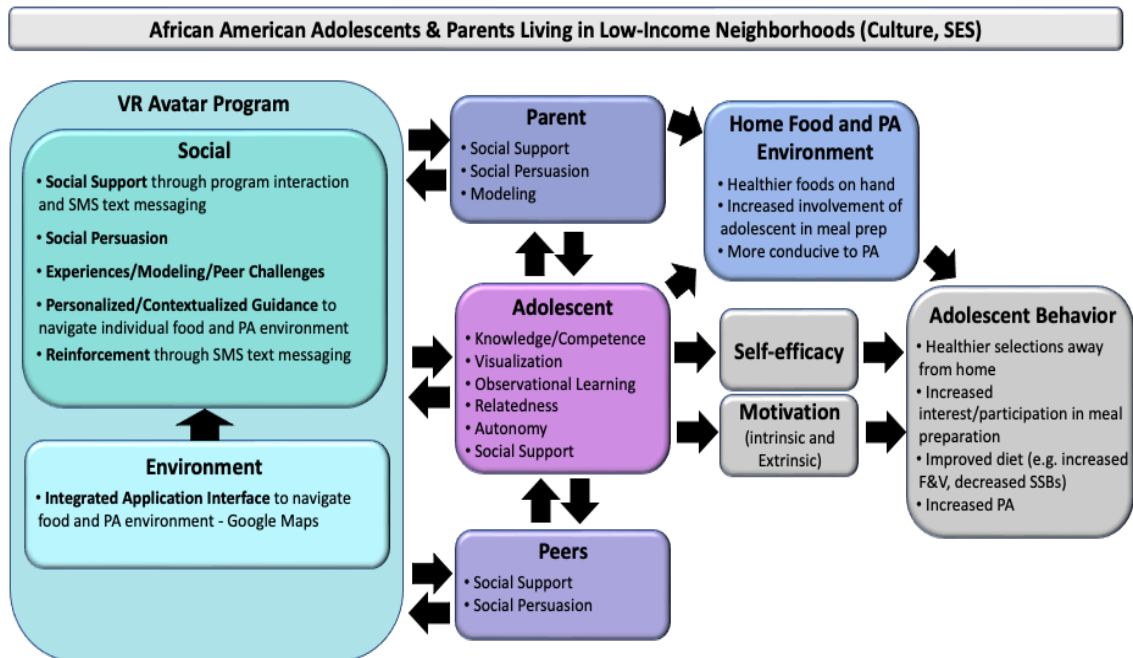
The VR avatar nutrition education program leverages key tenants of the Socioecological Model (SEM), Social Cognitive Theory (SCT), and Self-Determination Theory (SDT). SEM recognizes the interplay of multiple levels of influence on health behaviors.<sup>73,74</sup> The

intrapersonal or individual-level identifies personal factors that impact dietary habits, such as economic status, age, sex, race, ethnicity, individual eating behaviors, food preferences, attitudes, nutrition knowledge, and food preparation skills.<sup>74</sup> The avatar program impacts youth at the individual level via direct communication through short lessons and text messages. The interpersonal level includes a child's social networks, such as parents, siblings, extended family, and friends.<sup>73,74</sup> The avatar interacts with the child and parent directly and relays information to the parent, which in turn influences the interaction between the parent and child. The avatar program also impacts children at the community level, particularly the home food and physical activity level, as it helps children and parents navigate finding healthy food and physical activity resources in their neighborhood.

SCT postulates that personal, behavioral, and environmental determinants work in a dynamic and reciprocal manner to influence health behavior.<sup>75,76</sup> Personal determinants involve people's thoughts or beliefs and feelings. Self-efficacy is one of the most important personal determinants and key construct of SCT. Self-efficacy involves having the confidence and skills to carry out an intended behavior effectively and consistently.<sup>75,76</sup> The avatar program is poised to increase children's self-efficacy to eat well through personal mastery or guided practice from the avatar, social persuasion or encouragement from the avatar, and parental modeling of healthy habits. In addition, the social influences of peers become more pronounced during adolescence and may influence self-efficacy. Behavioral determinants of SCT include the individuals' food and nutrition-related knowledge and cognitive and behavioral skills needed to influence behavior change.<sup>75,76</sup> The avatar provides factual food and nutrition knowledge on fruit and vegetable servings to increase intake among children and parents. Finally, environmental determinants include those factors external to the individual, such as physical and social environments.<sup>71</sup> SCT emphasizes that our environment provides a source for modeling behavior. Observational learning and reinforcement are important environmental constructs of SCT, which the avatar program provides.

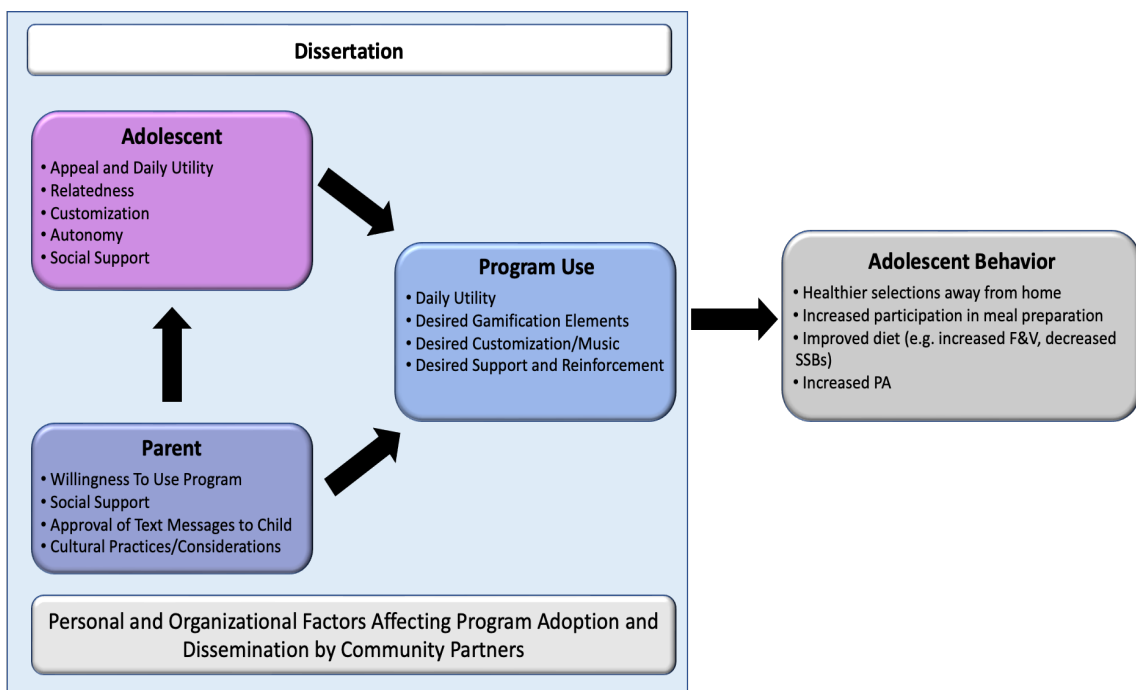
SDT suggests that individuals become self-motivated when their needs for competence, autonomy, and connection or relatedness are fulfilled.<sup>77</sup> Competence refers to the need for youth to experience themselves as capable of carrying out nutrition and physical activity behaviors that promote healthy growth and development.<sup>77</sup> Autonomy to make food-related decisions increases in adolescence, as youth spend more time apart from their parents and consume more meals and snacks away from home.<sup>10,15,46</sup> Adolescents are also increasingly more aware of their bodies as they mature and many begin to make health decisions related to body image.<sup>9,11</sup> Relatedness refers to the need for adolescents to feel cared for, to care for others, and relate to others.<sup>77</sup> Higher motivation occurs when adolescents experience authentic relatedness to others and satisfaction in participation and involvement with their social world.<sup>12</sup> An interpersonal interaction with the avatar enables the internalization of health behaviors and increases intrinsic and extrinsic motivation with a tone of understanding, acceptance, praise, and empathy.

**Figure 1. Conceptual model of the VR avatar nutrition education program experience**



While the initial version of the VR avatar program was well-received among younger children and adults, pilot testing of the current version of the program among adolescents is required. Additionally, understanding the acceptability of receiving text messages after engaging with the program and the frequency of text message delivery is necessary. Thus, this study aims to assess program appeal among African American adolescents and understand the required modifications to impact their unique health behaviors, such as increased snacking, skipping breakfast, greater food autonomy, and peer influences on dietary behaviors. Additionally, we will quantify program acceptance among African American adolescents and explore whether interaction with an avatar impacts dietary responses. Finally, the factors affecting the adoption and dissemination of the VR avatar nutrition education program among community agency stakeholders will be identified.

**Figure 2. Dissertation research conceptual model**



## CHAPTER III: EXAMINING A VIRTUAL REALITY AVATAR-BASED NUTRITION EDUCATION PROGRAM AMONG LOW-INCOME AFRICAN AMERICAN ADOLESCENTS

### **Abstract**

African American adolescents are at greater risk of obesity than their non-Hispanic white peers. As youth spend more time away from home during this period of life, diet quality declines, and few adolescents meet the dietary guidelines for healthy growth and development. As the use of digital technology increases among adolescents, innovative digital programs using avatars hold promise to provide nutrition education to limited-resource learners in a fun, cost-effective manner. Previous research demonstrates the appeal of a virtual reality (VR) avatar-led nutrition education program among school-age children. However, little is known about the program's appeal among Black or African American adolescents living in low-income communities. Thus, this study aims to understand how the VR avatar nutrition education program would best appeal to Black or African American adolescents to impact their unique health behaviors. Qualitative data were collected through semi-structured focus group discussions and in-depth interviews. We conducted six focus groups, five with adolescents and one with parents, and seven in-depth interviews with parents, for a total of thirty-eight participants (n=27 adolescents, n=11 parents). Youth suggested a theme-based storyline, a points-based reward system, increased gamification (rewards, points, challenges, character-led exploration of various countries and cultures), and music and avatar customization throughout the program to increase and sustain program engagement. Parents desired youth to develop life skills, such as healthy cooking skills, explore cultural foods, and for youth to see themselves reflected in the program to foster cultural identity. This research provides specific, culturally relevant program enhancements to appeal to African American adolescents to positively impact their health behaviors.

## Introduction

Adolescents (ages 11 to 19 years old) have the highest prevalence of obesity among children, and over 20% of adolescents are obese.<sup>1,5</sup> Black or African American adolescents living in low-income communities are also disproportionately affected with higher rates of severe obesity than non-Hispanic White adolescents.<sup>1,5,8</sup> As obese adolescents are more likely to remain obese as adults with a higher risk of type 2 diabetes, hypertension, and dyslipidemia, adolescence is a critical development phase for obesity prevention intervention programs.<sup>2,3,11</sup>

Adolescence is a significant time in the lifespan where youth form their own identities and develop lifelong habits.<sup>11</sup> However, as adolescents spend more time away from home, snacking increases, often displacing nutrient-rich foods required for healthy growth and development, such as fruits and vegetables.<sup>16,78</sup> Only 7.1% of adolescents in the United States meet intake recommendations for fruits and only 2.0% for vegetables.<sup>8,79,80</sup> Studies have also demonstrated that Black or African American adolescents consume more added sugar, fried foods, sugar-sweetened beverages (SSBs), and snack foods than non-Hispanic White adolescents.<sup>15,56</sup>

Peer influence becomes more pronounced as youth get older, with peers positively and negatively influencing health behaviors. Studies demonstrate that peer influences increased engagement in exercise among low-income Black or African American adolescents but led to poor dietary behaviors, with youth frequently acquiring and sharing chips, cookies, candy, and soda before and after school.<sup>12</sup> Peer interaction through online social networks and mobile devices has also increased in recent years.<sup>23,59</sup> The use of cell phones among US adolescents is nearly ubiquitous regardless of socioeconomic status, and almost half of all teens report they are constantly online.<sup>23,81</sup> As online social interaction becomes a predominant mode of socialization among adolescents, approaches that foster positive social support for Black or African American youth may play an important role in positively impacting health behaviors and preventing childhood obesity.



Research suggests that urban minority youth receive less than five hours of nutrition education per academic year.<sup>63</sup> Theory-driven interventions that promote health behavior change and involve parents have demonstrated low to moderate efficacy in treating childhood obesity.<sup>20,26,30,62</sup> However, few are culturally tailored for Black or African American adolescents, and families with low-income face significant barriers to participating in such interventions, including transportation, scheduling, and family responsibilities.<sup>26,62</sup>

Resource-constrained learners report interest in using the internet and technology-based learning solutions, with Black or African Americans reporting more reliance on smartphones to complete activities such as homework than White youth.<sup>68</sup> Adolescents are also enthusiastic about using technology as a source of entertainment, socialization, and active learning.<sup>81,82</sup> Youth also frequently use avatars, or digital characters, when engaging in digital media.<sup>81,83,84</sup> Adolescents strongly identify with avatars, as avatars represent friends or idealized versions of themselves.<sup>83,84</sup> Thus, innovative digital programs using avatars hold promise to provide nutrition education to limited-resource learners in a dynamic yet cost-effective manner.

Given this promise, the McGuirt research lab partnered with the UNCG Computer Science Department to build a virtual reality (VR), avatar-led nutrition education program. The program can be accessed via a web-enabled computer and utilizes an avatar to present evidenced-based nutrition education guidance based on the Health Resources and Services Administration sponsored Bright Futures in Practice clinical guidance manual. The VR avatar nutrition education program provides positive social interactions in a digital environment. The interpersonal interaction with the avatar in the program enables observational learning and increased self-efficacy to improve dietary intake. Also, this type of interaction may increase and influence motivation and behavior change by increasing autonomy, competence, and relatedness (development of a personal relationship with the avatar).

In 2019, the McGuirt lab pilot-tested an early version of the VR avatar nutrition education program, conducting structured observations and in-depth interviews with 15 African American

child-adult dyads ( $n = 30$  total participants). Children were an average age of 9 years old, with a nearly even distribution of boys and girls who completed the study.<sup>41</sup> Children and adults enjoyed the personal nature of interaction with the avatar and being provided tailored advice. The VR avatar nutrition education program also served as a discovery vehicle for adults to learn about their child's food preferences and plan for future meals and snacks based on this information. Participants also reported increased knowledge about healthy snacking and new food preparation methods. Almost all children and adults thought the program had the potential to positively impact their eating behaviors, such as eating more FVs.<sup>41</sup>

The avatar VR nutrition education program has not been examined in an older youth population, who are at increased risk of childhood obesity, given more time spent away from home. Older youth, adolescents ages eleven to fourteen years old, may find a digital avatar-led health approach more appealing, given increased technology access and usage. Thus, this research examines the use of the VR avatar-led health promotion program among adolescents. Specifically, this research aims to understand potential cultural-specific modifications to the VR avatar nutrition education program to appeal to Black or African American adolescents to impact their unique health behaviors, such as increased snacking, skipping breakfast, greater food autonomy, and peer influences.

## **Methods**

### **Participants and Recruitment**

The principal investigator partnered with Boys and Girls Clubs of America to recruit participants from clubs within a 30-mile radius of the Greensboro Triad area. Adolescents and parents were invited to participate in focus groups via email and flyers distributed by the Boys and Girls Club staff. Eligible participants were: (1) qualified as low-income (federal benefit eligible); (2) parents or caregivers and a child ages 11 to 14 years old; (3) Black or African American race; (4) English speaking; and (5) had access to a computer, smartphone or tablet with WIFI and video. Prior to collecting data, the principal investigator reviewed the study

information with the child and parent participants in-person at the Boys and Girl or via Zoom video and provided electronic consent and assent forms for participants to sign online in RedCap. On the day of focus groups or interviews, the principal investigator again reviewed the study information with the child and parent participants and verified that attendees signed the consent and assent forms. At the end of the focus groups or interviews, each study participant received a \$25 gift card. The University of North Carolina Greensboro Institutional Review Board (IRB) approved this study (approval no. FY22-49).

### **Procedures**

In Fall 2021, the principal investigator collected data through six focus groups and seven in-depth interviews. Data collection occurred online via Zoom video or at Boys and Girls Club sites for participant convenience and in an isolated room to maintain privacy. Youth attended separate focus groups from their parents to ensure that adults did not influence the opinions of adolescents. Seven in-depth interviews were conducted via video with parents who could not attend one of the scheduled focus groups. Youth focus groups began with a short icebreaker exercise and general conversation around favorite snacks to help participants feel comfortable. Next, participants were shown a short video overview explaining how the current avatar VR nutrition education program works to teach youth and parents about healthy snacking and physical activity. The video also showed the concept of sending SMS text messages after program engagement. After participants watched the conceptual program video overview, the principal investigator asked questions to gain their feedback. The principal investigator who trained in qualitative research methods and practiced conducting the focus groups and interviews in a trial run led focus groups and in-depth interviews. The principal investigator utilized a semi-structured question format, following a discussion guide that was content validated by the research team and face validated with community stakeholders (a middle school principal and four middle school students) before data collection. The discussion guide can be found in Appendix C.

## **Adolescent Focus Groups**

Adolescent focus group questions explored adolescents' perceptions of the VR avatar nutrition education program and attitudes and beliefs around healthy eating and lifestyle choices. Focus groups were used to obtain knowledge on the following areas: (1) daily appeal, usability, and intention to use the VR nutrition education program; (2) potential promise of avatars or virtual agents to promote healthy habits (breakfast consumption, reduced SSBs, reduced fast food consumption, increased water intake, increased F/V intake); (3) appeal of receiving text messages outside of the program, (4) health topics adolescents would like to see addressed in the avatar program; (5) potential VR program strategies to increase engagement and self-efficacy to improve dietary intake; (6) desired level of involvement of parents and peers in the program; (7) avatar customization (body shape, skin tone, hairstyles, clothing choices, music selection); and (8) where they would like to learn about this type of program. Focus groups lasted approximately forty-five minutes.

## **Parent Focus Groups and In-Depth Interviews**

Parent focus groups and in-depth interviews explored thoughts and perceptions of the avatar VR nutrition education program. Parents were asked questions concerning several topics, including (1) the daily appeal and usability of the VR nutrition education program for their child; (2) the potential promise of avatars or virtual agents to help their adolescent engage in healthy habits; (3) health topics they would like to see addressed in the avatar program; (4) the parent's approval of the avatar to sending text messages to youth outside of the program; (5) desired level of parent involvement in the program; (6) cultural practices and considerations and (7) where they would like to learn about this type of program. We further explored parental concerns about the child's eating habits and health in in-depth interviews. At the end of focus groups and in-depth interviews, parents completed a short online demographic survey, including questions about the age and gender of the adolescent participant, race/ethnicity, gender of the

parent, household access to technology, and income. Focus groups lasted approximately forty-five minutes, and in-depth interviews lasted about twenty minutes.

### **Data Analysis**

The focus groups and in-depth interviews were recorded and transcribed verbatim by the trained graduate students on the research team. After reviewing three transcripts, the research team developed a detailed consensus codebook with the generation of both inductive and deductive codes. Two trained researchers then utilized a qualitative content analysis approach to independently code transcripts using Atlas.ti (version 9, Atlas.ti Scientific Software Development GmbH, 2021). Research team members met to discuss coding discrepancies and came to a consensus on coding text, identifying common emerging themes, and extracting salient quotes.

### **Results**

A total of six focus groups were conducted, five with adolescents and one with parents, with four to six participants per group. There were seven in-depth interviews conducted with parents, for a total of thirty-eight participants (n=27 adolescents, n=11 parents). Most parents reported Black or African American race of the child (84.6%), with an average age of 12.4 years old (11-14 range), with more adolescent males (57.7%) than females (42.3%). All parents reported their child had access to a laptop or chromebook (100.0%) and a smartphone (100.0%). Participant demographic information is shown in Table 1.

**Table 1. Parent and adolescent participant characteristics**

<b>Participant Characteristics</b>	<b>Frequency (%)</b>
Race, adolescent	
Black or African American	23 (84.6)
Mixed Race/Other	4 (15.4)
Gender, adolescent	
Female	11 (42.3)
Male	15 (57.7)
Gender, adult	
Female	10 (90.9)

Male	1 (9.1)
Adolescent access to technology at home	
Laptop or chromebook	27 (100)
Smartphone access	27 (100)
Tablet or e-reader	8 (30.8)
Video gaming system	13 (50)
	<b>Mean (SD)</b>
Child average age in years	12.38 (1.02)

Several themes emerged during focus groups and in-depth interviews. A summary of findings by theme can be found in Table 2.

### **Avatar Familiarity and Acceptance**

All adolescents reported familiarity and comfortability with the use of avatars in apps and video games for both entertainment and educational purposes. Roblox was most frequently mentioned when asked what apps or games youth currently use with avatars, followed by Snapchat and Fortnite. Adolescents noted that the ability to play multiple games, explore and learn new things, interact with friends, and engage in fast-paced gameplay involving combat, sports, or speed racing, were the reasons they liked and played with games and apps that use avatars. Male participants reported playing video games with avatars for several hours a day, particularly games involving sports, combat, or speed racing. When asked what they did not like about apps or games using avatars, youth noted displeasure with payment requirements to access certain game features and avatar customization and the inability to master a specific level and advance through the game. The notion of level mastery or game mastery was particularly important to boys. Although most parents did not report using avatars themselves, they were familiar with avatars and comfortable with their child's use of avatars in apps and video games.

Adolescents viewed an avatar providing health guidance as positive and reported it would be helpful and motivating. As explained in the following statements, the youth explained that health and nutrition guidance from an avatar would feel more relatable:

Youth Participant Y20: *“it would feel like it’s coming from a kid.”*

Youth Participant Y22: *“I like the avatar providing help because sometimes when kids hear it from parents, it comes up a little different than hearing it from like a kid or somebody else. So, with an avatar helping, I think it will be more better.”*

When asked how they felt about an avatar providing their child with health and nutrition guidance, parents also reported they thought it would be helpful, particularly if the child could personalize the avatar. One parent participant explained:

*Parent Participant P31: Yeah. It, it does seem like, you know, being able to get it personal. Like a one-on-one, that's my avatar, Dad. You know? And then being able to dress them up and it might grab their attention enough to be able to listen to em and then like, I seen the little text messages and that's also interacting with them and not just like an at-home thing, kind of like all the time. So, I think kind of that'll really help them to be mindful. Oh yeah, I got a text message from my avatar, like, you know, it's, it's different. That's cool.”*

**Table 2. Focus group and interview themes**

<b>Theme</b>	<b>Illustrative Quotes</b>
<b>Avatar Familiarity and Acceptance</b> Avatar-led health guidance was viewed as positive, helpful, and motivating	Youth participant Y22: <i>“I like the avatar providing help because sometimes when kids hear it from parents, it comes up a little different than hearing it from like a kid or somebody else. So, with an avatar helping, I think it will be more better.”</i>
<b>Usability and Dietary Impact</b> Youth preferred gamified-type program engagement a few days a week after school. Youth agreed that receiving text message reminders to consume healthy snacks would help improve their diet.	Youth participant Y07: <i>“I eat a lot of junk food every day but I also eat a lot of protein. I mean, I think it would remind me to add more protein to my meals every day. Eat a little more healthy snacks like probably eat an apple, orange something like that.”</i>
<b>Program Customization</b> Youth desired a full range of avatar and music customization	Youth participant Y24: <i>“I’d want it to look like me, talk like me and everything else like me.”</i>
<b>Life Skills and Parental Involvement</b> Parents desired for youth to develop cooking skills, and youth viewed cooking as a	Youth participant Y22 <i>“Yeah, I definitely would be interested in learning how to cook different meals and especially if it's helping</i>

positive, fun way to interact with family and friends.	like make it better with my weight and stuff. That would be good.”
<b>Parental Concerns</b> Parents were concerned about picky eating, particularly around youth eating vegetables and intake of candy and sugar-sweetened beverages.	Parent participant P28: I want to know when will- when- when you think is a timeframe for my twins, I have twin girls, that they may, um, grow out of this uh picky eating mode?”
<b>Community Connection and Culture</b> Parents desired to engage with the program through community groups and viewed the child’s ability to see themselves in the program as a cultural identity.	Parent participant P31: “I just want my kids to see themselves in it and other Black kids too, you know. Coming from the YMCA is really good. They’re all about health and stuff and it would make it more of a community-wide thing.”

### Usability and Dietary Impact

Most adolescents saw themselves using the avatar VR nutrition education program a few days per week and agreed regular use would help make their diet healthier, particularly by improving snack choices:

*Youth Participant Y01: “Um, if like this message popped up and it said, like have you eaten a healthy snack, which I think would be great and like encourage kids to have healthy snacks instead of having junk food or junk snacks.”*

*Youth Participant Y07: “I eat a lot of junk food every day, but I also eat a lot of protein. I mean, I think it would remind me to add more protein to my meals every day. Eat a little more healthy snacks like probably eat an apple, orange something like that.”*

Several adolescents stated that the VR nutrition program would impact their beverage choices, helping them choose water versus caffeinated energy drinks. Alternatively, three youth participants noted that the VR program would not affect their dietary habits as they already eat well. Participant 19 stated, *“I don’t eat a lot of sweets. So, it’s not going to change for me.”*

In terms of the time of day, adolescents reported that the program would fit well into their daily routine after school, evenings, and weekends. Parents agreed the program would fit nicely into their child’s daily routine after school and on weekends. Adolescents and parents also valued the idea of the VR program providing text message reminders for mealtimes, such as



breakfast and snacks, and exercise. Several adolescents noted they often forget things, and seeing a daily notification would prompt action. As one adolescent male described:

*Youth Participant Y25: "Yeah, because notifications are like a very good like a reminder. And usually like, if I have like my phone in my pocket and a notification pops up and like vibrates a little bit, then I'll usually check my phone, and I'll see it. And then I'll try like do something with it."*

Adolescents expressed a desire to interact with the program for a time range of fifteen to twenty minutes. However, parents felt that shorter interaction periods of five to seven minutes would more likely hold their child's attention. Parents were also willing to engage with the program for short periods, such as three to five minutes. Youth emphasized that the VR nutrition education program must be fun and interactive to hold their attention. When asked what would help the program to be more interactive, youth described several VR nutrition education program enhancements to increase engagement, such as earning points or rewards, having a storyline that involved a fictional character progressing through various levels, exploring different countries and cuisines, including multiple mini-games, and interacting with friends through group chat and challenges. Boys, in particular, also emphasized the importance of high-quality graphics to increase program engagement. Parents were also enthusiastic about the idea of exploring different countries and cuisines and using a storyline to help youth learn about nutrition, health, and culture. Parents agreed that a high degree of game interaction was important to keep youth interested.

Finally, youth were open to interacting with the program via a computer or a mobile phone. However, youth noted spending the most time on their mobile phones and prefer reminder notifications sent to a smartphone.

### **Program Customization**

An important aspect of avatar-based programs expressed by adolescents was the need for customization. The majority of adolescents wanted a full range of customization to create an

avatar that looked precisely like themselves. Parents also desired for youth to see themselves reflected in the program through full avatar customization. Adolescents wanted the ability to customize the avatar throughout using the program, including changes to skin tone, body shape, facial features, hair, clothing, accessories, and voice. As female adolescent participant Y24 described, *“I’d want it to look like me, talk like me, and everything else like me.”* Two adolescents wanted a full range of customization and the option to create an avatar that represented an idealized version of themselves or someone they knew. Two adolescents also desired to customize the background environment or scenes of the program to coincide with certain holidays or their moods.

The ability to customize music, such as creating a customized playlist, and deciding when music would play during certain parts of the program, was also important to adolescents. Adolescents described music as helping them focus, stay energized and express themselves. As one male adolescent expressed:

*Youth Participant Y20: “Music is very important to me because music expresses how you feel. Most of the time, I listen to music to help me like do certain things, to help me focus.”*

Most adolescents desired to hear hip-hop in the program but preferred instrumental music that was upbeat yet contained some element of calm. Male adolescent participant 25 described this type of music as “LoFi Hip-hop.”

## Life Skills Development

Parents desired for adolescents to develop specific life skills, such as basic cooking skills, and learn to prepare simple meals for themselves. One parent participant mentioned that her son often chooses snacks out of convenience when hungry.

*Parent Participant P35: "He (14-year-old son) could stand to have more interest in preparing meals because if he doesn't have anything prepared for him, he'll go look for something quick. So, he likes to eat, but he, he's waiting. [Quoting her son] Okay, well, I'd rather be hungry or grab a bag of chips than make something myself. I'll just wait until the lunch bell is rung."*

Adolescents were also interested in learning basic cooking skills and highlighted that it would benefit their health:

*Youth Participant Y22 "Yeah, I definitely would be interested in learning how to cook different meals and especially if it's helping like make it better with my weight and stuff. That would be good."*

Parents highlighted that the VR nutrition education program might help expose their children to new foods and provide advice in a different way that may resonate more with youth to make healthier choices. Youth also recognized that interacting with the program and learning to cook might help them try new foods. As one female adolescent described:

*Youth Participant Y01: "If you're like a picky person that doesn't eat a lot of healthy food, it could challenge you to like eating more healthy food. Like, for example, there could be this spin the wheel thing. You would spin the wheel and it chooses on something healthy. Then you cook that food, okay. So, if you, you cook and try that food, that would be your challenge, and you'd get some points around that. Slowly, like one leaf or two bites of spinach, not that much because you don't like it, but, um, it's still like, it's like getting the hang of it and trying.'*

Youth also emphasized they wanted to have fun while learning to cook and noted they would find a program that focused solely on cooking and eating healthy foods less appealing. As female adolescent participant 05 stated: *"It can't be too boring or too healthy. It's gotta be fun, with food that tastes good."*

Finally, Learning to fuel for sports, or learning to eat to enhance performance in sports such as basketball, football, and dance, was also of interest to adolescents.

### **Parental Involvement**

Adolescents expressed interest in cooking meals or making snacks with their parents, other family members, or friends. Youth were also interested in using the VR nutrition education program to exercise with parents, other family members, and friends. Adolescents also suggested engaging in cooking and exercise challenges with their family and friends.

Most parents reported they would be willing to interact with the VR nutrition education program for a few minutes once a week. They also emphasized that if their child enjoyed the program, they would share information with their parents. One parent suggested the ability for youth to "favorite" a recipe, exercise, or challenge in the program they enjoyed, allowing parents to review it at a later time.

### **Parental Concerns**

As expressed in the following quotes, most parents were concerned about picky eating, particularly around eating vegetables. One parent questioned:

*Parent Participant P28: I want to know when will- when- when you think is a timeframe for my twins, I have twin girls, that they may, um, grow out of this uh picky eating mode?"*

Another parent stated,

*Parent Participant P33: Well, I have one child that's like really picky. He doesn't... only vegetables he would eat is, like, um, corn. He don't really like... Uh, he will maybe eat a little bit of greens on a taco, but he's really, he's really not about it."*

Several parents also expressed concern about older adolescents (14 years old) eating candy and drinking sugar-sweetened beverages, such as soda and caffeinated energy drinks, and being influenced by their peers to make poor food choices outside of the home. As one parent stated, *“So, yeah, I do. I think her peers are giving her candy at school. With the wrappers we’re finding, we’re like, we never, we don’t even bring candy in the house.”*

### **Community Connection and Culture**

Parents were most interested in finding out about the VR avatar nutrition program through after-school programs, community centers, and their child’s school. Parents highlighted that community organizations like the Boys & Girls Club and the YMCA encourage health and wellness, and they trust these organizations. Parents also noted that participating in programs within their community would also help youth and parents feel connected and motivated to engage in positive health behaviors.

As Parent Participant 31 explained, *“Coming from the YMCA is really good. They’re all about health and stuff and it would make it more of a community-wide thing.”*

Parents expressed that while they appreciate their family physician, they generally only see their doctor once a year, which may not be frequent enough to encourage participation in the VR Nutrition program. Adolescents were also interested in finding out about the VR avatar nutrition program through their after-school program (Boys & Girls Club), school, friends, and social media.

When asked explicitly about cultural considerations, parents noted that seeing their child reflected in the program would provide a strong sense of self-identity and cultural identity. Parents also valued connection with other youth who looked like their child, using a storyline and exploring cultural practices and food origins of different countries, such as Africa.

### **Discussion**

This study demonstrated the appeal of the VR avatar nutrition education program to help improve the dietary habits of Black or African American adolescents living in low-income

communities. Findings revealed that Black or African American adolescents find avatar-led health guidance helpful, motivating, and more relatable than advice from an adult. This aligns with previous research demonstrating that teenagers prefer receiving personalized health advice from an avatar when the avatar is viewed as a personal extension of themselves.<sup>40</sup> Also aligned with previous research, Black or African American adolescents in this study desired full avatar customization to look like and sound like themselves.<sup>41,83</sup> Participants also expressed the ability to continuously personalize the avatar clothing and accessories and customize music selections as key program features they would like included to increase program appeal. Similarly, Baysden et al. (2021) found that youth felt a sense of connection with their personalized avatars, which increased enjoyment and vigorous play in an exergame designed to promote physical activity among adolescents.<sup>83</sup>

To support sustained interaction with the program, adolescents suggested activities such as earning points or rewards, a storyline with progression through increasing levels, exploring different countries, engaging in multiple mini-games, and interacting with friends through group chat or challenges. While these suggested program modifications should be further explored and tested in future research, younger children in our previous study also desired increased gamification.<sup>41</sup> Gamification techniques, such as rewards and team challenges, utilized in computer-based nutrition education programs have shown efficacy to improve fruit and vegetable intake among youth.<sup>85-87</sup> Adolescents also found the concept of receiving text messages after program engagement appealing and beneficial to remind them to eat well. In a text message-focused intervention, Markowitz et al (2014) also found high acceptance of daily motivational text messages focused on healthy eating and physical activity among teens and young adults living with type 1 or 2 diabetes.<sup>88</sup>

Furthermore, these findings align with the theoretical constructs of the Socioecological Model, Self-Determination Theory, and Social Cognitive Theory. Results indicate that interacting with an avatar in a digital environment helps satisfy basic psychological needs, including

relatedness, autonomy, and connection, increasing intrinsic motivation to engage in healthy behaviors. Connection with a personalized avatar may also help increase self-efficacy through observational learning.

Parents desired for adolescents to increase their cooking skills, and adolescents agreed cooking would provide a fun way to interact with family and friends and earn points or rewards. Numerous studies have linked the benefits of cooking at home to increased intake of fruits, vegetables, and whole grains, reduced BMI, and improved general health.<sup>89</sup> In addition, Utter et al. (2018) found that the perception of adequate cooking skills among emerging adults predicted better nutrition-related health outcomes ten years later as adults.<sup>90</sup> Thus, adolescence is a key time period to develop cooking skills. Including culinary nutrition education in the VR avatar nutrition education program holds promise to impact adolescent dietary behaviors. Future research should examine this approach.

For parents, the notion of tailoring the program to meet cultural needs centered around content personalization and connection. Youth participants emphasized music as a means of expression and desired to hear hip-hop music in the VR avatar program. Corneille et al. (2005) implemented a culturally tailored substance abuse prevention intervention among African American girls in which storytelling through spoken-word poetry and hip-hop dancing were used to facilitate a positive self-identity and cultural connection.<sup>66</sup> Additionally, a narrative-based health intervention demonstrated efficacy to improve blood pressure among African American adults.<sup>91</sup> Thus, narrative-based interventions hold promise among populations with storytelling traditions, such as Black or African American communities.

The benefit of the focus group approach in this study exploring cultural-specific program modifications is that it allowed adolescents to generate ideas and discussion with their peers. Furthermore, structured and systematic qualitative methodological approaches were utilized to identify common themes related to program appeal and impact among this understudied population. Despite these strengths, this qualitative study is not without limitations. The use of a

convenience sample from one geographic area limits generalizability to other populations. Social desirability bias may have also influenced responses. Additionally, the adolescents and parents only saw a video overview of the program and received a verbal explanation of how text messages could be sent to youth after engaging with the program. Thus, it is unknown if actual interaction with the program would have generated different responses.

### **Conclusions and Future Implications**

Overall, this study revealed several key VR avatar program enhancements to appeal to Black or African American adolescents and sustain program engagement. Furthermore, it expands the literature on VR-related approaches to nutrition education and obesity prevention intervention design and implementation. Future VR avatar program development should incorporate this feedback from adolescents to improve program engagement and efficacy. A community-based participatory approach (CBPR) is recommended for continued exploration of cultural modifications to the VR avatar nutrition education program. Furthermore, future research is required to assess the efficacy of adolescents using the program and receiving text message reinforcements after program engagement. Future research should also explore the effect of certain gamification elements on adolescent dietary behaviors, the impact of culinary-focused nutrition education on knowledge, skills, and dietary intake, as well as various types of text messaging content and the impact on adolescent health behaviors.



## CHAPTER IV: ASSESSING ADOPTION AND DISSEMINATION OF A VIRTUAL AVATAR-BASED NUTRITION EDUCATION PROGRAM AMONG COMMUNITY PARTNERS

### **Abstract**

Childhood overweight and obesity are significant health challenges in the United States, disproportionately affecting low-income, minority children. Recommendations to prevent childhood obesity include eating a healthy diet and exercising for one hour a day. Given the promise of digital programs to promote healthy behaviors, the McGuirt research lab developed a virtual reality (VR) avatar-led nutrition education program. The VR avatar nutrition education program is intended to be utilized in community settings and disseminated to youth and parents by community partners, such as healthcare systems and civic organizations (i.e., Boys & Girls Clubs, United Way). However, little is known about the factors influencing the diffusion of technology-based nutrition education programs into communities. This study aimed to examine program appeal and the factors associated with adopting and disseminating a VR avatar-based nutrition education program for youth among community agency partners. A total of one hundred community partners serving families across North Carolina completed the survey, with the majority of participants working for a hospital system (27%), school system (27%), or health department (16%). The VR avatar nutrition education program was viewed favorably by community partners, with over 80% agreeing the program was an innovative and convenient way to reach and teach families about nutrition. Community partners who perceived the VR avatar nutrition program as having a relative advantage to current programs ( $p < 0.05$ ) and compatible ( $p < 0.001$ ) with organizational and personal values had significantly higher odds of future use intention. Thus, community partners in North Carolina are interested in using the VR avatar nutrition education program with the youth and families they serve. The adoption and dissemination of the VR avatar nutrition program are more likely when perceived as a relative advantage to current offerings and compatible with organizational and personal values.

## Introduction

Childhood obesity is a serious public health concern, affecting 14.4 million children and adolescents in the US, with low-income Hispanic and African-American youth at the highest risk of obesity.<sup>1,3,8</sup> While the causes of childhood obesity are complex and multifactorial, lifestyle factors such as poor dietary habits and lack of physical activity are commonly associated with excess weight gain.<sup>4-6</sup> As these poor health behaviors often track from childhood into adulthood, finding effective ways to prevent childhood obesity is paramount.

The use of innovative technology, such as virtual reality (VR) and mobile applications, in nutrition education to promote health behavior change is an emerging approach that could help address childhood obesity. In a systematic review assessing the effectiveness of eHealth interventions to increase fruit and vegetable intake among healthy populations, Rodriguez-Rocha and Kim (2019) found a small positive effect among adolescents through computer-based, SMS-based, and internet-based interventions.<sup>37</sup> Although the findings of this systematic review were positive, there were few eHealth interventions focused on children and adolescents. McGuirt et al. also found few studies that evaluated the use of technology, particularly virtual reality (VR) and extended reality technologies, in nutrition education among children and adolescents.<sup>25</sup> Yet, using technology-based tools may make learning about nutrition and health more engaging and appealing to youth.<sup>81,82,84,92</sup> Adolescents, in particular, have demonstrated a preference for receiving health information in a digital way rather than from printed materials.<sup>69</sup>

Given the dearth of technology-based nutrition interventions, the McGuirt lab developed a VR, avatar-led nutrition education program to reduce childhood obesity among low-income youth. The computer-based program utilizes an avatar to guide children and parents to make healthy snack choices and increase physical activity in short 7-minute modules or lessons.

Community settings provide optimal settings to reach youth, as community organizations engage children daily, support healthy growth and development, and are trusted by parents and

caregivers. Integrating new technology-based nutrition education programs into community settings requires that community partners perceive their value and adopt them into regular engagement with families. However, little is known about the factors influencing the adoption and dissemination of novel technology-based nutrition education programs, including VR.

The Diffusion of Innovation Theory (DOIT) can provide a framework to examine the factors influencing the adoption and dissemination of the VR avatar nutrition education program among community partners. However, to date this theory has not been utilized to assess the adoption of digital nutrition education programs.

The Diffusion of Innovation Theory seeks to explain how new ideas or innovations are adopted. It proposes there are five attributes of innovation that affect adoption: (1) relative advantage, (2) compatibility, (3) complexity or ease of use, (4) trialability, and (5) observability.<sup>44</sup> Relative advantage is the perceived potential value or benefit of the innovation relative to current programs and how much the innovation improves upon existing technology. DOIT suggests that innovations with a clear advantage over current programs will be more easily adopted and disseminated.<sup>44</sup> Compatibility relates to how the innovation fits the user's or organization's values, experiences, needs, and behaviors. Literature suggests that the more an innovation, like the VR avatar nutrition education program, can integrate with behaviors, values, and technologies already in place, the higher likelihood of adoption.<sup>71,93-95</sup> Complexity is the degree to which an innovation is difficult to understand or use. The more users perceive innovations as simple to use (or less complex), the more they will be readily adopted.<sup>44,94,95</sup> Previous research has demonstrated that relative advantage, compatibility, and complexity are significant predictors of the adoption and dissemination of mobile health apps.<sup>96-98</sup> Trialability describes how readily potential adopters can experience an innovation firsthand on a limited basis.<sup>44</sup> As innovations often require an investment of time, energy, and resources, the greater the extent to which a potential adopter can trial or foresee themselves trying an innovation, the

more easily it will be adopted.<sup>93,94</sup> Finally, observability is the degree to which potential adopters can see the results of the innovation.<sup>44</sup>

Rogers also describes the process of innovation adoption by individuals as a normal, bell-shaped distribution, with five adopter categories: (1) innovators, (2) early adopters, (3) early majority adopters, (4) late majority adopters, and (5) laggards.<sup>71,72</sup> Greenhalgh et al. (2004) have used these categories to predict new technology adoption along with other factors, such as organizational readiness and support.

Thus, utilizing diffusion of innovation theory constructs, this paper aims to assess if community agency partners are interested in the VR avatar nutrition education program and what DOIT characteristics are associated with the willingness to adopt and disseminate the program.

## **Methods**

### **Survey Recruitment**

In September 2021, we recruited community agency representatives at federally qualified health clinics (pediatricians, family medicine practitioners), civic organizations (i.e., United Way, Salvation Army), health departments, school systems (health educators and school-based health centers), large hospital systems (pediatricians, pediatric dietitians), NC Cooperative Extension offices (EFNEP, SNAP-Ed), after school programs and government programs (Guilford Healthy Communities, Guilford Partnership for Children) in North Carolina. We recruited through email, phone, established research contacts, and internet searches. Eligibility to participate in the survey included individuals: (1) who were 18 years of age or older, (2) communicate fluently in English (read/write), (3) work for a community entity (government, private, or non-profit) or healthcare organization that provides nutrition education programs and (4) has influence or authority to provide nutrition information or nutrition education programs to end-users. All eligible participants (n = 211) were sent an email describing the study and an invitation to participate by accessing the web survey through an embedded hyperlink. Two

weeks later and one month later, a follow-up email reminder was sent to eligible participants. Respondents completed the first part of the survey asking for demographic information and existing nutrition education program information. Then participants watched a short, roughly 2-minute-long overview video embedded in the survey. The video demonstrated how the VR avatar nutrition education program is used by youth and parents to learn about healthy snacking and physical activity. The video also showed a concept of a child receiving SMS text messaging to reinforce healthy behaviors. Ten survey participants were randomly selected to receive a \$25 electronic gift card. The University of North Carolina Greensboro Institutional Review Board (IRB) approved this study (approval number 20-0477).

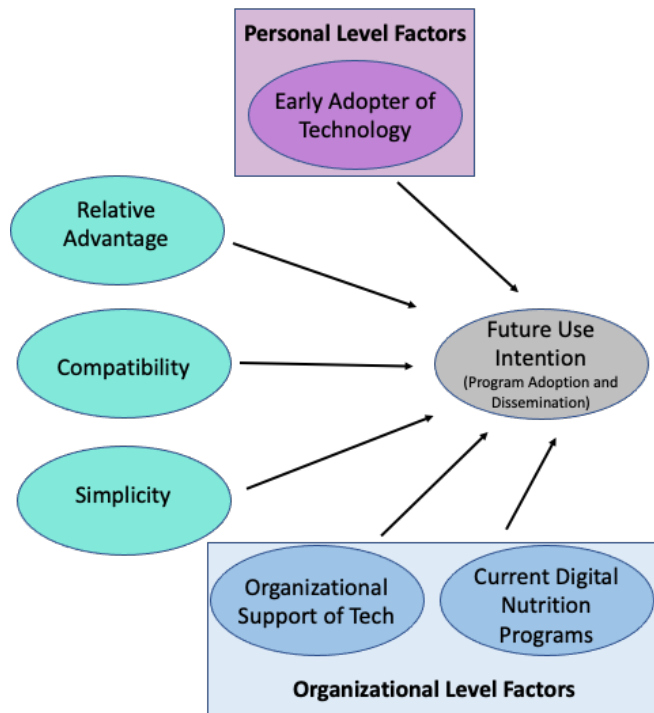
### **Measures**

In April 2021, a fifty-seven-item survey was developed in REDCap utilizing questions modified from the previously validated research of Kunn et al. (2016) and Miller et al. (2019), assessing clinician adoption of a mobile health app (Cronbach's alpha ranging from 0.75 to 0.84), based on the DOIT constructs of relative advantage, compatibility, complexity (or simplicity/ease of use), trialability and observability.<sup>96,98</sup> Questions were asked on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The research team and two experts (Registered Dietitians working in pediatrics) first reviewed the survey for face validity. Next, a subset of twenty-three agency partners was sent the survey via email for process validation. A lower-than-expected completion rate of 43% indicated potentially too high a participant burden. Thus, the survey was modified, reducing the length to thirty-three questions.

The modified survey included questions assessing the DOIT constructs of relative advantage (nine items), compatibility (four items), and simplicity (three items). The items assessing trialability and observability were deleted, as these constructs were difficult to interpret as participants watched a video overview of the program explaining how the program worked. The relative advantage of the VR avatar program was dimensionalized in terms of innovation and convenience to reach and teach nutrition education and for families to learn

about nutrition, compared to current programs. Questions such as “The avatar program is a more innovative way for families/children my organization serves to learn about nutrition” were asked to assess relative advantage. In addition, four items in the revised survey assessed future use intention or agency willingness to adopt and disseminate the VR nutrition education program. Participants were asked questions regarding future use intention, including: “I would use this program with the families and children my organization serves,” I would provide this program to the families and children my organization serves when it becomes available, “ and “The families and children my organization serves would use this program.” An additional open-ended question on future use intention also asks participants about the reason behind their intention to use or not use the VR avatar nutrition education program. Finally, additional questions assessed demographics. Respondents selected the type of agency or community partner (i.e., hospital system, afterschool program, school system, civic organization), the age range of youth served by the community partner (infant to 19 years old), current use of technology-based tools to deliver nutrition education (yes/no), type of technology or innovation adopter (early adopter vs. laggard), organizational readiness and support for new technology, and the counties served by the community partner. We also provided respondents with definitions to select their organizational role in the adoption of new technology (decision-maker, influencer, disseminator of information, or other). The survey was emailed to all eligible participants (n=211). The proposed conceptual framework is presented in Figure 3 and the complete survey can be found in Appendix E.

**Figure 3. Conceptual framework based on diffusion of innovation theory**



### **Statistical Analysis**

Data were analyzed using IBM SPSS 28.0 (SPSS, Chicago, IL). Normality assumptions were validated for all variables using the Shapiro-Wilk test. Agency type or affiliation, the age range of children served, current use of technology-based learning tools, and counties served were summarized with descriptive statistics (frequency, % of the total sample, mean, median). Reliability analysis was conducted, with Chronbach's alpha computed for the questions assessing the DOIT constructs of relative advantage (nine items), compatibility (four items), simplicity (three items), and future use intention (three items). We removed two items in the relative advantage subscale, given low corrected item-total correlations (the VR avatar nutrition education program is on par with existing programs in terms of convenience ( $r = -0.145$ ) and innovation ( $r = 0.001$ )). The revised relative advantage subscale consisted of seven items for analysis. All subscales were found reliable with Chronbach's alpha  $>0.7$  [relative advantage ( $\alpha = 0.897$ ), compatibility ( $\alpha = 0.851$ ), simplicity ( $\alpha = 0.836$ ), and future use intention ( $\alpha = 0.895$ )]. Each

subscale of the DOIT constructs [relative advantage (seven items), compatibility (four items), simplicity (three items), and future use intention (three items)] was transformed into an overall composite index in SPSS, and an estimated mean for the new index variable was calculated (AdvantageIndex, CompatibilityIndex, SimplicityIndex, FutureUseIndex).<sup>88</sup> Given the low frequency of responses of disagree/strongly disagree as 3-category variables (low, neutral, high), the index variables were dichotomized as 1 = agree (strongly agree, agree), 0 = disagree (neutral, disagree, strongly disagree), with high representing the VR program as having a high likelihood of a perceived advantage, compatibility, simplicity, and future use, compared to current nutrition education programs. Chi-square tests or Likelihood ratio were employed to test if the agency type (hospital system, school system, civic org, EFNEP, after-school), the age range of youth served (infant to 2 years old, 3 to 5 years old, 6 to 10 years old, 11 to 15 years old, 16 to 19 years old), current use of technology-based tools (yes/no), early adopter status (yes/no), organizational support for technology (yes/no), or technology adoption role (decision-maker, disseminator, influencer, other) accounted for differences in future use intention. Logistic regression was conducted to investigate the relationships between early adopter status, use of online programs, agency support for technology, and perceived DOIT construct attributes (high/low; relative advantage, simplicity, and compatibility) and the likelihood of future use (high/low; willingness to adopt, and disseminate the VR avatar nutrition education program). We explored perceived DOIT constructs, relative advantage, simplicity, and compatibility, as sole predictors of future use intention; however, the Nagelkerkel R<sup>2</sup> decreased from 0.482 to 0.466, explaining less variance in the model.

## **Results**

### **Participant Characteristics**

Of the 211 invited to participate in the survey, 144 responded to the survey, for an overall response rate of 68.24%. One hundred respondents completed the survey, for a completion rate of 47.62%. As presented in Table 3, the majority of respondents worked for a



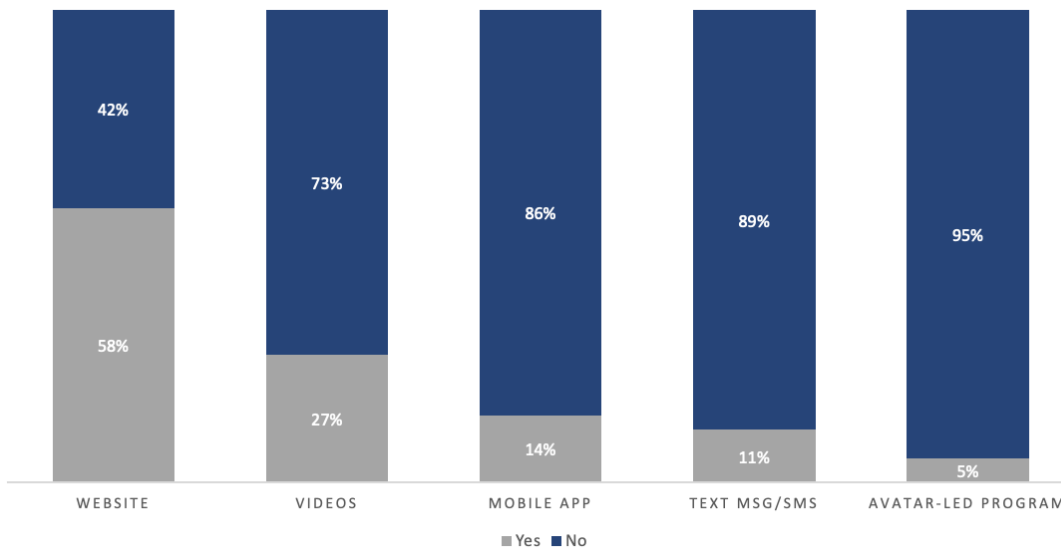
hospital system (27%), school system (27%), or health department (16%) and served youth across all age ranges. Over half of participants (51.5%) considered themselves as early adopters of technology, a decision-maker (33.6%), or influencer (22.9%) in the adoption of new nutrition programs, with high organizational support to adopt new technology (54.2%) (see Table 3).

**Table 3. Community agency characteristics (n = 100)**

<b>Participant Characteristics</b>	<b>Frequency (%)</b>
<b>Community Partner Affiliation</b>	
Hospital System	27 (27.0)
School System	27 (27.0)
Health Department	16 (16.0)
Community or Civic Org	11 (11.0)
EFNEP or SNAP-Ed	10 (10.0)
Afterschool, Daycare, Headstart	9 (9.0)
<b>Age Group of Children Served</b>	
Infant to 2 years old	41 (41.0)
3 to 5 years old	56 (56.0)
6 to 10 years old	59 (59.0)
11 to 15 years old	65 (65.0)
16 to 19 years old	71 (71.0)
<b>Use of Digital Tools for Nutrition Ed</b>	
Yes	49 (49.5)
No	50 (50.5)
<b>Early Adopter of Technology</b>	
Yes	50 (51.5)
No	47 (45.8)
<b>Organizational Support for Tech</b>	
Yes	52 (54.2)
No	44 (45.8)
<b>New NE Program Adoption Role</b>	
Decision Maker	32 (33.6)
Influencer	20 (22.9)
Disseminator	41 (29.3)
Other	20 (14.3)

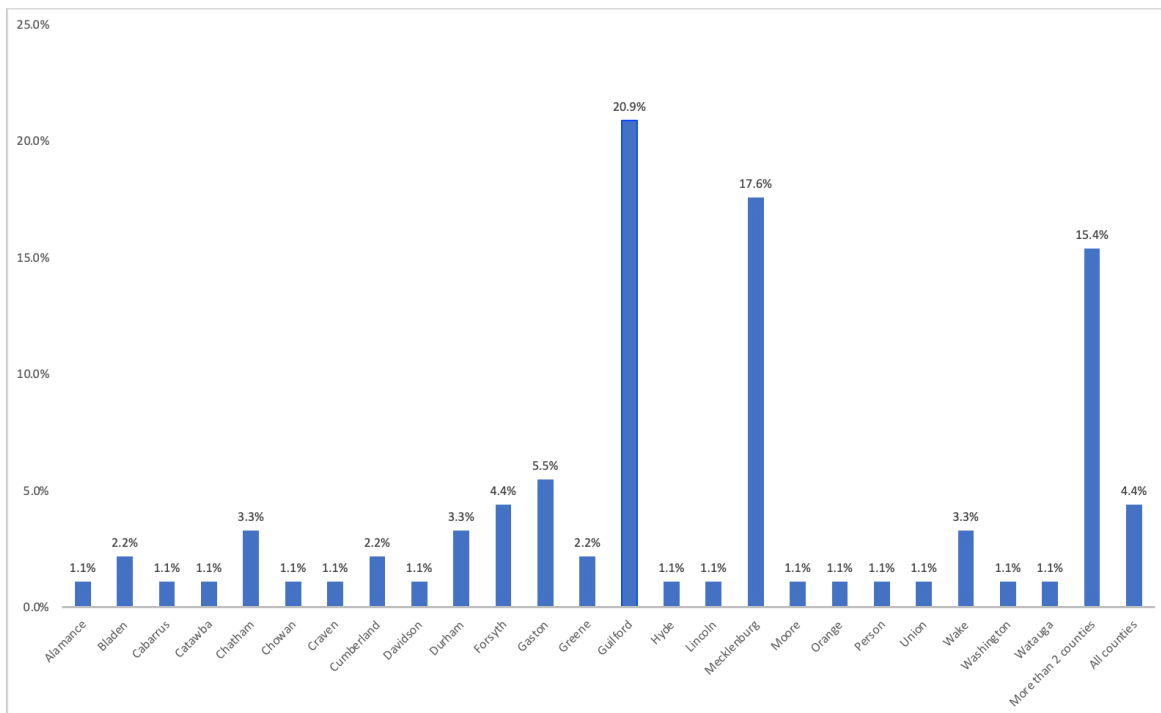
Nearly half (49.5%) of the participants use digital tools to provide nutrition education, with websites (58%) and videos (27%) being the most commonly used tools (Figure 4).

**Figure 4. Community agency current use of digital tools to teach nutrition education**



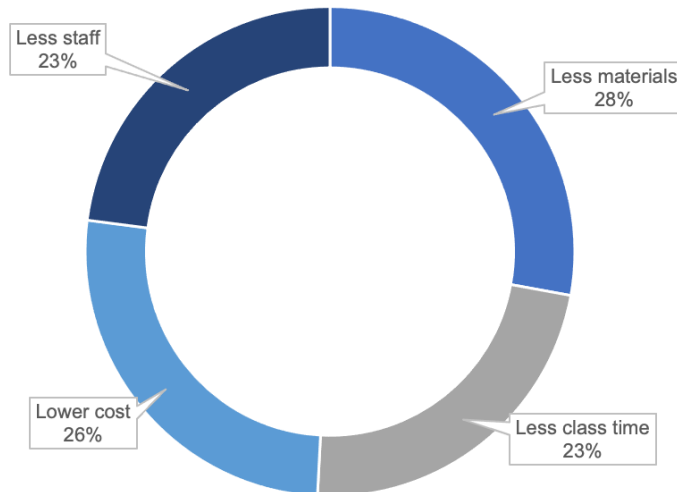
Participants served families in all one hundred North Carolina counties, with most respondents in Guilford (20.9%) and Mecklenburg (17.9%) counties (Figure 5).

**Figure 5. North Carolina counties served by community agency partners**



In addition, 30.9% of community partners agreed the VR avatar nutrition program would require fewer resources than current programs, including less class time (23.0%), less staff (23.0%), fewer materials (27.9%), and less monetary resources (26.2%) (Figure 6).

**Figure 6. Community agency perceptions of less used resources with the VR Avatar program**



There were no differences in future use intention observed by agency type, the age range of youth served, current use of digital tools to teach nutrition education (NE), early adopter status, organizational support for technology, or role in the adoption of new nutrition programs (Table 4).

**Table 4. Future use intention by participant characteristics**

Participant Characteristics	Future Use Intention		$\chi^2$ or $G^2$	P value
	Agree	Disagree		
Community Partner Affiliation				
Hospital System	18	9	5.17	0.396
School System	15	12		
Health Department	11	5		
Community or Civic Org	7	4		
EFNEP or SNAP-Ed	3	7		
Afterschool, Daycare, Headstart	6	3		
Age Group of Children Served				

Infant to 2 years old	31	10	12.127	0.066
3 to 5 years old	39	17		
6 to 10 years old	35	24		
11 to 15 years old	41	24		
16 to 19 years old	45	26		
<b>Use of Digital Tools for Nutrition Ed</b>				
Yes	27	22	1.23	0.267
No	33	17		
<b>Early Adopter of Technology</b>				
Yes	33	17	1.16	0.425
No	23	21		
<b>Organizational Support for Tech</b>				
Yes	35	17	2.25	0.133
No	23	21		
<b>New NE Program Adoption Role</b>				
Decision Maker	20	12	4.99	0.289
Influencer	8	12		
Disseminator	25	16		
Other	12	8		

### **Adoption of the VR Avatar Nutrition Education Program (DOIT)**

Overall perceptions of the VR avatar nutrition education program were favorable in terms of DOIT constructs. Results showed that over 80% of community partners perceived the VR avatar nutrition education program as a relative advantage to current programs in terms of convenience and innovation to reach and teach families and for families to learn about nutrition education. The majority of participants (72%) also agreed that the VR avatar program could positively impact the dietary behaviors of the families they serve. Over 70% of community partners perceived the program as compatible with organizational and personal values, and over 60% perceived the program as simple to use. The majority (83%) of community partners agreed they would consider using the VR avatar program with the children and families they serve, and 78% agreed they would provide the program to the families they serve in the future. Most community partners (60%) also agreed the families they serve would use the VR avatar program. See Table 5 for DOIT subscales and corresponding items.

**Table 5. Participant perceptions of the VR avatar nutrition education program Likert scale responses**

<b>Subscales and Items</b>	<b>Disagree n (%)</b>	<b>Agree n (%)</b>
<b>Relative Advantage (<math>\alpha = 0.897</math>)</b>		
The avatar program is a more <u>convenient</u> way for families to <u>learn</u> about nutrition	18 (18.0)	82 (82.0)
The avatar program is a more <u>convenient</u> way to <u>reach</u> families with nutrition education	15 (15.0)	85 (85.0)
The avatar program is a more <u>convenient</u> way to <u>teach</u> nutrition education	18 (18.0)	82 (82.0)
The avatar program is a more <u>innovative</u> way for families to <u>learn</u> about nutrition	13 (13.0)	87 (87.0)
The avatar program is a more <u>innovative</u> way to <u>reach</u> families with nutrition ed	16 (16.0)	84 (84.0)
The avatar program is a more <u>innovative</u> way to <u>teach</u> nutrition education	13 (13.0)	87 (87.0)
The avatar program may improve the dietary behaviors of youth and families	28 (28.0)	72 (72.0)
<b>Compatibility (<math>\alpha = 0.851</math>)</b>		
My organization may benefit from using the avatar program	22 (22.0)	78 (78.0)
The avatar program is easily integrated into our current health promo practices	35 (35.0)	65 (65.0)
The avatar program aligns with my organization's mission to improve health	18 (18.0)	82 (82.0)
The avatar program aligns with my personal values on health and wellness	22 (22.0)	78 (78.0)
<b>Simplicity (<math>\alpha = 0.836</math>)</b>		
The avatar program seemed easy to use	27 (27.0)	73 (73.0)
It would be easy to offer the avatar program to the families we serve	35 (35.0)	65 (65.0)
The families we serve would find the avatar program easy to use	33 (33.0)	66 (66.0)
<b>Future Use Intention (<math>\alpha = 0.895</math>)</b>		
I would use this program with the youth and families my organization serves	17 (17.0)	83 (83.0)
I would provide this program to the youth and families my organization serves	22 (22.0)	78 (78.0)
The youth and families my organization serves would use this program	40 (40.0)	60 (60.0)

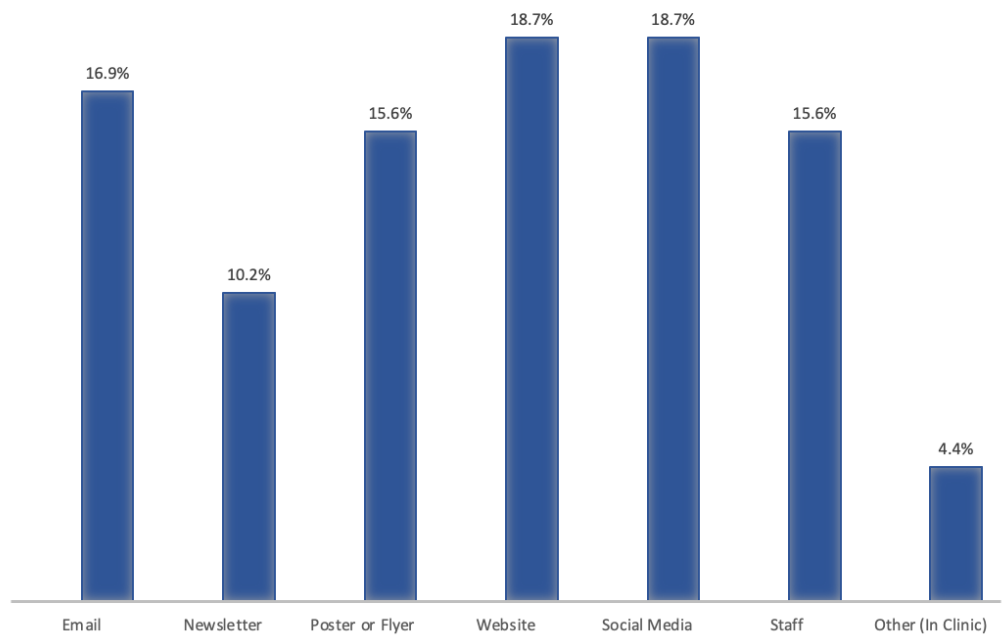
As detailed in Table 6, logistic regression demonstrated that community partners who perceived the VR avatar nutrition program as having a relative advantage to current programs and compatible with organizational and personal values had significantly higher future use intention. Those who perceived the avatar program as a relative advantage over current programs are almost six times more likely to intend to use the program in the future ( $p=0.005$ ). Additionally, those who perceived the avatar program as compatible with organizational and personal values are nearly eight times more likely to intend to use the program in the future ( $p < 0.001$ ). Early adopter status, current use of digital programs to teach nutrition education, and organizational support for technology were not significant predictors of future use.

**Table 6. Logistic Regression model predicting intention to use the VR avatar program in the future**

Variable	B	S.E.	Wald	df	p-value	Odds Ratio	95% CI for Exp(B)	
							Lower	Upper
Relative advantage	1.720	0.608	7.995	1	0.005*	5.586	1.695	18.405
Compatibility	2.045	0.571	12.845	1	<0.001*	7.731	2.526	23.660
Simplicity	0.416	0.617	0.453	1	0.501	1.515	0.452	5.081
Early Adopter	-0.550	0.585	0.883	1	0.993	1.005	0.183	1.816
Current Digital Programs	0.005	5.38	0.000	1	0.993	1.005	0.350	2.885
Org Tech Support	0.171	0.553	0.096	1	0.757	1.186	0.402	3.505
Constant	-1.713	0.637	7.372	1	0.007	0.180		
*p < 0.05								

As shown in Figure 7, participants with high future use intention indicated they would utilize numerous methods to promote the VR Avatar program to the youth and families they serve once it becomes available. Promotional methods included website (18.7%), social media (18.7%), email (16.9%), staff (15.6%), newsletter (10.2%), and other (4.4%; in clinic or word of mouth).

**Figure 7. Potential VR Avatar promotion methods among participants with high future use intentions**



Seventy-seven participants also provided open-ended responses detailing why they do or do not intend to use the VR avatar program. Several themes emerged from a thematic analysis of the open-ended responses. Positive reasons to use the program in the future included (1) avatar personalization, (2) fun engagement for youth, (3) increasing the reach of nutrition education, and (4) parents and children learning together. Negative reasons limiting participants' future use included (1) language barriers, (2) lack of internet access among families, and (3) concern for eating disorder development with some of the programming language (healthy vs. unhealthy, discussion on weight) (Table 7).

**Table 7. Open-ended participant responses regarding why they would use or would not use the VR avatar program in the future.**

Theme	Quotes
<b>Positive Responses</b>	
Avatar Personalization	<p>"From the video this looks like an engaging tool. It goes beyond just a video or workshop and allows for a more personal connection."</p> <p>"Its personalized and easily accessible"</p> <p>"I like that users can create a personalized avatar to look like them. Children love to see themselves like this!"</p> <p>"I like that the avatars can be personalized."</p>
Fun and Engaging for Youth	<p>"I am interested because it would provide a fun, interactive experience for parents and their children. I am curious to know if it's accessible via a smartphone app, as well as how user friendly it is, as we primarily serve low-income families."</p> <p>"I think the program is interactive and would work well to capture children's attention in comparison to a 1:1 time lecture/education."</p> <p>"I think it would keep them engaged because it is a form of a game."</p> <p>"The program looks very interactive and appealing to younger students."</p> <p>"it would give a game-like environment for healthier habits and the steps to work at their own pace."</p> <p>"Love being able to use technology to help students engage"</p>

Increases reach of nutrition education	<p>"This would allow education to continue outside of face-to-face interaction."</p> <p>"I think this would serve as a great supplemental learning course after participating in my lessons."</p> <p>"I think we have seen many changes over the last two years and virtual is a way for families to participate on their time line"</p> <p>"I like that the program is virtual and may be able to reach those that have transportation issues."</p> <p>"With more and more services being offered virtually this tool would be beneficial and add value to virtual teaching and counseling sessions."</p>
<b>Negative Responses</b>	
Language barriers	<p>"not offered in bilingual format avatars are odd speaking and moving. I don't like the greater screen time use which we are trying to discourage."</p> <p>"It would be neat idea for the children/adolescents to receive this information at the clinic as our provider verbally reviews importance of healthy eating. Concern is language and barriers to technology."</p>
Lack of internet access	<p>"I worry about insufficient system resources, computer, internet for the families we serve."</p> <p>"If a computer and wifi are available through a school program, that would also make it more accessible for low-income groups."</p> <p>"Lack of access to internet and desktop capabilities may be a challenge."</p>
Eating disorder development	<p>"I would want to know more about the content. I am potentially uncomfortable with some of the verbiage used in this preview (ex. 'those foods are unhealthy and should only be eaten once a week')."</p> <p>"In the video the avatar recommended eating food like chips once per week. While I agree with the statement I do become concerned over whether or not a small subset of children could develop restrictive eating behaviors depending on the way the avatars relay info."</p> <p>"The language used around foods like cookies, chips, etc is not conducive for my population of individuals struggling with eating disorders or disordered eating."</p> <p>"There are certain things I would have to look at further and see if I could omit, such as asking how the child feels about their weight, before I would use this with my own participants."</p>



## Discussion

This study aimed to investigate the interest in the VR avatar nutrition education program among community agency partners and identify organizational characteristics that may influence future use intentions (willingness to adopt and disseminate the program). The research findings indicate that community partners are interested in the VR avatar nutrition education program and recognize the program's potential to conveniently and innovatively reach and teach and impact the dietary behaviors of the children and families the organizations serve.

Two DOIT constructs, relative advantage and compatibility, emerged as significant predictors of future use, with six to eight times higher odds of future use among community partners. Previous studies have also demonstrated that relative advantage and compatibility are critical DOIT constructs predicting technology adoption. In assessing factors associated with the adoption of mobile health apps, Kuhn et al. (2016) and Nezamdoust et al. (2022) found relative advantage and compatibility as significant predictors of future use intentions.<sup>96,99</sup> In contrast, Emani et al. (2018) found that relative advantage and simplicity were significant predictors of mobile health app future use, but compatibility was not a significant predictor.<sup>94</sup> In this present study, simplicity was not a predictor of future use intention and may be related to low variability on the simplicity index. On the open-ended future use intention question, participants noted concerns that poor WIFI access may limit program use among low-income families. These concerns may explain low variability among those who agreed that families would find the program easy to use and those who disagreed.

Smartphone ownership also predicted future use intention in previous studies.<sup>96,98</sup> However, this study did not assess smartphone ownership among community agency partners. Instead, we surveyed participants about their use of digital tools to teach nutrition education. There were no statistically significant differences in future use intention among community partners who use digital tools for nutrition education compared to those who do not, likely due to low variability.

In open-ended responses regarding future use intention, survey participants also expressed concern regarding the use of program language around healthy versus unhealthy foods and the potential development of disordered eating among youth. However, numerous factors increase the risk of disordered eating development in adolescence, including adverse childhood experiences, such as bullying and social pressure.<sup>100,101</sup> Additionally, studies have demonstrated positive outcomes among children, such as increased fruit and vegetable intake, when utilizing theory-driven lessons discussing the connection between food, health, and the body (i.e. This food is healthy and will help your bones and muscles get strong).<sup>30,102-104</sup> Thus, highlighting the VR avatar program's theoretical underpinnings may also be important in communication with community partners.

Strengths of the study include the use of a previously validated survey instrument, and participation of a diverse population of community partners that serve children and families in each county in North Carolina across various agency types, including federally qualified health clinics, school systems, public health departments, Cooperative Extension agents, and after-school programs. Additionally, open-ended responses were collected, providing further detail into why an agency would use the program in the future, as well as opportunities for program enhancements.

Despite these strengths, the conclusions drawn from this study are not without limitations. This study was conducted only among community partners in North Carolina and may not be generalizable to other settings. In this study, the VR avatar program's relative advantage was conceptualized in terms of convenience and innovation to reach and teach children and families about nutrition and health and the potential to impact dietary behaviors. However, community partners may conceptualize the relative advantage of digital nutrition programs in alternative ways, such as cost savings. Furthermore, community partners were only shown a video overview of the VR avatar nutrition education program and did not experience it firsthand. Although this approach is commonly used to estimate technology adoption, it is

unknown if firsthand exposure to the program would have generated different responses.<sup>44,93</sup> Additionally, although we assessed program acceptance and future use among a wide range of community partner types, program usage may vary vastly depending on community partner job function and time spent interacting with children. For example, Cooperative Extension agents and pediatric registered dietitians may spend nearly an hour discussing food and nutrition with a child and parent, while a pediatrician or family medical doctor may only interact with a child or family for a limited time per year and only discuss nutrition for a few minutes.

### **Conclusion and Future Implications**

To our knowledge, this is the first study to examine interest in a virtual reality-based nutrition education program among community partners and factors that could influence the adoption, dissemination, and future program use. This study highlights the need for nutrition programs to clearly demonstrate to community partners the advantages of using digital technologies such as avatars and virtual reality compared to existing programs. The VR avatar nutrition education program is an early entrant in the field and shows promise for future use among community partners in North Carolina if they perceive it to be a relative advantage over current offerings with high compatibility with personal and organizational values. Future research and program development should consider further testing the VR avatar nutrition education program with a select subset of community partners and the children and families they serve while considering the factors identified in this study. Assessing program acceptance, usage, and dissemination by job function (i.e. pediatrician versus a school health educator or Registered Dietitian) is also warranted.

CHAPTER V: ACCEPTANCE AND USABILITY OF A VIRTUAL REALITY AVATAR-BASED  
NUTRITION EDUCATION PROGRAM AMONG LOW-INCOME YOUTH

**Abstract**

Many US children have poor dietary behaviors, which increases the risk of overweight and obesity, and lifestyle-related chronic diseases, such as hypertension and type 2 diabetes. The McGuirt research lab developed and pilot-tested a virtual reality avatar-led nutrition education program with youth. However, quantitative formative testing has not been conducted. Thus, this study aims to assess the acceptability and usability of the VR avatar-based nutrition education program among Black or African American adolescents. Also, in an exploratory analysis, we compared youth dietary intake responses on standard dietary assessment survey tools versus the VR avatar program to assess if youth might respond differently to the avatar probing about diet. A quantitative formative process evaluation was conducted with thirty-nine children, who were majority African American (79.5%), and an average age of  $11 \pm 1.79$  years old. Findings revealed that overall program appeal and useability were favorable, with the majority of youth reporting the VR avatar program was fun to use (84.6%), easy to use (92.3%), would be useful in daily life (79.4%), and would use the program often if it becomes available (71.8%). Significantly more children who owned a smartphone agreed that regular use of the program would increase confidence to eat healthy ( $p=0.013$ ,  $d=0.322$ ), would be useful in daily life ( $p=0.020$ ,  $d=0.298$ ), and intend to use the program regularly when it becomes available ( $p=0.002$ ,  $d=0.415$ ), compared to youth without smartphones. Significantly more adolescents (ages 11 to 14 years old) agreed they liked learning about healthy snacking compared to younger children (ages 9 to 10 years old) ( $p=0.024$ ,  $d=0.346$ ). There were no statistically significant differences in perceived measures of program enjoyment, utility, ease of use, and future use intention by race or gender. There was a positive, statistically significant association between VR avatar program fruit servings and the FV Screener fruit servings ( $r = 0.363$ ,  $p =$

0.023). This research quantifies the favorable appeal, usability, and acceptance of the VR avatar-based nutrition education program among African American youth. Interaction with an avatar does not appear to impact children's dietary responses related to fruit intake.

## Introduction

Few school-aged children and adolescents meet the 2020 to 2025 Dietary Guidelines for Americans, falling short of recommended intakes of fruits, vegetables, whole grains, and dairy.<sup>105</sup> As youth age and the gap between recommended and actual intake of healthy food groups widens, intakes of added sugar, saturated fat, and salt increase, with greater disparities among low-income minority adolescents.<sup>15,16,18,49,79,106</sup> Eating a well-balanced diet is imperative to healthy growth and development and preventing chronic diseases, such as obesity, hypertension, and type 2 diabetes. However, as youth age, adhering to a healthy diet becomes increasingly challenging, particularly for low-income, minority youth who often experience increased access to convenience stores and fast-food outlets that promote energy-dense, unhealthy foods.<sup>18,62,67,79</sup>

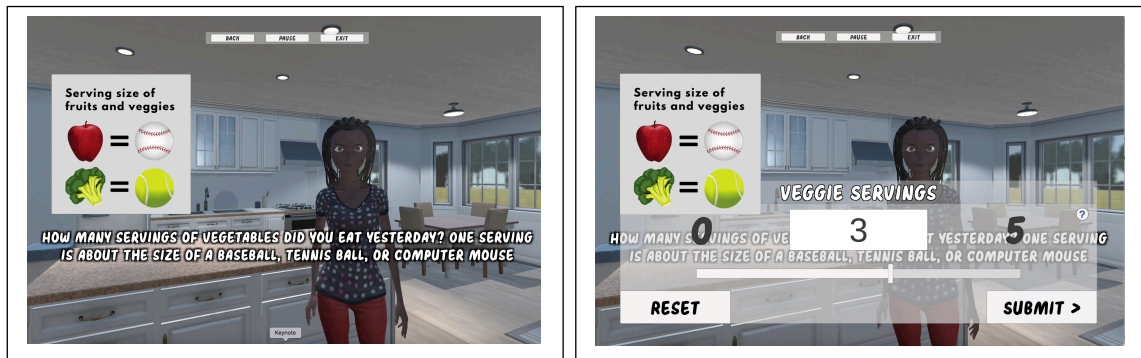
Nutrition interventions among youth show moderate efficacy in improving dietary intake. Yet, as most nutrition interventions targeting adolescents are conducted in school-based settings, with teachers delivering the information, lack of classroom resources and time are significant barriers.<sup>33-37</sup> Due to the poor dietary behaviors of youth and the lack of exposure to nutrition education, a change in health-promotion strategies is warranted. The utilization of technology-based learning solutions can be useful to capture the attention of youth and promote healthy habits. Youth use digital technology and media constantly in their daily lives.<sup>82,84,107</sup> Teens spend 3 hours more per day using digital devices than children in middle childhood (8-10 year old), and low-income teens use digital devices roughly two hours more per day than teens of higher income (8 hours, 32 minutes v 6 hours, 49 minutes), excluding time spent doing schoolwork.<sup>76</sup> Adolescents, in particular, communicate via digital technology, increasingly using smartphones, and view it as a source of entertainment, socialization, and active

learning.<sup>68,82,84,107,108</sup> Youth enthusiastically use avatars, or digital characters, to engage with digital media and strongly identify with avatars as friends or idealized versions of themselves.<sup>40,83</sup> Our formative research revealed that adolescents use avatars daily in digital games such as Roblox and Fortnite and on social media platforms such as Snapchat. The few studies that have evaluated digital avatar-based nutrition programs among children have shown a positive impact on fruit and vegetable intake.<sup>32,36</sup> Thus, innovative digital programs using avatars hold promise to influence the health behaviors of children.

Given this promise, the McGuirt research lab developed and pilot-tested a virtual reality (VR) avatar-led nutrition education program in 2019, utilizing structured observations and in-depth interviews with fifteen African American child-adult dyads (*n* = 30 total participants). Children were an average age of 9 years old, with a nearly even distribution of boys and girls who completed the study.<sup>41</sup> The VR avatar nutrition education program is accessed via a web-enabled computer. An avatar presents evidenced-based nutrition education guidance based on the Health Resources and Services Administration sponsored Bright Futures in Practice clinical guidance manual. While qualitative methods have been used to assess the current program, there is a need to collect more detailed quantitative information. Therefore, further testing of the program's appeal and useability is required.

In the VR avatar nutrition education program, the avatar asks the child about their current dietary behaviors. Regarding fruit and vegetable intake, the avatar asks the child how many servings they consumed yesterday and provides a visual guide of a serving (e.g., a serving of an apple is about the size of a baseball). Then the child uses the computer mouse (or finger if the computer is touch-screen enabled) to slide the indicator bar and select the number of servings of fruit or vegetables they consumed (Figure 8).

**Figure 8. VR avatar program screens showing how fruits and vegetable servings are selected in the program**



Dietary intake is typically measured in youth by self-report, utilizing a 24-hour dietary recall or food frequency questionnaires (FFQs), which are subject to various forms of bias, such as recall and social desirability bias.<sup>109–112</sup> Other challenges in collecting dietary data in children include the child possessing the required cognitive skills and literacy level to understand a self-report instrument and estimate portion sizes. The VR avatar program may be useful in overcoming these challenges with guidance from the avatar, as youth often view avatars as idealized versions of themselves. The Veggie Meter®, a reflection spectroscopy device (The Veggie Meter®, Longevity Link Corporation, Salt Lake City, UT, USA), has also been utilized to obtain an objective measure of fruit and vegetable intake in children and minority populations.<sup>109–112</sup>

Before evaluating the efficacy of the VR avatar nutrition education program to improve dietary intake, an important step is to explore if interaction with an avatar impacts dietary responses. While studies have examined the impact of technology-based nutrition education programs on dietary intake, published literature examining the impact of the interaction with an avatar on dietary responses could not be found.<sup>42,53</sup>

Thus, utilizing a quantitative formative process evaluation, this research examines program acceptance and usability among low-income, minority children. We also explore

similarities and differences in youth reporting of dietary intake to the avatar versus standard assessment approaches (FFQs, 24-hr recalls, Veggie Meter®). We hypothesize that smartphone ownership and older age will be associated with positive program acceptance and useability. We also anticipate similarities between 24-hour dietary recall data and diet-related VR avatar program responses (fruits, vegetables).

## **Methods**

### **Participant Recruitment**

Through an established relationship with Boys and Girls Clubs of America within a 30-mile radius of the Greensboro Triad area, we invited children to participate in the formative process evaluation via email and flyers distributed by the staff at each Boys and Girls Club. Eligible participants were: (1) qualified as low-income (federal benefit eligible); (2) a child aged 8 to 14 years old; (3) Black or African American race; (4) Fluent in English; and (5) willing to engage with the VR avatar nutrition education program for this study. Although we aimed to recruit African American youth, low-income youth of other races participating in Boys and Girls Club afterschool programs were not excluded.

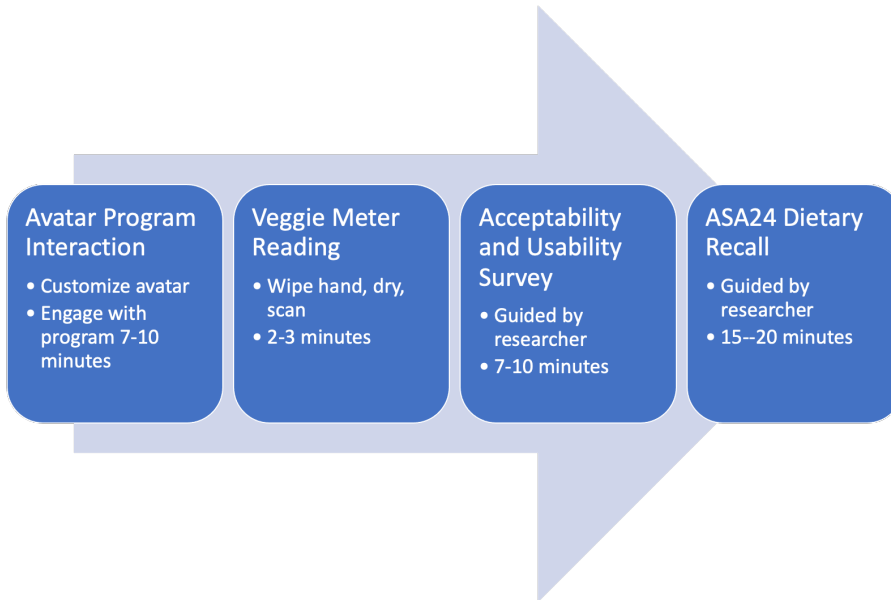
Data collection took place at three Boys and Girls Clubs sites to minimize participant burden, on a Tuesday, Wednesday, Thursday, or Friday during the month of March 2022. A week prior to collecting data, the principal investigator reviewed the study information with the child and parent during parent pickup and provided electronic consent and assent forms for participants to sign online in RedCap. The Boys and Girls Club staff also provided all eligible attendees with consent and assent forms to take home to sign. On the day of the formative process evaluation, the principal investigator again reviewed the study information with each child and verified consent and assent form signatures. Each study participant received a \$50 gift card at the end of the formative process evaluation. The University of North Carolina Greensboro Institutional Review Board (IRB) approved this study (approval no. FY22-300).



## Procedures

The formative process evaluation consisted of four steps, as outlined in Figure 9.

**Figure 9. Formative Process Evaluation Study Flow Diagram**



First, trained research staff observed youth participants engaging with the VR avatar nutrition education program on password-protected UNCG laptops. To engage with the program, youth participants customized their avatar, input their study ID, age, and Boys & Girls Club center address then completed the snacking module of the program. Following program engagement, youth completed a short twenty-two-item online survey assessing program acceptance and usability online in RedCap. Trained research staff then conducted a 24-hour dietary recall with children utilizing the Automated Self-Administered 24-hour Dietary Assessment Tool (ASA24). Although ASA24 is designed as an online self-reporting tool, a research staff member helped guide each child through completing the dietary recall. One 24-hour recall was completed for each child. Finally, given equipment malfunction, a subset of youth (n=14) completed a Veggie Meter® scan by placing their index finger into the Veggie Meter® device. A single scan method was utilized, only requiring the child to place their finger into the device once, with the Veggie Meter® taking three measurements. The total time for the

formative process evaluation was approximately forty-five minutes. Youth responses to avatar questions about dietary intake were saved automatically on a UNCG server as the youth engaged with the VR avatar nutrition education program. After completing the formative process evaluation, VR avatar program responses were manually entered into an Excel file. Participant 24-hour recall data was downloaded from the ASA24 researcher site as a CSV file.

## **Measures**

### *Dietary Intake*

Program responses consisted of fruit consumed yesterday in servings and vegetables consumed yesterday in servings. 24-hour dietary intake data collected in ASA24 was reported in cups. The researcher observed the child interacting with the avatar program, but did not help the child input what they consumed into the program.

24-hour dietary recalls were conducted on a Tuesday, Wednesday, Thursday, or Friday afternoon from approximately 4 pm to 6 pm. Researchers guided each child through the 24-hour recall and began by asking the child to recall what they ate for dinner the night before. The researcher continued probing the child for details related to all meals, snacks, and beverages consumed from the night before to the afternoon of the 24-hr recall. The researcher asked the child how each food was prepared, to identify the portion size consumed, based on images provided in ASA24, and all toppings or additions to foods (e.g., cheese, ketchup or lettuce on a burger).

### *Program Acceptance and Usability*

A short twenty-two-item online survey measured program acceptance and usability. The survey consisted of modified questions from previously validated questionnaires on technology acceptance of e-learning tools.<sup>113,114</sup> The survey assessed participant demographics, home technology access, perceptions of program enjoyment (three items), program ease of use (three items), program utility (four items), and future use intentions (three items).

Questions such as “the avatar program was fun to use,” “I liked learning about healthy eating,” “moving through the sections of the avatar program was easy,” and “using the avatar program helped me learn about healthy eating” were asked on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The survey also included two questions from the National Cancer Institute (NCI) Fruit and Vegetable (FV) screener to assess gross estimates of fruit and vegetable intake in servings.<sup>115,116</sup> Participants selected one of six responses to the dietary screener questions ranging from 0 servings to 5 or more servings per day. Children also self-reported their age, race, gender (male, female, transgender/non-binary, other/prefer not to say), home-computer access (yes/no), home video-game system access (yes/no), and smartphone ownership (do you have a smartphone of your own; yes/no) in the survey. The complete survey can be found in Appendix F.

#### *Skin Carotenoids Measurements*

For an objective measure of fruit and vegetable intake, skin carotenoids were assessed using the Veggie Meter®. The Veggie Meter® (Veggie Meter, Longevity Link Corp.) is a relatively lower-cost, minimally invasive, portable device that utilizes pressure-mediated reflection spectroscopy (RS) or broad-band white light to measure skin carotenoids through their respective absorption from 400 to 750 nm.<sup>117</sup> Scores range from 0 to 800, with a higher score indicating more skin carotenoids. The device measures the individual’s finger and has been validated in a racially diverse sample (n = 30) with a correlation between plasma carotenoids and Veggie-Meter-assessed carotenoids of  $r = 0.71$ ,  $p < 0.001$ .<sup>118</sup> May et al. 2020 also utilized the Veggie Meter to assess fruit and vegetable intake in youth in North Carolina and found a significant inverse association between soda intake and Veggie Meter® readings in middle school children ( $r = -0.22$ ,  $p < 0.05$ ).<sup>119</sup>

Given an equipment malfunction, Veggie Meter® readings were collected on a subset of children from two Boys & Girls Clubs centers (n=14). Youth placed their index finger into the Veggie Meter device for a reading, and a single scan method was utilized.

## Statistical Analysis

Data were analyzed using IBM SPSS 28.0 (SPSS, Chicago, IL). Univariate descriptive statistics were used to summarize the sample demographic characteristics. Responses for program acceptance and useability, including perceived enjoyment (three items), program ease of use (three items), program utility (four items), and future use intentions (three items), were analyzed for means, standard deviations, and frequency distributions. Given the low frequency of responses of disagree/strongly disagree as 3-category variables (low, neutral, high), items assessing program acceptance and useability were dichotomized as 1 = agree (strongly agree, agree), 0 = disagree (neutral, disagree, strongly disagree), with agree representing favorable program acceptance and useability. To assess differences in program acceptance and useability by gender (male/female), age (middle childhood(ages 9-10)/adolescence(ages 11-15)), race (African American/non-African American), smartphone ownership (yes/no), home computer access (yes/no), and home video game system access (yes/no), we conducted likelihood ratio tests, given expected cell frequencies of less than five.

Individual 24-hour dietary recall data on fruits and vegetables were used for analysis. Data were analyzed, including and excluding fruit juice and including and excluding white potatoes, which also included French fries. However, fruit juices and white potatoes were not used as visual aids in obtaining diet-related data in the VR avatar nutrition education program or on FV dietary screener questions. For consistency with diet-related program responses and FV screener questions, we converted 24-hour diet recall cups to servings utilizing the Food and Nutrient Database for Dietary Studies. Portions or fractions were rounded to the closest serving (i.e., 1.75 servings were rounded to 2 servings). Given non-normally distributed data, similarities and differences in VR avatar diet-related program responses (fruit servings, vegetable servings) and data from 24-hour recalls were assessed utilizing Spearman correlations, with ASA24 24-hour recall data in servings as the criterion measure. Comparisons between avatar diet-related

program responses and the FV Screener were also assessed using Spearman correlations, given non-normally distributed data.

Normality assumptions for Veggie Meter-scores were assessed with the Shapiro-Wilk test. Spearman correlations were used to determine associations between VR avatar diet-related program responses (fruit servings, vegetable servings) and Veggie-Meter-scores (given non-normal distributions of VR avatar diet-related responses). Differences in Veggie Meter® scores by VR avatar fruit serving and vegetable serving categories (0 servings, 1 serving, 2 servings, 3 servings, 4 servings and 5 servings) were assessed by one-way ANOVA. We utilized bootstrapping at 5,000 replications to account for violation of homogeneity of variances and to better calculate standard errors and construct 95% confidence intervals.

## Results

### Participant Characteristics

Of the forty-two youth who participated in the study, complete data were available on thirty-nine youth for analysis. As detailed in Table 8, the majority of participants reported African American race (79.5%), with an average age of 11.06 years old (9-14 range), and there were more males (53.8%) than females (46.2%).

**Table 8. Participant characteristics**

<b>Participant Characteristics</b>	<b>Frequency (%)</b>
Race (Child self-reported)	
African American	31 (79.5)
White	5 (12.8)
Latino	2 (5.1)
Other or Prefer Not To Say	1 (2.6)
Gender (Child self-reported)	
Male	21 (53.8)
Female	18 (46.2)
Access to Technology at Home	
WiFi	33 (84.6)
Chromebook or Laptop	26 (66.7)
Smartphone ownership	29 (74.4)
Tablet or e-reader	16 (41.0)
Video gaming system	24 (61.5)

	Mean (SD)
Average age	11.06 (1.79)

Less than half (46.2%) of youth met 2020 to 2025 Dietary Guideline recommendations for fruit (1.5 cups or 3 servings), and only 20.5% of youth met recommendations for vegetables (2.5 cups or 5 servings). Mean and median fruit and vegetable servings can be found in Table 9 and demonstrate low intake among youth.

**Table 9. Servings of fruits and vegetables measured in the Avatar program, 24-hour Recalls, and brief FV screener**

	Mean	SE	Minimum	Median	Maximum
Fruit, servings					
Avatar program	2.4	0.27	0.0	2.0	5.0
FV Screener	3.1	0.19	1.0	3.0	5.0
24-h recall	2.4	0.45	0.0	1.0	10.0
Fruit ex Juice, servings					
24-h recall	1.6	0.35	0.0	1.0	8.0
Vegetable, servings					
Avatar program	2.0	0.28	0.0	1.0	5.0
FV Screener	2.4	0.22	1.0	2.0	5.0
24-h recall	1.8	0.27	0.0	2.0	6.0
Vegetables ex Potatoes, servings					
24-h recall	1.2	0.19	0.0	1.0	4.0

### Program Acceptability and Usability

Overall, program acceptance and usability were favorable, with the majority of youth reporting the VR avatar program was fun to use (84.6%), overall easy to use (92.3%), would be useful in daily life (79.4%), would make it easier to eat healthier (84.6%), would use the program often if it becomes available (71.8%), intend to use when it becomes available (66.7%), and would recommend the VR avatar program to a friend (92.3%) (Table 10).

**Table 10. Overall program acceptance and useability**

Questionnaire Items	Frequency (%)	
	High	Low
Perceived Enjoyment		
The avatar program was fun to use	33 (84.6)	6 (15.4)
I enjoyed using the avatar program	36 (92.3)	3 (7.7)
I liked learning about healthy snacking	32 (82.1)	7 (17.9)

Perceived Ease of Use		
Easy to move through each section of the program	35 (89.7)	4 (10.3)
I understood how to use the avatar program	31 (79.4)	8 (20.5)
Overall, using the avatar program was easy	36 (92.3)	3 (7.7)
Perceived Utility		
Regular use would help me learn about healthy eating	35 (89.7)	4 (10.3)
Regular use would increase confidence to eat healthy	30 (76.9)	9 (23.1)
Regular use would make it easier for me to eat healthier	33 (84.6)	6 (15.4)
I think the program would be useful in my daily life	31 (79.4)	8 (20.5)
Future Use Intention		
Would use this program often if it becomes available	28 (71.8)	11 (28.2)
I intend to use this program when it becomes available	26 (66.7)	13 (33.3)
I would recommend this program to a friend	36 (92.3)	3 (7.7)

The perceived program enjoyment measure of “I like learning about healthy snacking” was significantly higher among adolescents (ages 11 to 14) compared to younger children (ages 9-10) ( $p=0.024$ ,  $d=0.346$ ). There were no statistically significant differences in other perceived program enjoyment measures by age or measures of perceived program ease of use, utility, or future use intention (Table 11).

**Table 11. Program acceptance and usability by age**

Age	Agree, N (%)		G <sup>2</sup>	P value
	9-10yo	11-14yo		
Perceived enjoyment				
The avatar program was fun to use	16 (48.5)	17 (51.5)	0.005	0.946
I enjoyed using the avatar program	17 (47.2)	19 (52.8)	0.425	0.963
I liked learning about healthy snacking	13 (40.6)	19 (59.4)	5.068	0.024*
Perceived ease of use				
Easy to move through each section of the program	17 (48.6)	18 (51.4)	0.003	0.957
I understood how to use the avatar program	14 (45.2)	17 (54.8)	0.770	0.380
Overall, using the avatar program was easy	18 (50.0)	18 (50.0)	0.314	0.575
Perceived utility				
Regular use would help me learn about healthy eating	18 (51.4)	17 (48.6)	1.049	0.306
Regular use would increase confidence to eat healthy	16 (53.3)	14 (46.7)	1.127	0.501
Regular use would make it easier for me to eat healthier	15 (45.5)	18 (54.5)	0.927	0.336
I think the program would be useful in my daily life	15 (48.4)	16 (51.6)	0.007	0.935
Future use intention				
Would use this program often if it becomes available	16 (57.1)	12 (42.9)	2.906	0.088
I intend to use this program when it becomes available	14 (53.8)	12 (46.2)	0.827	0.363
I would recommend this program to a friend	18 (50.0)	18 (50.0)	0.314	0.575
* $p<0.05$				

The program was viewed favorably equally among males and females. There were no statistically significant differences in measures of perceived program enjoyment, ease of use, utility, or future use intention by gender (Table 12).

**Table 12. Program acceptance and useability by gender**

Gender	Agree, N (%)		G <sup>2</sup>	P value
	Male	Female		
Perceived enjoyment				
The avatar program was fun to use	17 (51.5)	16 (48.5)	0.479	0.489
I enjoyed using the avatar program	19 (52.8)	17 (47.2)	0.220	0.639
I liked learning about healthy snacking	15 (46.9)	17 (53.1)	3.857	0.050
Perceived ease of use				
Easy to move through each section of the program	19 (54.3)	16 (45.7)	0.0260	0.871
I understood how to use the avatar program	17 (54.8)	14 (45.2)	0.060	0.807
Overall, using the avatar program was easy	19 (52.8)	17 (47.2)	0.220	0.639
Perceived utility				
Regular use would help me learn about healthy eating	19 (54.3)	16 (45.7)	0.026	0.871
Regular use would increase confidence to eat healthy	16 (53.3)	14 (46.7)	0.014	0.907
Regular use would make it easier for me to eat healthier	16 (48.5)	17 (51.5)	2.710	0.100
I think the program would be useful in my daily life	16 (51.6)	15 (48.4)	0.307	0.580
Future use intention				
Would use this program often if it becomes available	15 (53.6)	13 (46.4)	0.003	0.956
I intend to use this program when it becomes available	16 (61.5)	10 (38.5)	1.865	0.172
I would recommend this program to a friend	19 (52.8)	17 (47.2)	0.220	0.639
*p<0.05				

Additionally, there were no statistically significant differences in measures of perceived program enjoyment, ease of use, utility, or future use intention by race (Table 13).

**Table 13. Program acceptance and usability by Race**

Race	Agree, N (%)		G <sup>2</sup>	P value
	African Am	Non-AA		
Perceived enjoyment				
The avatar program was fun to use	28 (84.8)	5 (15.2)	3.190	0.074
I enjoyed using the avatar program	30 (83.3)	6 (16.7)	3.320	0.068
I liked learning about healthy snacking	25 (78.1)	7 (21.9)	0.217	0.641
Perceived ease of use				
Easy to move through each section of the program	28 (80.0)	7 (20.0)	0.053	0.818
I understood how to use the avatar program	24 (77.4)	7 (22.6)	0.433	0.510
Overall, using the avatar program was easy	29 (80.6)	7 (19.4)	0.293	0.588
Perceived utility				
Regular use would help me learn about healthy eating	29 (82.9)	6 (17.1)	1.964	0.161
Regular use would increase confidence to eat healthy	26 (86.7)	4 (13.3)	3.654	0.056
Regular use would make it easier for me to eat healthier	27 (81.8)	6 (18.2)	0.648	0.421



I think the program would be useful in my daily life	26 (83.9)	5 (16.1)	1.603	0.206
Future use intention				
Would use this program often if it becomes available	24 (85.7)	4 (14.3)	2.192	0.139
I intend to use this program when it becomes available	20 (76.9)	6 (23.1)	0.327	0.568
I would recommend this program to a friend	29 (80.6)	7 (19.4)	0.293	0.588
*p<0.05				

Differences were observed in perceived program utility and future use intention by smartphone ownership. Significantly more children who owned a smartphone agreed with the perceived program utility measures of “regular program use would increase confidence to eat healthy” (p=0.013, d=0.322) and “I think this program would be useful in my daily life” (p=0.020, d=0.298) compared to those without a smartphone. Additionally, significantly more children with smartphones intend to use the program when it becomes available than those without smartphones (p=0.002, d=0.415). There were no statistically significant differences in perceived program enjoyment or ease of use by smartphone ownership (Table 14).

**Table 14. Program acceptance and usability by smartphone ownership**

	Agree, N (%)		G <sup>2</sup>	P value
	Yes	No		
<b>Smartphone Ownership</b>				
Perceived enjoyment				
The avatar program was fun to use	26 (78.8)	7 (21.2)	1.979	0.159
I enjoyed using the avatar program	28 (77.8)	8 (22.2)	2.445	0.118
I liked learning about healthy snacking	23 (71.9)	9 (28.1)	0.637	0.425
Perceived ease of use				
Easy to move through each section of the program	27 (77.1)	8 (22.9)	1.230	0.267
I understood how to use the avatar program	24 (77.4)	7 (22.6)	0.700	0.403
Overall, using the avatar program was easy	27 (75.0)	9 (25.0)	0.096	0.757
Perceived utility				
Regular use would help me learn about healthy eating	26 (74.3)	9 (25.7)	0.001	0.975
Regular use would increase confidence to eat healthy	20 (66.7)	10 (33.3)	6.212	0.013*
Regular use would make it easier for me to eat healthier	24 (72.7)	9 (27.3)	0.323	0.570
I think the program would be useful in my daily life	21 (67.7)	10 (32.3)	5.417	0.020*
Future use intention				
Would use this program often if it becomes available	21 (75.0)	7 (25.0)	0.021	0.884
I intend to use this program when it becomes available	16 (61.5)	10 (38.5)	9.756	0.002*
I would recommend this program to a friend	27 (75.0)	9 (25.0)	0.096	0.757
*p<0.05				

Significantly more children with a home computer agreed with the perceived program ease of use measure of “I understood how to use the avatar program” ( $p=0.006$ ,  $d=0.359$ ) than those without home computer access. There were no statistically significant differences in perceived program enjoyment, utility, or future use intention by home computer access (Table 15). Finally, there were no statistically significant differences in measures of perceived program enjoyment, ease of use, utility, or future use intention by home video game system ownership.

**Table 15. Program acceptance and usability by home computer access**

	Agree, N (%)		G <sup>2</sup>	P value
	Yes	No		
<b>Home Computer Access</b>				
Perceived enjoyment				
The avatar program was fun to use	23 (69.7)	10 (30.3)	0.845	0.358
I enjoyed using the avatar program	23 (63.9)	13 (36.1)	2.556	0.110
I liked learning about healthy snacking	21 (65.6)	11 (34.4)	0.089	0.766
Perceived ease of use				
Easy to move through each section of the program	22 (62.9)	13 (37.1)	3.468	0.063
I understood how to use the avatar program	18 (58.1)	13 (41.9)	7.483	0.006*
Overall, using the avatar program was easy	24 (66.7)	12 (33.3)	0.000	1.000
Perceived utility				
Regular use would help me learn about healthy eating	23 (65.7)	12 (34.3)	0.146	0.703
Regular use would increase confidence to eat healthy	20 (66.7)	10 (33.3)	0.000	1.000
Regular use would make it easier for me to eat healthier	21 (63.6)	12 (36.4)	0.980	0.322
I think the program would be useful in my daily life	19 (61.3)	12 (38.7)	2.2239	0.135
Future use intention				
Would use this program often if it becomes available	17 (60.7)	11 (39.3)	1.697	0.193
I intend to use this program when it becomes available	18 (69.2)	8 (30.8)	0.228	0.633
I would recommend this program to a friend	24 (66.7)	12 (33.3)	0.000	1.000
* $p<0.05$				

### Measuring Fruit and Vegetable Intake

There was a weak positive statistically significant association between VR avatar program fruit servings and the FV Screener fruit servings ( $r = 0.363$ ,  $p = 0.023$ ). Compared to 24-hr recalls, the associations with avatar program servings of fruit and fruit excluding juice were positive but not statistically significant (Table 16).

**Table 16. Correlations between VR avatar fruit servings and FV screener fruit servings and 24-hr recall fruit servings**

	<b>Spearman's coefficients (r)</b>	<b>p-value</b>
FV screener fruit	0.363	0.023*
24-hr recall fruit	0.289	0.074
24-hr recall fruit ex juice	0.184	0.263

\*p<0.05

Although associations were positive, there were no significant associations between VR avatar program vegetable servings and FV Screener vegetable servings. Additionally, there were no significant associations between VR avatar program vegetable servings and 24-hour recall vegetable servings or 24-hour recall vegetables, excluding potatoes servings (Table 17).

**Table 17. Correlations between VR avatar vegetable servings and FV screener vegetable servings and 24-hr recall vegetable servings**

Measure	<b>Spearman's coefficients (r)</b>	<b>p-value</b>
FV screener vegetables	0.143	0.387
24-hr recall vegetables	0.208	0.204
24-hr recall vegetables ex potatoes	0.244	0.134

\*p<0.05

No statistically significant associations were found between Veggie Meter® scores and VR avatar fruit servings or VR avatar vegetable servings (Table 18).

**Table 18. Veggie Meter Scores by dietary intake collection method**

	<b>Spearman's coefficients (r)</b>	<b>P-Value</b>
VR Avatar Fruit Servings	0.079	0.789
VR Avatar Vegetable Servings	-0.030	0.918

In analyzing VR avatar fruit serving categories, Veggie Meter® scores decreased from zero to one fruit serving, increased from one to three fruit servings, decreased from three to four fruit servings, and increased from four to five fruit servings. Veggie Meter-scores were not

significantly different by VR avatar fruit serving categories,  $F(5,13) = 8.316$ ,  $p = 0.605$  (Table 19).

**Table 19. Veggie Meter® scores by VR avatar fruit serving categories**

	N	Mean (SD)	Bootstrap 95% Confidence Interval		F, Sig.
			Lower	Upper	
VR Avatar Fruit Servings					
0 Servings	2	185.0 (1.41)	184.00	186.00	F(5,13) = 0.756 p = 0.605
1 Serving	4	160.0 (51.48)	112.33	206.00	
2 Servings	2	175.5 (12.02)	167.00	184.00	
3 Servings	1	235.0 (0.00)	235.00	235.00	
4 Servings	1	107.0 (0.00)	107.00	107.00	
5 Servings	4	198.3 (72.79)	134.33	266.00	
Total	14	178.3 (52.13)	154.14	203.52	

In analyzing VR avatar vegetable serving categories, Veggie Meter® scores decreased from zero to one vegetable serving and from one to two vegetable servings, increased from two to three vegetable servings, remained the same from three to four servings, and decreased from four to five vegetable servings. Veggie Meter-scores were not significantly different by VR avatar vegetable serving categories,  $F(5,13) = 8.316$ ,  $p = 0.605$  (Table 20).

**Table 20. Veggie Meter® scores by VR avatar vegetable serving categories**

for	N	Mean (SD)	Bootstrap 95% Confidence Interval		F, Sig.
			Lower	Upper	
VR Avatar Vegetable Servings					
0 Servings	3	171.0 (56.15)	107.00	212.00	F(5,13) = 1.052 p = 0.451
1 Serving	4	170.0 (50.56)	103.33	224.00	
2 Servings	1	131.0 (0.00)	131.00	131.00	
3 Servings	2	235.0 (72.83)	184.00	287.00	
4 Servings	1	235.0 (0.00)	235.00	235.00	
5 Servings	3	155.3 (31.88)	121.33	184.00	
Total	14	178.3 (52.13)	154.18	205.92	

## Discussion

In terms of program acceptance and usability, the overall response among this predominantly African American sample of youth was positive. The majority of youth enjoyed using the program, found it easy to use, reported regular use would help them learn about healthy snacking, increase confidence to eat healthier snacks, would use the program often,

intend to use the program when it becomes available, and would recommend the program to a friend. In addition, the program was perceived equally favorable by boys and girls among this predominantly African American sample.

Interestingly, significantly more youth with smartphones agreed the VR avatar program would increase confidence to eat healthy, be useful in daily life, and intend to regularly use the program when it becomes available, compared to youth without smartphones, with weak to medium effect sizes. Additionally, significantly more adolescents (ages 11 to 14) liked learning about healthy snacking than younger children (ages 9 to 10 years old). These findings support our primary hypothesis that smartphone ownership and older age would be positively associated with program acceptance and usability. The positive associations with smartphone ownership in this study may be related to increased smartphone and digital media usage among low-income adolescents.<sup>24,59</sup> Additionally, studies have demonstrated smartphone ownership as a significant predictor of the adoption of mobile apps among adult populations.<sup>96</sup>

This study also supports the findings from previous formative work (focus groups and in-depth interviews) and pilot testing of an earlier version of the VR avatar program, demonstrating that the VR avatar nutrition education program may positively impact the health behaviors of low-income African American adolescents.<sup>41</sup> Over 80% of youth in this study reported the VR avatar program would help them learn about healthy eating, increase their confidence to eat healthy, make it easier to eat healthy, and be useful in daily life. In pilot testing of a computer-based nutrition education program using avatars, Quest to Lava Mountain (QTLM), Sharma, et al. (2015) found positive acceptance and usage among an ethnically diverse sample of youth ages nine to ten years old.<sup>33</sup> Youth engaged with the nutrition education program for approximately 4 hours over six weeks, with over 80% of youth wanting to use the program again, agreed it would help them make healthy choices (80.4%) and would recommend it to their peers (84.4%).<sup>33</sup> Additionally, Casazza and Ciccazzo (2006) found that compared to traditional health education programs, adolescents who received a computer-based health

education intervention showed increased knowledge ( $p < 0.001$ ), self-efficacy ( $p < 0.001$ ), social support ( $p < 0.001$ ), physical activity ( $p = 0.001$ ), and decreased meals skipped ( $p < 0.001$ ) compared to the control group.<sup>69</sup>

While our secondary hypothesis that similarities would be observed between 24-hour dietary recall data and diet-related VR avatar program responses was not fully supported, there was a positive weak association between VR avatar program fruit servings and the FV Screener fruit servings ( $r = 0.363$ ,  $p = 0.023$ ). Although not significant, associations with VR avatar servings and other dietary assessment measures (FV Screener, 24-hour recall) were positive. Thus, interaction with an avatar does not appear to impact dietary responses. It should also be noted that the fruit and vegetable intake of the youth in this study was low, with few children meeting the recommended dietary guidelines for daily fruit and vegetable servings. A lack of significant associations seen in our study could be due to low variability in dietary intake of fruits and vegetables. Additionally, 24-hour recall results may differ from VR avatar program responses due to a higher participant burden. Furthermore, previous studies demonstrate that short FV screeners often overestimate intake compared to 24-hour recalls and are best utilized for gross estimates to rank individuals with regard to intake.<sup>115,120</sup>

Additionally, although associations were positive, there were no significant associations between Veggie Meter® readings and VR avatar fruit and vegetable servings. However, Veggie Meter® readings were collected among a small subset of youth ( $n = 14$ ) due to an equipment malfunction. Also, as Veggie Meter-scores measured skin carotenoids, the comparison with VR avatar program responses is based on different units of measurement. Future research with a larger sample size investigating the VR avatar program responses compared to Veggie Meter-assessed skin carotenoids is warranted. Digital nutrition education programs should consider utilizing multiple standard dietary assessment approaches (FFQs, 24-hr recalls, Veggie Meter®) when examining program efficacy.

Additionally, the findings of this study must be interpreted in light of several limitations. The sample was small (n=39), predominantly African American ages nine to fourteen years old, from one geographical area. Therefore, the results of this study may not be generalizable to other youth. In addition, we recruited youth from Boys and Girls Clubs, which provide regular access to technology such as computers and video gaming systems. The technology access at Boys and Girls Clubs was not evaluated in this study and may influence perceptions and appeal of the VR avatar program among youth. Children also engaged with the VR avatar nutrition education program in one sitting for about seven minutes. Engaging with the VR avatar program over a longer extended time period may yield different results. Furthermore, each Boys and Girls club serves the children food. On Fridays in particular, a day of the week when data were collected, children are served pizza and are able to purchase sugar-sweetened beverages. These food practices impacted the children's dietary habits and may reflect the child's dietary intake on other days of the week. Despite these limitations, VR avatar program appeal and useability were high among a sample of predominantly African-American youth, a group understudied in the literature.

### **Conclusions and Future Implications**

This novel study quantitatively assessed the appeal and usage of a virtual reality avatar-led nutrition education program among low-income youth. In addition, the VR avatar program responses were positively associated with a short FV screener, and the program does not appear to impact responses regarding fruit intake among low-income youth. Given this study's limited sample size and short duration, future research with a larger sample size and longer duration is needed to assess the VR avatar nutrition education program's efficacy to impact dietary intake among youth. In addition, given increased smartphone usage among minority youth in the United States, future program development should explore using a mobile smartphone app approach. Digital nutrition education programs should consider utilizing

multiple standard dietary assessment approaches (FFQs, 24-hr recalls, Veggie Meter®) when assessing program efficacy.



## CHAPTER VI: EPILOGUE

### **Summary of Findings**

The findings of this study culminate in several meaningful outcomes for the development of digital nutrition interventions among low-income minority youth. Firstly, formative research identified key cultural-specific program modifications to increase appeal, support sustained program engagement, and positively impact the health behaviors of African American adolescents. Youth desired continuous avatar and music customization throughout the program. Increased gamification utilizing a storyline, exploration of different countries and cuisines, group chat, earning points, rewards, and challenges, was also suggested by youth to support sustained interaction in the VR avatar program. Parents were also interested in interacting with the VR avatar nutrition education program for short 3-5-minute durations and desired for their children to develop life skills such as basic cooking skills. Parents also desired youth to see themselves reflected in the program to foster cultural identity and to find out about the VR avatar nutrition education program through trusted community organizations like the YMCA and Boys & Girls Clubs.

Additionally, community agency partners, such as pediatricians, pediatric registered dietitians, health educators working in school systems (27%), and cooperative extension agents, are interested in using the VR avatar nutrition education program with the families they serve. Of the one hundred community agency partners surveyed across North Carolina, over 80% agreed the program was an innovative and convenient way to reach and teach families about nutrition. Community partners agreed the VR avatar nutrition education program would require fewer resources, including less class time, less staff, fewer materials, and less monetary resources. The majority of community partners (72%) agreed that the VR avatar nutrition education program might positively impact the dietary behaviors of the families they serve. Community partners who perceived the VR avatar nutrition program as having a relative

advantage over current programs ( $p < 0.05$ ) and compatible ( $p < 0.001$ ) with organizational and personal values had significantly higher odds of future use intention. Thus, it is imperative to demonstrate the advantages of using digital technologies such as avatars and virtual reality compared to existing programs. This study adds to the body of evidence examining digital nutrition programs by identifying factors that may impact the adoption and dissemination of novel programs among community organizations.

To further examine the VR avatar nutrition program acceptance and usability among low-income minority children, we conducted a quantitative formative process evaluation with thirty-nine youth, who were majority African American (79.5%), and an average age of  $11 \pm 1.79$  years old. The majority of youth reported the VR avatar program was fun to use (84.6%), easy to use (92.3%), would be useful in daily life (79.4%), and would use the program often if it became available (71.8%). We found differences in program enjoyment and useability among children who owned smartphones compared to those without smartphones. Additionally, we found differences in the enjoyment measure “I like learning about healthy snacking” among adolescents than younger children. These findings suggest that older youth and those who own smartphones may find the VR avatar nutrition education program more appealing and useful in daily life.

We also explored if children may respond differently to dietary probes from an avatar. In an exploratory analysis, we compared youth dietary intake responses on standard dietary assessment survey tools versus the VR avatar program. There was a positive, statistically significant association between VR avatar program fruit servings and the FV Screener fruit servings ( $r = 0.363$ ,  $p = 0.023$ ). Although not significant, associations with VR avatar servings and other dietary assessment measures (FV Screener, 24-hour recall) were positive. Thus, interaction with an avatar does not appear to impact dietary responses, particularly related to fruit intake.

This study provides information that can be used to design culturally-tailored avatar-led digital nutrition programs to engage low-income African American adolescents in the uptake of healthy lifestyle skills to improve dietary intake. Furthermore, considering the factors identified in this study will help the adoption and dissemination of digital nutrition education programs among community partners who serve low-income families.

Future research with a larger sample size and longer duration is needed to assess the VR avatar nutrition education program's impact on dietary behaviors. Additionally, given the increase in mobile phone use among adolescents, a mobile app-based approach should be explored incorporating these findings.

### **Difficulties Encountered and Lessons Learned**

I encountered numerous difficulties throughout this study. The first difficulty was related to participant recruitment for focus groups. It took several months and persistent emails and phone calls to develop a relationship with Boys and Girls Clubs in the Greensboro Triad area. Once I had the support of the center directors at three Boys and Girls clubs, we were able to recruit focus group participants as parents picked up their children from the clubs. As youth were already present at the Boys & Girls Clubs after school, it was a relatively seamless process to coordinate a date and time with each center director to conduct focus groups with the adolescents in the afternoon. However, finding a suitable time to conduct focus groups with all parents was much more challenging. We were able to conduct one parent focus group, then decided to conduct individual in-depth interviews on weekends via Zoom with the remaining parents who were unable to attend an in-person group.

Recruitment for the community agency survey was also challenging. We aimed to recruit community partners from every county in North Carolina and across a wide variety of types of agencies, including federally qualified health clinics, civic organizations (i.e., United Way, Salvation Army), health departments, school systems (health educators and school-based health centers), pediatricians, pediatric dietitians, NC Cooperative Extension offices (EFNEP,

SNAP-Education), after school programs and government programs (Guilford Healthy Communities, Guilford Partnership for Children) in North Carolina. I spent many months conducting extensive internet searches to identify contacts, along with numerous phone calls and emails to reach participants who were eligible for the study. Contacting individuals at federally qualified health clinics was by far the hardest and often took many months for eligible participants to respond to emails and phone calls.

Another problem I encountered was with the programming enhancements of the VR avatar nutrition education program. The Computer Science undergraduate research assistant working on updating the program was often delayed in making enhancements to the program, despite agreed-upon deadlines in team meetings. This study provided an important reminder that working across disciplines can be challenging, and consistent communication and follow-up is required. Additionally, the program responses of five participants from the quantitative formative process evaluation were missing from the backend program server. We are still unsure how or why this data error occurred and are investigating how to mitigate data collection errors with the appropriate protocols in the future.

### **Future Areas of Interest**

My research is motivated by the desire to reduce health disparities in minority communities and my clinical practice as a Registered Dietitian. Racial and ethnic minorities carry a disproportionate burden of diet-related chronic diseases, such as cardiovascular disease, type 2 diabetes, and obesity. I am very fortunate that this doctoral research aligned with my interests in improving health outcomes among disadvantaged families and the work of my mentor to utilize innovative technologies to increase the accessibility and reach of health promotion programs. My overall objective as a researcher is to address barriers at the environmental and individual levels to improve diet quality. My long-term plans involve continuing to build on my training in developing technology-based nutrition interventions. I am particularly interested in developing community-based interventions that increase culinary skills,

food preparation knowledge, and food resource management skills among disadvantaged youth and families. The acquisition of culinary and food resource management skills is an important aspect of improving nutritional status and preventing chronic lifestyle-related diseases. Along with improved access to healthy foods, these skills are vital among low-income families who often experience limited food access and face difficulty allocating time to prepare meals that fit within a limited budget and meet dietary needs. Mobile health (mHealth) tools are well-suited to deliver culinary-focused nutrition interventions by providing readily accessible step-by-step instruction and continued support for acquiring new skills. Thus, my future research objectives include developing and disseminating a culinary-focused mHealth app, then assessing the impact on dietary intake and other health outcomes among low-income adults and children.

## WORKS CITED

1. Childhood Obesity Facts | Overweight & Obesity | CDC. Published June 24, 2019. Accessed August 23, 2020. <https://www.cdc.gov/obesity/data/childhood.html>
2. Engeland A, Bjørge T, Tverdal A, Sjøgaard AJ. Obesity in Adolescence and Adulthood and the Risk of Adult Mortality. *Epidemiology*. 2004;15(1):79-85.
3. Ogden CL, Fryar CD, Hales CM, Carroll MD, Aoki Y, Freedman DS. Differences in Obesity Prevalence by Demographics and Urbanization in US Children and Adolescents, 2013-2016. *JAMA*. 2018;319(23):2410. doi:10.1001/jama.2018.5158
4. Kiess W, Galler A, Reich A, et al. Clinical aspects of obesity in childhood and adolescence. *Obes Rev Off J Int Assoc Study Obes*. 2001;2(1):29-36. doi:10.1046/j.1467-789x.2001.00017.x
5. Sanyaolu A, Okorie C, Qi X, Locke J, Rehman S. Childhood and Adolescent Obesity in the United States: A Public Health Concern. *Glob Pediatr Health*. 2019;6. doi:10.1177/2333794X19891305
6. Singh GK, Siahpush M, Kogan MD. Rising Social Inequalities in US Childhood Obesity, 2003–2007. *Ann Epidemiol*. 2010;20(1):40-52. doi:10.1016/j.annepidem.2009.09.008
7. Jenssen BP, Kelly MK, Powell M, Bouchelle Z, Mayne SL, Fiks AG. COVID-19 and Changes in Child Obesity. *Pediatrics*. 2021;147(5):e2021050123. doi:10.1542/peds.2021-050123
8. Youth Online: High School YRBS - United States 2019 Results | DASH | CDC. Accessed April 3, 2021. <https://nccd.cdc.gov/youthonline/App/Results.aspx?TT=B&OUT=0&SID=HS&QID=QNOB ESE&LID=LL&YID=RY&LID2=&YID2=&COL=&ROW1=&ROW2=&HT=&LCT=&FS=&FR=&FG=&FA=&FI=&FP=&FSL=&FRL=&FGL=&FAL=&FIL=&FPL=&PV=&TST=&C1=&C2=&QP=&DP=&VA=CI&CS=Y&SYID=&EYID=&SC=&SO=>
9. Christie D, Viner R. Adolescent development. *BMJ*. 2005;330(7486):301-304.
10. Story M, Neumark-sztainer D, French S. Individual and Environmental Influences on Adolescent Eating Behaviors. *J Am Diet Assoc*. 2002;102(3, Supplement):S40-S51. doi:10.1016/S0002-8223(02)90421-9
11. Zarrett N, Eccles J. The passage to adulthood: challenges of late adolescence. *New Dir Youth Dev*. 2006;(111):13-28, 7. doi:10.1002/yd.179
12. Steeves ETA, Johnson KA, Pollard SL, et al. Social influences on eating and physical activity behaviours of urban, minority youths. *Public Health Nutr*. 2016;19(18):3406-3416. doi:10.1017/S1368980016001701
13. Bogart LM, Elliott MN, Ober AJ, et al. Home Sweet Home: Parent and Home Environmental Factors in Adolescent Consumption of Sugar-Sweetened Beverages. *Acad Pediatr*. 2017;17(5):529-536. doi:10.1016/j.acap.2017.01.015

14. Powell LM, Auld MC, Chaloupka FJ, O'Malley PM, Johnston LD. Associations between access to food stores and adolescent body mass index. *Am J Prev Med.* 2007;33(4 Suppl):S301-307. doi:10.1016/j.amepre.2007.07.007
15. Wang Y, Jahns L, Tussing-Humphreys L, et al. Dietary Intake Patterns of Low-Income Urban African-American Adolescents. *J Am Diet Assoc.* 2010;110(9):1340-1345. doi:10.1016/j.jada.2010.06.005
16. Tripicchio GL, Kachurak A, Davey A, Bailey RL, Dabritz LJ, Fisher JO. Associations between Snacking and Weight Status among Adolescents 12-19 Years in the United States. *Nutrients.* 2019;11(7). doi:10.3390/nu11071486
17. Shimizu R, Rodwin AH, Munson MR. A Systematic Review of Psychosocial Nutrition Interventions for Young Adults. *J Nutr Educ Behav.* Published online February 25, 2021. doi:10.1016/j.jneb.2021.01.002
18. Wroblewski MM, Parker EA, Hager E, et al. Friends and Family: How African-American Adolescents' Perceptions of Dietary Beliefs and Behaviors of Others Relate to Diet Quality. *J Acad Nutr Diet.* 2018;118(12):2302-2310. doi:10.1016/j.jand.2018.07.021
19. Bogart LM, Elliott MN, Cowgill BO, et al. Two-Year BMI Outcomes From a School-Based Intervention for Nutrition and Exercise: A Randomized Trial. *Pediatrics.* 2016;137(5). doi:10.1542/peds.2015-2493
20. Story M, Lytle LA, Birnbaum AS, Perry CL. Peer-led, school-based nutrition education for young adolescents: Feasibility and process evaluation of the TEENS study. *J Sch Health.* 2002;72(3):121-127. doi:10.1111/j.1746-1561.2002.tb06529.x
21. Kohlstadt IC, Anderson Steeves ET, Rice K, Gittelsohn J, Summerfield LM, Gadhoke P. Youth peers put the "invent" into NutriBee's online intervention. *Nutr J.* 2015;14(1):60. doi:10.1186/s12937-015-0031-2
22. Birnbaum AS, Lytle LA, Story M, Perry CL, Murray DM. Are differences in exposure to a multicomponent school-based intervention associated with varying dietary outcomes in adolescents? *Health Educ Behav Off Publ Soc Public Health Educ.* 2002;29(4):427-443. doi:10.1177/109019810202900404
23. Pew Research Center. Demographics of Internet and Home Broadband Usage in the United States. Accessed July 10, 2020. <https://www.pewresearch.org/internet/fact-sheet/internet-broadband/>
24. The Common Sense Census: Media Use by Tweens and Teens, 2019 | Common Sense Media. Accessed April 21, 2021. <https://www.common Sense Media.org/research/the-common-sense-census-media-use-by-tweens-and-teens-2019>
25. McGuirt JT, Cooke NK, Burgermaster M, et al. Extended Reality Technologies in Nutrition Education and Behavior: Comprehensive Scoping Review and Future Directions. *Nutrients.* 2020;12(9):2899. doi:10.3390/nu12092899

26. Cui Z, Seburg EM, Sherwood NE, Faith MS, Ward DS. Recruitment and retention in obesity prevention and treatment trials targeting minority or low-income children: a review of the clinical trials registration database. *Trials*. 2015;16. doi:10.1186/s13063-015-1089-z
27. Joo JY, Liu MF. Culturally tailored interventions for ethnic minorities: A scoping review. *Nurs Open*. n/a(n/a). doi:https://doi.org/10.1002/nop2.733
28. Kumanyika SK, Whitt-Glover MC, Haire-Joshu D. What works for obesity prevention and treatment in black Americans? Research directions: Conclusions and recommendations. *Obes Rev*. 2014;15:204-212. doi:10.1111/obr.12213
29. Di Noia J, Furst G, Park K, Byrd-Bredbenner C. Designing culturally sensitive dietary interventions for African Americans: review and recommendations. *Nutr Rev*. 2013;71(4):224-238. doi:10.1111/nure.12009
30. Murimi MW, Moyeda-Carabaza AF, Nguyen B, Saha S, Amin R, Njike V. Factors that contribute to effective nutrition education interventions in children: a systematic review. *Nutr Rev*. 2018;76(8):553-580. doi:10.1093/nutrit/nuy020
31. Seo DC, Sa J. A Meta-Analysis of Obesity Interventions Among U.S. Minority Children. *J Adolesc Health*. 2010;46(4):309-323. doi:10.1016/j.jadohealth.2009.11.202
32. Hartlieb KB, Jacques-Tiura AJ, Naar-King S, Ellis DA, Jen KLC, Marshall S. Recruitment Strategies and the Retention of Obese Urban Racial/Ethnic Minority Adolescents in Clinical Trials: The FIT Families Project, Michigan, 2010–2014. *Prev Chronic Dis*. 2015;12. doi:10.5888/pcd12.140409
33. Sharma SV, Shegog R, Chow J, et al. Effects of the Quest to Lava Mountain Computer Game on Dietary and Physical Activity Behaviors of Elementary School Children: A Pilot Group-Randomized Controlled Trial. *J Acad Nutr Diet*. 2015;115(8):1260-1271. doi:10.1016/j.jand.2015.02.022
34. Rolling TE, Hong MY. The Effect of Social Cognitive Theory-Based Interventions on Dietary Behavior within Children. *J Nutr Health Food Sci*. 2016;4(5). doi:10.15226/jnhfs.2016.00179
35. Jacob CM, Hardy-Johnson PL, Inskip HM, et al. A systematic review and meta-analysis of school-based interventions with health education to reduce body mass index in adolescents aged 10 to 19 years. *Int J Behav Nutr Phys Act*. 2021;18(1):1. doi:10.1186/s12966-020-01065-9
36. Perry CL, Bishop DB, Taylor G, et al. Changing fruit and vegetable consumption among children: the 5-a-Day Power Plus program in St. Paul, Minnesota. *Am J Public Health*. 1998;88(4):603-609. doi:10.2105/ajph.88.4.603
37. Rodriguez Rocha NP, Kim H. eHealth Interventions for Fruit and Vegetable Intake: A Meta-Analysis of Effectiveness. *Health Educ Behav*. 2019;46(6):947-959. doi:10.1177/1090198119859396



38. Gabrielli S, Dianti M, Maimone R, et al. Design of a Mobile App for Nutrition Education (TreC-LifeStyle) and Formative Evaluation With Families of Overweight Children. *JMIR MHealth UHealth*. 2017;5(4). doi:10.2196/mhealth.7080
39. What is Virtual Reality (VR) | IGI Global. Accessed March 12, 2021. <https://www.igi-global.com/dictionary/augmented-reality-framework-socialization-between/31774>
40. LeRouge C, Dickhut K, Lisetti C, Sangameswaran S, Malasanos T. Engaging adolescents in a computer-based weight management program: avatars and virtual coaches could help. *J Am Med Inform Assoc JAMIA*. 2016;23(1):19-28. doi:10.1093/jamia/ocv078
41. McGuirt JT, Enahora B, Dyson OL, Tripicchio GL, Mallard L, Rhea CK. Virtual Avatar Coaching With Community Context for Adult-Child Dyads with Low Income. *J Nutr Educ Behav*. 2021;53(3):232-239. doi:10.1016/j.jneb.2020.12.004
42. do Amaral e Melo GR, de Carvalho Silva Vargas F, dos Santos Chagas CM, Toral N. Nutritional interventions for adolescents using information and communication technologies (ICTs): A systematic review. *PLoS ONE*. 2017;12(9). doi:10.1371/journal.pone.0184509
43. Meiklejohn S, Ryan L, Palermo C. A Systematic Review of the Impact of Multi-Strategy Nutrition Education Programs on Health and Nutrition of Adolescents. *J Nutr Educ Behav*. 2016;48(9):631-646.e1. doi:10.1016/j.jneb.2016.07.015
44. *Diffusion of Innovations, 5th Edition.*; 2003. Accessed March 27, 2021. <https://www.simonandschuster.com/books/Diffusion-of-Innovations-5th-Edition/Everett-M-Rogers/9780743222099>
45. Larson NI, Story MT, Nelson MC. Neighborhood environments: disparities in access to healthy foods in the U.S. *Am J Prev Med*. 2009;36(1):74-81. doi:10.1016/j.amepre.2008.09.025
46. Christiansen KMH, Qureshi F, Schaible A, Park S, Gittelsohn J. Environmental Factors That Impact the Eating Behaviors of Low-income African American Adolescents in Baltimore City. *J Nutr Educ Behav*. 2013;45(6):652-660. doi:10.1016/j.jneb.2013.05.009
47. Morland K, Wing S, Diez Roux A, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. *Am J Prev Med*. 2002;22(1):23-29. doi:10.1016/S0749-3797(01)00403-2
48. Sallis JF, Saelens BE, Frank LD, et al. Neighborhood Built Environment and Income: Examining Multiple Health Outcomes. *Soc Sci Med* 1982. 2009;68(7):1285-1293. doi:10.1016/j.socscimed.2009.01.017
49. Hager ER, Cockerham A, O'Reilly N, et al. Food swamps and food deserts in Baltimore City, MD, USA: associations with dietary behaviours among urban adolescent girls. *Public Health Nutr*. 2017;20(14):2598-2607. doi:10.1017/S1368980016002123

50. Shin A, Surkan PJ, Coutinho AJ, et al. Impact of Baltimore Healthy Eating Zones: An Environmental Intervention to Improve Diet Among African American Youth. *Health Educ Behav.* 2015;42(1\_suppl):97S-105S. doi:10.1177/1090198115571362
51. Trude ACB, Surkan PJ, Cheskin LJ, Gittelsohn J. A multilevel, multicomponent childhood obesity prevention group-randomized controlled trial improves healthier food purchasing and reduces sweet-snack consumption among low-income African-American youth. *Nutr J.* 2018;17(1):96. doi:10.1186/s12937-018-0406-2
52. Powell LM, Wada R, Kumanyika SK. Racial/Ethnic and Income Disparities in Child and Adolescent Exposure to Food and Beverage Television Ads across U.S. Media Markets. *Health Place.* 2014;29:124-131. doi:10.1016/j.healthplace.2014.06.006
53. Baranowski T, Ryan C, Hoyos-Cespedes A, Lu AS. Nutrition Education and Dietary Behavior Change Games: A Scoping Review. *Games Health J.* 2019;8(3):153-176. doi:10.1089/g4h.2018.0070
54. Home | Dietary Guidelines for Americans. Accessed March 30, 2021. <https://www.dietaryguidelines.gov/>
55. Wroblewski MM, Parker EA, Hurley KM, Oberlander S, Merry BC, Black MM. Comparison of the HEI and HEI-2010 Diet Quality Measures in Association with Chronic Disease Risk among Low-Income, African American Urban Youth in Baltimore, Maryland. *J Am Coll Nutr.* 2018;37(3):201-208. doi:10.1080/07315724.2017.1376297
56. Ducharme-Smith K, Caulfield LE, Brady TM, Rosenstock S, Mueller NT, Garcia-Larsen V. Higher Diet Quality in African-American Adolescents Is Associated with Lower Odds of Metabolic Syndrome: Evidence from the NHANES. *J Nutr.* 2021;151(6):1609-1617. doi:10.1093/jn/nxab027
57. Bradbury KM, Turel O, Morrison KM. Electronic device use and beverage related sugar and caffeine intake in US adolescents. *PloS One.* 2019;14(10):e0223912. doi:10.1371/journal.pone.0223912
58. Williams Jr Ronald D, Housman JM, Odum M, Rivera AE. Energy Drink Use Linked to High-sugar Beverage Intake and BMI among Teens. *Am J Health Behav.* 2017;41(3):259-265. doi:10.5993/AJHB.41.3.5
59. NW 1615 L. St, Suite 800 Washington, Inquiries D 20036USA202 419 4300 | M 857 8562 | F 419 4372 | M. Teens, Social Media & Technology Overview 2015. Pew Research Center: Internet, Science & Tech. Published April 9, 2015. Accessed May 12, 2021. <https://www.pewresearch.org/internet/2015/04/09/teens-social-media-technology-2015/>
60. Bentley F, Church K, Harrison B, Lyons K, Rafalow M. Three Hours a Day: Understanding Current Teen Practices of Smartphone Application Use. *ArXiv151005192 Cs.* Published online October 17, 2015. Accessed April 21, 2021. <http://arxiv.org/abs/1510.05192>
61. Anderson M, Jiang J. Teens, Social Media & Technology 2018. :10.

62. Pratt CA, Boyington J, Esposito L, et al. Childhood Obesity Prevention and Treatment Research (COPTR): Interventions addressing multiple influences in childhood and adolescent obesity. *Contemp Clin Trials*. 2013;36(2):406-413. doi:10.1016/j.cct.2013.08.010
63. CDC: Schools aren't doing enough to teach kids about nutrition. UPI. Accessed February 5, 2022. [https://www.upi.com/Health\\_News/2019/12/05/CDC-Schools-arent-doing-enough-to-teach-kids-about-nutrition/9491574879196/](https://www.upi.com/Health_News/2019/12/05/CDC-Schools-arent-doing-enough-to-teach-kids-about-nutrition/9491574879196/)
64. Airhihenbuwa CO, Kumanyika S. Cultural aspects of African American eating patterns. *Ethn Health*. 1996;1(3):245. doi:10.1080/13557858.1996.9961793
65. Kumanyika S, Grier S. Targeting Interventions for Ethnic Minority and Low-Income Populations. *Future Child*. 2006;16(1). doi:http://dx.doi.org/10.1353/foc.2006.0005
66. Corneille MA, Ashcraft AM, Belgrave FZ. What's Culture Got To Do With It? Prevention Programs for African American Adolescent Girls. *J Health Care Poor Underserved*. 2005;16(4):38-47. doi:http://dx.doi.org/10.1353/hpu.2005.0076
67. Christiansen KMH, Qureshi F, Schaible A, Park S, Gittelsohn J. Environmental factors that impact the eating behaviors of low-income African American adolescents in Baltimore City. *J Nutr Educ Behav*. 2013;45(6):652-660. doi:10.1016/j.jneb.2013.05.009
68. Case P, Cluskey M, Hino J. Online Nutrition Education: Enhancing Opportunities for Limited-Resource Learners. *J Ext*. 2011;49(6).
69. Casazza K, Ciccazzo M. The method of delivery of nutrition and physical activity information may play a role in eliciting behavior changes in adolescents. *Eat Behav*. 2007;8(1):73-82. doi:10.1016/j.eatbeh.2006.01.007
70. Yamada-Rice D, Mushtaq F, Woodgate A, et al. Children and Virtual Reality: Emerging Possibilities and Challenges. Published September 12, 2017. Accessed March 12, 2022. <http://digilitey.eu/wp-content/uploads/2015/09/CVR-Final-PDF-reduced-size.pdf>
71. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of Innovations in Service Organizations: Systematic Review and Recommendations. *Milbank Q*. 2004;82(4):581-629. doi:10.1111/j.0887-378X.2004.00325.x
72. Jacob C, Sanchez-Vazquez A, Ivory C. Understanding Clinicians' Adoption of Mobile Health Tools: A Qualitative Review of the Most Used Frameworks. *JMIR MHealth UHealth*. 2020;8(7). doi:10.2196/18072
73. Ohri-Vachaspati P, DeLia D, DeWeese RS, Crespo NC, Todd M, Yedidia MJ. The relative contribution of layers of the Social Ecological Model to childhood obesity. *Public Health Nutr*. 2015;18(11):2055-2066. doi:10.1017/S1368980014002365
74. Townsend N, Foster C. Developing and applying a socio-ecological model to the promotion of healthy eating in the school. *Public Health Nutr*. 2013;16(6):1101-1108. doi:https://doi.org/10.1017/S1368980011002655

75. Bandura A. Social Cognitive Theory: An Agentic Perspective. *Annu Rev Psychol.* 2001;52(1):1-26. doi:10.1146/annurev.psych.52.1.1
76. Bandura A. *Social Foundations of Thought and Action: A Social Cognitive Theory.* Prentice-Hall, Inc; 1986:xiii, 617.
77. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol.* 2000;55(1):68-78. doi:10.1037/0003-066X.55.1.68
78. Alan KS. Snacking behavior in adolescents and adults in the United States. :182.
79. Lange SJ. Percentage of Adolescents Meeting Federal Fruit and Vegetable Intake Recommendations — Youth Risk Behavior Surveillance System, United States, 2017. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7003a1
80. Home | Dietary Guidelines for Americans. Accessed April 30, 2020. <https://www.dietaryguidelines.gov/>
81. Teens, Social Media & Technology 2018. Pew Research Center: Internet, Science & Tech. Published May 31, 2018. Accessed February 5, 2022. <https://www.pewresearch.org/internet/2018/05/31/teens-social-media-technology-2018/>
82. Joshi SV, Stubbe D, Li STT, Hilty DM. The Use of Technology by Youth: Implications for Psychiatric Educators. *Acad Psychiatry.* 2019;43(1):101-109. doi:10.1007/s40596-018-1007-2
83. Baysden E, Mendoza N, Callender C, Deng Z, Thompson D. Teen reactions to a self-representational avatar: A qualitative exploration. *J Sport Health Sci.* Published online July 20, 2021. doi:10.1016/j.jshs.2021.07.004
84. Abrol E, Groszmann M, Pitman A, Hough R, Taylor RM, Aref-Adib G. Exploring the digital technology preferences of teenagers and young adults (TYA) with cancer and survivors: a cross-sectional service evaluation questionnaire. *J Cancer Surviv.* 2017;11(6):670-682. doi:10.1007/s11764-017-0618-z
85. Yang YTC, Wang CJ, Tsai MF, Wang JS. Technology-enhanced game-based team learning for improving intake of food groups and nutritional elements. *Comput Educ.* 2015;88:143-159. doi:10.1016/j.compedu.2015.04.008
86. Jones BA, Madden GJ, Wengreen HJ. The FIT Game: preliminary evaluation of a gamification approach to increasing fruit and vegetable consumption in school. *Prev Med.* 2014;68:76-79. doi:10.1016/j.ypmed.2014.04.015
87. Wengreen HJ, Joyner D, Kimball SS, Schwartz S, Madden GJ. A Randomized Controlled Trial Evaluating the FIT Game's Efficacy in Increasing Fruit and Vegetable Consumption. *Nutrients.* 2021;13(8):2646. doi:10.3390/nu13082646
88. Markowitz JT, Cousineau T, Franko DL, et al. Text Messaging Intervention for Teens and Young Adults With Diabetes. *J Diabetes Sci Technol.* 2014;8(5):1029-1034. doi:10.1177/1932296814540130

89. Reicks M, Kocher M, Reeder J. Impact of Cooking and Home Food Preparation Interventions Among Adults: A Systematic Review (2011–2016). *J Nutr Educ Behav.* 2018;50(2):148-172.e1. doi:10.1016/j.jneb.2017.08.004
90. Utter J, Larson N, Laska MN, Winkler M, Neumark-Sztainer D. Self-Perceived Cooking Skills in Emerging Adulthood Predict Better Dietary Behaviors and Intake 10 Years Later: A Longitudinal Study. *J Nutr Educ Behav.* 2018;50(5):494-500. doi:10.1016/j.jneb.2018.01.021
91. Houston TK, Allison JJ, Sussman M, et al. Culturally appropriate storytelling to improve blood pressure: a randomized trial. *Ann Intern Med.* 2011;154(2):77-84. doi:10.7326/0003-4819-154-2-201101180-00004
92. LeRouge C, Durneva P, Sangameswaran S, Gloster AM. Design Guidelines for a Technology-Enabled Nutrition Education Program to Support Overweight and Obese Adolescents: Qualitative User-Centered Design Study. *J Med Internet Res.* 2019;21(7):e14430. doi:10.2196/14430
93. Balas EA, Chapman WW. Road Map For Diffusion Of Innovation In Health Care. *Health Aff (Millwood).* 2018;37(2):198-204. doi:http://dx.doi.org/10.1377/hlthaff.2017.1155
94. Emani S, Peters E, Desai S, et al. Perceptions of adopters versus non-adopters of a patient portal: an application of diffusion of innovation theory. *BMJ Health Care Inform.* 2018;25(3). doi:10.14236/jhi.v25i3.991
95. Stephenson R, Phelps A, Colburn J. Diffusion of Innovations and Program Implementation in Areas of Health Behavior/ Education/Promotion, Physical Activity, and Physical Education. *ICHPER-SD J Res Health Phys Educ Recreat Sport Dance.* 2018;10(1):3-11.
96. Kuhn E, Weiss BJ, Taylor KL, et al. CBT-I Coach: A Description and Clinician Perceptions of a Mobile App for Cognitive Behavioral Therapy for Insomnia. *J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med.* 2016;12(4):597-606. doi:10.5664/jcsm.5700
97. Lin TTC, Bautista JR. Understanding the Relationships between mHealth Apps' Characteristics, Trialability, and mHealth Literacy. *J Health Commun.* 2017;22(4):346-354. doi:10.1080/10810730.2017.1296508
98. Miller KE, Kuhn E, Owen JE, et al. Clinician Perceptions Related to the Use of the CBT-I Coach Mobile App. *Behav Sleep Med.* 2019;17(4):481-491. doi:10.1080/15402002.2017.1403326
99. Nezamdoust S, Abdekhoda M, Rahmani A. Determinant factors in adopting mobile health application in healthcare by nurses. *BMC Med Inform Decis Mak.* 2022;22(1):47. doi:10.1186/s12911-022-01784-y
100. Dunn CP, Riley JB, Hawkins KB, Tercyak KP. Factors Associated With Disordered Eating Behavior Among Adolescent Girls: Screening and Education. *J Prim Care Community Health.* 2022;13:21501319211062670. doi:10.1177/21501319211062673

101. McKnight Investigators. Risk factors for the onset of eating disorders in adolescent girls: results of the McKnight longitudinal risk factor study. *Am J Psychiatry*. 2003;160(2):248-254. doi:10.1176/ajp.160.2.248
102. DeJesus JM, Du KM, Shutts K, Kinzler KD. How information about what is “healthy” versus “unhealthy” impacts children’s consumption of otherwise identical foods. *J Exp Psychol Gen*. 2019;148(12):2091-2103. doi:10.1037/xge0000588
103. Gripshover SJ, Markman EM. Teaching young children a theory of nutrition: conceptual change and the potential for increased vegetable consumption. *Psychol Sci*. 2013;24(8):1541-1553. doi:10.1177/0956797612474827
104. Contento IR. *Nutrition Education: Linking Research, Theory & Practice*. 3 edition. Jones & Bartlett Learning; 2015.
105. 2015-2020 Dietary Guidelines | health.gov. Accessed July 10, 2020. <https://health.gov/our-work/food-nutrition/2015-2020-dietary-guidelines/guidelines/>
106. Shriver LH, Marriage BJ, Bloch TD, et al. Contribution of snacks to dietary intakes of young children in the United States. *Matern Child Nutr*. 2018;14(1):e12454. doi:<https://doi.org/10.1111/mcn.12454>
107. Reid Chassiakos Y (Linda), Radesky J, Christakis D, et al. Children and Adolescents and Digital Media. *Pediatrics*. 2016;138(5):e20162593. doi:10.1542/peds.2016-2593
108. Moreno MA, Binger K, Zhao Q, Eickhoff J. Measuring Interests Not Minutes: Development and Validation of the Adolescents’ Digital Technology Interactions and Importance Scale (ADTI). *J Med Internet Res*. 2020;22(2):e16736. doi:10.2196/16736
109. Kirkpatrick SI, Collins CE, Keogh RH, Krebs-Smith SM, Neuhauser ML, Wallace A. Assessing Dietary Outcomes in Intervention Studies: Pitfalls, Strategies, and Research Needs. *Nutrients*. 2018;10(8):1001. doi:10.3390/nu10081001
110. Burrows T, Golley RK, Khambalia A, et al. The quality of dietary intake methodology and reporting in child and adolescent obesity intervention trials: a systematic review. *Obes Rev*. 2012;13(12):1125-1138. doi:10.1111/j.1467-789X.2012.01022.x
111. Collins CE, Watson J, Burrows T. Measuring dietary intake in children and adolescents in the context of overweight and obesity. *Int J Obes*. 2010;34(7):1103-1115. doi:10.1038/ijo.2009.241
112. Magarey A, Watson J, Golley RK, et al. Assessing dietary intake in children and adolescents: Considerations and recommendations for obesity research. *Int J Pediatr Obes*. 2011;6(1):2-11. doi:10.3109/17477161003728469
113. Teo T. Modelling technology acceptance in education: A study of pre-service teachers. *Comput Educ*. 2009;52(2):302-312. doi:10.1016/j.compedu.2008.08.006
114. Cheung R, Vogel D. Predicting user acceptance of collaborative technologies: An extension of the technology acceptance model for e-learning. *Comput Educ*. 2013;63:160-175. doi:10.1016/j.compedu.2012.12.003

115. Yaroch AL, Tooze J, Thompson FE, et al. Evaluation of three short dietary instruments to assess fruit and vegetable intake: The National Cancer Institute's Food Attitudes and Behaviors (FAB) Survey. *J Acad Nutr Diet*. 2012;112(10):1570-1577. doi:10.1016/j.jand.2012.06.002
116. Greene GW, Resnicow K, Thompson FE, et al. Correspondence of the NCI Fruit and Vegetable Screener to Repeat 24-H Recalls and Serum Carotenoids in Behavioral Intervention Trials. *J Nutr*. 2008;138(1):200S-204S. doi:10.1093/jn/138.1.200S
117. Ermakov IV, Gellermann W. Dermal carotenoid measurements via pressure mediated reflection spectroscopy. *J Biophotonics*. 2012;5(7):559-570. doi:10.1002/jbio.201100122
118. Jilcott Pitts SB, Jahns L, Wu Q, et al. A non-invasive assessment of skin carotenoid status through reflection spectroscopy is a feasible, reliable and potentially valid measure of fruit and vegetable consumption in a diverse community sample. *Public Health Nutr*. 2018;21(9):1664-1670. doi:10.1017/S136898001700430X
119. May K, Jilcott Pitts S, Stage VC, et al. Use of the Veggie Meter® as a tool to objectively approximate fruit and vegetable intake among youth for evaluation of preschool and school-based interventions. *J Hum Nutr Diet Off J Br Diet Assoc*. 2020;33(6):869-875. doi:10.1111/jhn.12755
120. Peterson KE, Hebert JR, Hurley TG, et al. Accuracy and Precision of Two Short Screeners to Assess Change in Fruit and Vegetable Consumption among Diverse Populations Participating in Health Promotion Intervention Trials. *J Nutr*. 2008;138(1):218S-225S. doi:10.1093/jn/138.1.218S

## APPENDIX A: VR AVATAR PROGRAM CONCEPTUAL MODEL

The VR avatar nutrition education program leverages key tenants of the Socioecological Model (SEM), Social Cognitive Theory (SCT), and Self-Determination Theory (SDT). SEM recognizes the interplay of multiple levels of influence on health behaviors.<sup>73,74</sup> The intrapersonal or individual-level identifies personal factors that impact dietary habits, such as economic status, age, sex, race, ethnicity, individual eating behaviors, food preferences, attitudes, nutrition knowledge, and food preparation skills.<sup>74</sup> The avatar program impacts youth at the individual level via direct communication through short lessons and text messages. The interpersonal level includes a child's social networks, such as parents, siblings, extended family, and friends.<sup>73,74</sup> The avatar interacts with the child and parent directly and relays information to the parent, which in turn influences the interaction between the parent and child. The avatar program also impacts children at the community level, particularly the home food and physical activity level, as it helps children and parents navigate finding healthy food and physical activity resources in their neighborhood.

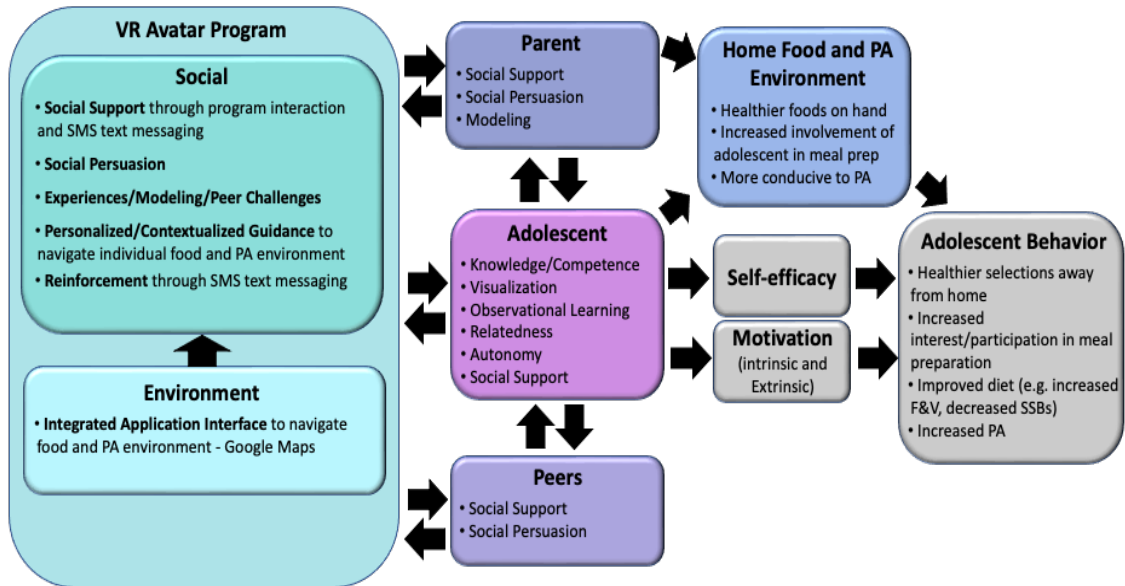
SCT postulates that personal, behavioral, and environmental determinants work in a dynamic and reciprocal manner to influence health behavior.<sup>75,76</sup> Personal determinants involve people's thoughts or beliefs and feelings. Self-efficacy is one of the most important personal determinants and key construct of SCT. Self-efficacy involves having the confidence and skills to carry out an intended behavior effectively and consistently.<sup>75,76</sup> The avatar program is poised to increase children's self-efficacy to eat well through personal mastery or guided practice from the avatar, social persuasion or encouragement from the avatar, and parental modeling of healthy habits. In addition, the social influences of peers become more pronounced during adolescence and may influence self-efficacy. Behavioral determinants of SCT include the individuals' food and nutrition-related knowledge and cognitive and behavioral skills needed to influence behavior change.<sup>75,76</sup> The avatar provides factual food and nutrition knowledge on fruit



and vegetable servings to increase intake among children and parents. Finally, environmental determinants include those factors external to the individual, such as physical and social environments.<sup>71</sup> SCT emphasizes that our environment provides a source for modeling behavior. Observational learning and reinforcement are important environmental constructs of SCT, which the avatar program provides.

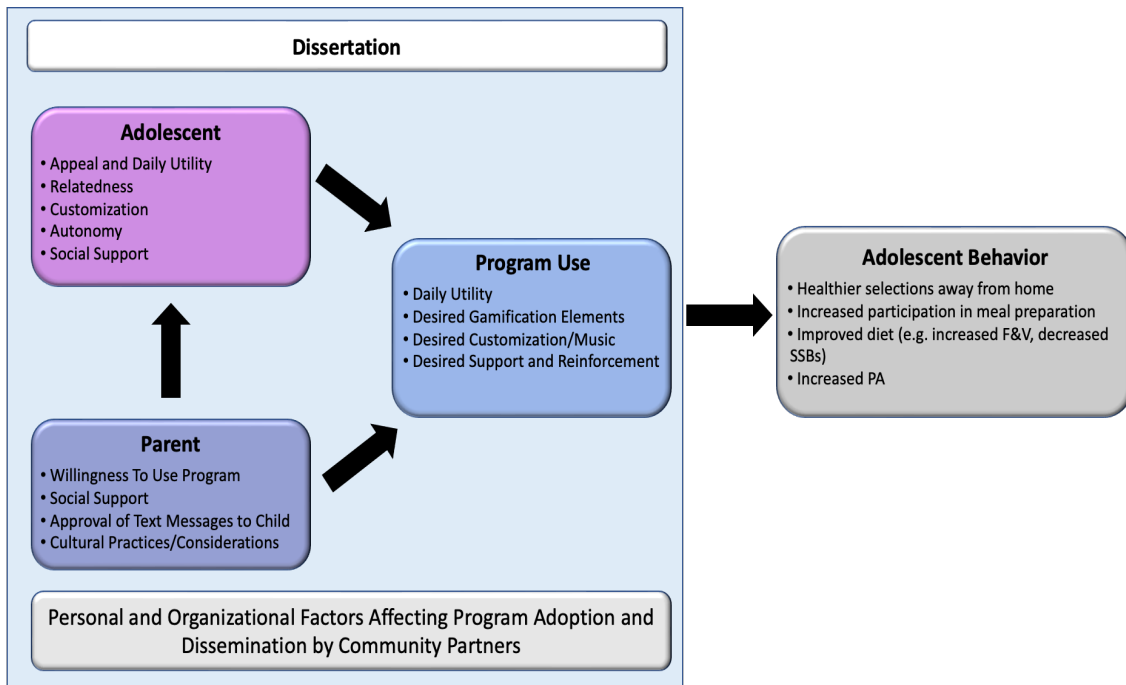
SDT suggests that individuals become self-motivated when their needs for competence, autonomy, and connection or relatedness are fulfilled.<sup>77</sup> Competence refers to the need for youth to experience themselves as capable of carrying out nutrition and physical activity behaviors that promote healthy growth and development.<sup>77</sup> Autonomy to make food-related decisions increases in adolescence, as youth spend more time apart from their parents and consume more meals and snacks away from home.<sup>10,15,46</sup> Adolescents are also increasingly more aware of their bodies as they mature and many begin to make health decisions related to body image.<sup>9,11</sup> Relatedness refers to the need for adolescents to feel cared for, to care for others, and relate to others.<sup>77</sup> Higher motivation occurs when adolescents experience authentic relatedness to others and satisfaction in participation and involvement with their social world.<sup>12</sup> An interpersonal interaction with the avatar enables the internalization of health behaviors and increases intrinsic and extrinsic motivation with a tone of understanding, acceptance, praise, and empathy.

**African American Adolescents & Parents Living in Low-Income Neighborhoods (Culture, SES)**



## APPENDIX B: DISSERTATION CONCEPTUAL MODEL

This study aims to assess program appeal among African American adolescents and understand the required modifications to impact their unique health behaviors, such as increased snacking, skipping breakfast, greater food autonomy, and peer influences on dietary behaviors. Additionally, we will quantify program acceptance among African American adolescents and explore whether interaction with an avatar impacts dietary responses. Finally, the factors affecting the adoption and dissemination of the VR avatar nutrition education program among community agency stakeholders will be identified.



## APPENDIX C: FOCUS GROUP AND IN-DEPTH INTERVIEW DISCUSSION GUIDES

### Focus Group and In-Depth Interview Guide for Adolescents and Parents – VR Avatar Nutrition Education Program

#### Moderator's Guide Outline:

Welcome  
Informed Consent  
Icebreaker  
Topic Introduction and Opening Question  
Exploration Questions  
Wrap Up  
Post Survey/Questionnaire (parents only)

#### Welcome – 10 mins

Moderator/PhD student introduces herself, along with note-taker or anyone else from the research team that is present

- “Hello my name is Basheerah Enahora. I’m a PhD student in Nutrition at the University of North Carolina Greensboro and I’m excited to have you all here today and truly appreciate your time. We will spend a little over one hour together today, but first, I’d like to give you a brief overview of our topic today and get your verbal agreement to participate. Our goal today is to gain your feedback on a new nutrition education program and how you would use the program.
- **Informed Consent**
  - o Consent and assent will be obtained in RedCap prior to focus groups.
- **Ground rules**
- Again, thank participants for being present. Remind them of the purpose of the focus group and that everyone’s input is valuable and appreciated. Ask everyone to turn off their phones or place on vibrate. Parents will go to waiting room for ~60 mins
  - o Again, thank you for being here today. Our goal today is to gain your feedback on a new digital program and how you would use the program to help improve your diet and increase physical activity. I’ll be asking you questions during our time together and there are no right or wrong answers. We simply want your honest opinion, as it will help us develop a program that may benefit youth in North Carolina and throughout the United States. We would also like to hear from everyone today and what you say here will be kept confidential. To make sure we can fully hear and collect your opinions, please turn off or at least place your phones or other electronic devices not being used in this focus group on vibrate. Then have parents go into the waiting room for ~60 mins (or come back in 60 mins). Then have parents go into the waiting room for ~60 mins (or come back in 60 mins).
- A few ground rules: First, this is a safe space. Everyone’s ideas and opinions are valued and respected and what you say will not leave this room. So please show respect at all times when people share their opinion. It’s ok to disagree or have a different opinion.
- Next, please allow one person to speak at a time. We will practice what we call “step up step back.” This means that after you share your point, you allow someone else to speak or if you haven’t shared, that you step up and share your thoughts. This keeps the conversation balanced and ensure everyone’s voice is heard.

- Does anyone have any other rules they'd like to propose before we begin?

### **Youth Ice Breaker – 5 mins**

- Let's start with a fun exercise to get to know each other a little better.
- Ice breaker options (will choose one):
  - o Two truths and a lie (centered around food)
  - o What food describes you best?
  - o What's your favorite snack and why?
  - o Who's your favorite movie character and do they have a favorite snack?

### **Exploratory Questions – Avatar Enhancements & Useability with Youth – 35 mins**

Show the short video montage, then ask participants to write down their initial reaction first, before sharing with the group. Then explore adolescent's perceptions of the VR avatar nutrition education program.

1. What are your initial thoughts about the program? *(Additional follow up questions if needed - What first came to mind for you and why? Does anyone else have any thoughts? Does anyone agree or disagree with what's been shared and describe why?)*
2. In what ways did the program appeal to you? *(Follow up - What did you find most appealing? Least appealing? What did you like or not like? Does anyone else have any thoughts? Does anyone agree or disagree with what's been said (why?)*
3. How would using this program help you or impact the way you eat? *(Moderator provides suggestions, i.e. – do you think it would change any of the foods you eat or drink? Would it help you eat more fruits and vegetables and drink less sugary beverages?)*
4. Do you currently use digital programs or apps that use an avatar? If so, what programs or apps do you use? *(Follow up – If yes: What do you like about this/those program(s)? If no: Why don't you use programs with avatars? What do you like or dislike about this/those program(s)?)*
5. How do you feel about an avatar, or virtual friend, providing you with guidance to help you eat healthy? *(Follow up - How helpful do you think this would be? Or In what ways could an avatar or virtual friend help you?)*
6. How often would you want to interact with an avatar, or virtual friend? Daily, weekly, monthly? *(Follow up - What made you choose this timing or timeframe?)*
7. What did you think about the ability of the avatar to send you text messages outside of the program? *(Follow up – Is this something that you would like to do with a virtual friend? Why or why not? What do you find appealing? unappealing about this? How often would you want to receive text messages from the avatar and why?)*
8. Thinking about your daily routine, how would this program fit into your life? *(Follow up - Why would it fit into your life in this way? What time of day would you be willing to use this program? Why would you use it during that timeframe? Any other way that you would use it that hasn't been suggested?)*
9. In an ideal world, if you could create a program about nutrition and health that youth would use daily, what would that look like?

Discuss potential program enhancements.

Moderator: Now, I'm going to ask questions to get your feedback on what you want the avatar to look like.

10. If you could customize the avatar, what would you want to change or add to the way the avatar looks? Moderator asks youth for their initial thoughts, then provides prompts below if necessary

- a. How would you change the avatar's body shape? Moderator then shows options and ask the youth for their thoughts and why. *(Follow up - Tell me a little more about why you chose this option?)*
  - b. What if you could customize the hair style of the avatar? Moderator then shows options and ask the youth for their thoughts. *(Follow up - Tell me a little more about why you chose this option? How many different hair styles would you want the avatar to have?)*
  - c. What if you could change the clothes of the avatar? *(Follow up - How many different clothing options would you want?)*
11. What are your thoughts on including background music in the program? *(Follow up - How would including music help you use the program? What types of music would you want to have in the program? If you could choose your own music, how would you feel about this option?)*

### **Exploratory Questions Regarding Program Content & Adult Involvement – 15 min**

Moderator: Now, let's discuss the foods and content that we cover in the program.

12. What if we talked about snacking within the context of a mini-game or as a challenge that you could play among friends? *(Follow up - What do you find appealing about this? Unappealing about this?)*
13. When it comes to eating healthy, what topics do you want to learn more about and why? *Moderator provides topic suggestions if needed: (1) healthy snacking, (2) healthy beverages, (3) eating on the go/making healthier fast-food choices, (4) basic cooking skills, (5) eating for a more sustainable planet, (6) body image and (7) movement and exercise. (Follow up – What topics would be interesting to you? What topics would be helpful to you?)*
14. How much do you want your parents to be involved as you use the program? *(Follow up - Would you want your parents to know about what you're learning and the foods you like to eat?)*
15. How would you like to learn about or receive information about this program? *(Follow up - Would you want information to come from your primary care doctor, your school, a community program or center like the YMCA, from friends and family, or social media?)*
16. Is there anything else about the program that you'd like to share with us today that hasn't been said?

### **Wrap Up with Youth – 5 mins**

Thank everyone for their time and participation. Youth will then complete the google sheet for their gift card while in Zoom. Then bring the parents into the Zoom meeting from the waiting room

### **Exploratory Questions with Parents – Avatar Useability – 30 mins**

Moderator welcomes parents back, thanks them for being present. Parents then briefly introduce themselves to the group. Moderator then shows the short video montage to parents.

1. What are your initial thoughts about the program? *(Additional follow up questions if needed - What first came to mind for you and why? Does anyone else have any thoughts? Does anyone agree or disagree with what's been shared and describe why?)*
2. In what ways did the program appeal to you? *(Follow up - What did you find appealing? Unappealing? Does anyone else have any thoughts? Does anyone agree or disagree (why?)*
3. How do you feel about an avatar presenting your child with information and guidance? What do you like most or least about this?

4. How involved would you want to be as your child is interacting with the program? Would you want to know about what your child is learning and the foods they like to eat?
5. Can you share with me any concerns you have about your child's eating habits and health? *(Feel free to message me directly if you don't want to share with the group. Additional probe – Are there any challenges you face in getting your child to eat healthy?)*
6. What topics would you like to learn more about in the program to help your child stay healthy? *(moderator provides suggestions if none mentioned – healthy family meals, snacking, healthy beverages, body image, exercise, etc.)*
7. How often would you want to interact with the avatar? Daily, weekly, monthly? *(Follow up - What made you choose this timing or timeframe?)*
8. What did you think about the ability of the avatar to send you text messages outside of the program to you and your child? *(Follow up - What do you find most appealing about this? What did you find least appealing about this? How often would you want to receive additional messages from the avatar outside of the program?)*
9. What do you think would help make your child want to use this program regularly?
10. Are there any cultural considerations or cultural information that you would like to be included in the program?
11. Would you use this program? Why or why not (ask this if it doesn't come up earlier in the group)?
12. How would you like to learn about or receive information about this program? *(Additional probe - Would you want information to come from your primary care doctor, your school, a community program or center like the YMCA, from friends and family, or social media?)*
13. Is there anything else about the program that you'd like to share with us today that hasn't been said?

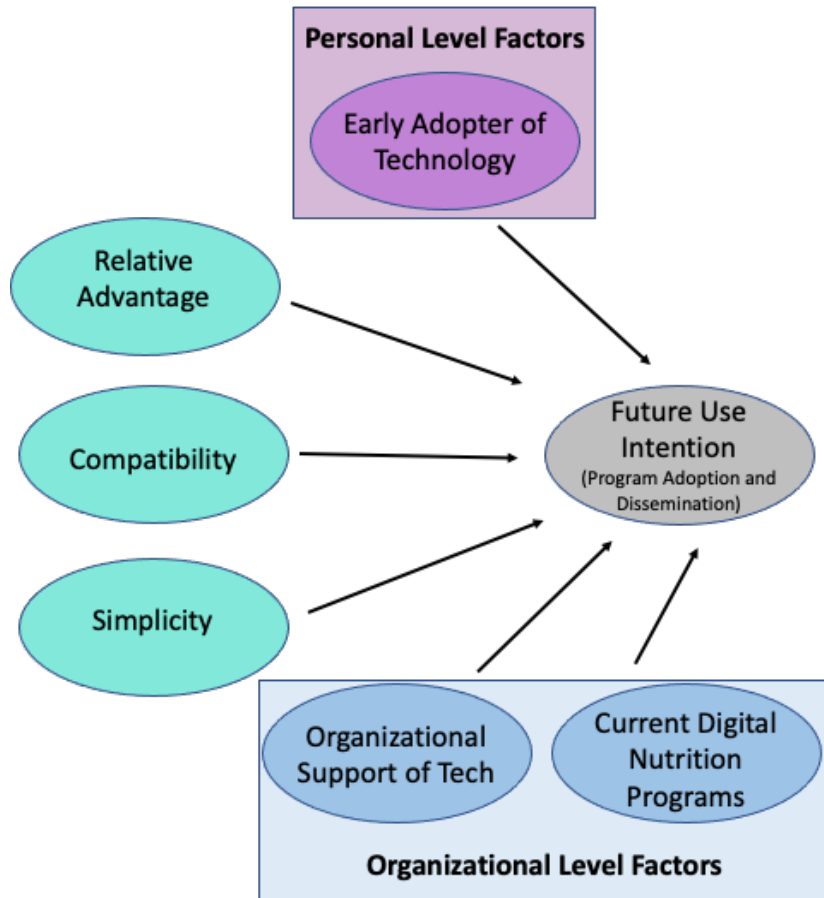
#### **Wrap Up with Parents – 5 mins**

Thank everyone for their time and participation. Parents will then complete the post survey online in RedCap while in the Zoom meeting. Finally, they will complete the google sheet for their gift card while in the Zoom meeting

## APPENDIX D: COMMUNITY AGENCY SURVEY CONCEPTUAL MODEL

The community agency survey included questions assessing the DOIT constructs of relative advantage (nine items), compatibility (four items), and simplicity (three items). The relative advantage of the VR avatar program was dimensionalized in terms of innovation and convenience to reach and teach nutrition education and for families to learn about nutrition, compared to current programs. Questions such as “The avatar program is a more innovative way for families/children my organization serves to learn about nutrition” were asked to assess relative advantage. In addition, four items in the revised survey assessed future use intention or agency willingness to adopt and disseminate the VR nutrition education program. Participants were asked questions regarding future use intention, including: “I would use this program with the families and children my organization serves,” “I would provide this program to the families and children my organization serves when it becomes available, “ and “The families and children my organization serves would use this program.” An additional open-ended question on future use intention also asks participants about the reason behind their intention to use or not use the VR avatar nutrition education program. Finally, additional questions assessed demographics. Respondents selected the type of agency or community partner (i.e., hospital system, afterschool program, school system, civic organization), the age range of youth served by the community partner (infant to 19 years old), current use of technology-based tools to deliver nutrition education (yes/no), type of technology or innovation adopter (early adopter vs. laggard), organizational readiness and support for new technology, and the counties served by the community partner. We also provided respondents with definitions to select their organizational role in the adoption of new technology (decision-maker, influencer, disseminator of information, or other).





## APPENDIX E: COMMUNITY AGENCY ADOPTION QUESTIONNAIRE

### Introduction:

A team of researchers at the University of North Carolina Greensboro (UNCG) would like your feedback about a virtual reality avatar nutrition education program, accessible via the internet, aimed to help parents and children eat healthier and exercise. We would like your feedback to help us assess if the avatar program is a good fit for the individuals your organization serves. By completing this online survey, ten participants will have an opportunity to win a \$25 electronic Amazon gift card. To be eligible to participate in the internet-based survey, you must be 18 years of age or older, fluently communicate in English (reading and writing), and in a position of authority to implement or disseminate a nutrition education program in your agency (or through partner agencies). We anticipate the survey will take approximately 10 minutes to complete. If you would like to speak to our research team prior to completing the survey, please contact Basheerah Enahora or Jared McGuirt for more information.

Email: [brenahor@uncg.edu](mailto:brenahor@uncg.edu)  
Faculty Advisor: Jared McGuirt, [jtmcguir@uncg.edu](mailto:jtmcguir@uncg.edu)  
Phone: 336-355-6684

If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with participating in this project, please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

### Page Break

### Screening Questions:

1. Are you 18 years of age or older
  - a. Yes
  - b. No
2. Can you communicate fluently in English (reading and writing)?
  - a. Yes
  - b. No
3. Do you work for a healthcare organization or community entity (government, private, or non-profit) that provides nutrition programs or guidance?
  - a. Yes
  - b. No
4. Do you have influence on or authority to provide nutrition education programs to end users (children and families)?
  - a. Yes
  - b. NO

If NO to any of the questions above, the participant is told they do not qualify to participate in the study, and the survey terminates

**Survey Questions:**

5. What type of agency are you affiliated with (work for)?
  - a. Hospital system
  - b. School system
  - c. Health department
  - d. Community/civic organization
  - e. After school program
  - f. Daycare center/Head Start/Smart Start
  - g. Parks & Rec
  - h. Library
  - i. EFNEP/SNAP-Ed
  
6. What is the age range of the children that (you) your agency serves? Please select all that apply.
  - a. Infant to 2 years old
  - b. 3 years old to 5 years old
  - c. 6 years old to 10 years old
  - d. 11 years old to 15 years old
  - e. 16 years old to 19 years old
  
7. Does your organization currently have in-class or in-person tools to teach children and/or adults about nutrition and/or physical activity?
  - a. Yes
  - b. No
  - c. Unsure
  
8. [If Yes to Q7] Are these programs designed to help children and parents learn together?
  - a. Yes
  - b. No
  - c. Unsure
  
9. Does your organization currently have online tools to teach children and/or adults about nutrition and/or physical activity?
  - a. Yes
  - b. No
  - c. Unsure
  
10. [If Yes to Q9] Are these programs designed to help children and parents learn together?
  - a. Yes
  - b. No
  - c. Unsure
  
11. What online or technology-based tools do you currently use to teach parents and children about nutrition and/or health? Please select all that apply.
  - a. Website
  - b. Avatar-based program
  - c. Video
  - d. Video game

- e. Smartphone app
- f. Texting
- g. Chat Bot
- h. Instant messaging
- i. List-serve messaging
- j. Messaging from program staff
- k. Other
- l. Our organization does not have online education or technology-based tools

12. If you selected “Other” above, please describe the online tools your organization uses in more detail.
- a. \_\_\_\_\_ [open-ended response]

Now we would like for you to learn more about our digital nutrition program. Please view the short 2.5-minute video explaining the program below. After viewing the short video, please complete the follow-up questions based on your thoughts about the program. **Again, please continue completing the survey after viewing the short video.**

The program video montage is embedded in the survey for viewing <https://youtu.be/qlvEKvOPibs>

13. For the following questions, please select to the extent you agree or disagree.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I would use this program with the individuals (children/families) my organization serves.					
I would provide this program to the individuals my organization serves when it becomes available.					
The individuals (children/families) my organization serves would use this program.					

14. What are your reasons for wanting to use or not use the program in the future? \_\_\_\_\_ [open-ended response]

**Page break**

15. The following questions will ask about nutrition and physical activity programs and how the avatar program compares to your organization’s current programs. For the following questions, please select to the extent you agree or disagree.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I would use this program with the individuals (children/families) my organization serves.					
I would provide this program to the individuals my organization serves when it becomes available.					
The individuals (children/families) my organization serves would use this program.					

**Page break**

16. The following questions will ask about nutrition and physical activity programs and how the avatar program compares to your organization's current programs. For the following questions, please select to the extent you agree or disagree.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The avatar program may be a more <b>convenient</b> way for my organization to <b>teach</b> about nutrition and physical activity.					
The avatar program may be a more <b>convenient</b> way for my the families/children my organization serves to <b>learn</b> about nutrition and physical activity.					
The avatar program may be a more <b>convenient</b> way to <b>reach</b> the families/children my organization serves with nutrition and physical activity lessons.					
The avatar program seems comparable to our existing program(s) in terms of convenience.					

**Page break**

17. The following questions will ask about nutrition and physical activity programs and how the avatar program compares to your organization's current programs. For the following questions, please select to the extent you agree or disagree

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The avatar program may be a more <b>innovative</b> way for my organization to <b>teach</b> about nutrition and physical activity.					
The avatar program may be a more <b>innovative</b> way for my the families/children my organization serves to <b>learn</b> about nutrition and physical activity.					
The avatar program may be a more <b>innovative</b> way to <b>reach</b> the families/children my organization serves with nutrition and physical activity lessons.					
The avatar program seems comparable to our existing program(s) in terms of innovation.					

**Page break**

18. The avatar program may improve the dietary behaviors of the individuals (children/families) we serve.

- a. Strongly disagree
- b. Disagree
- c. Neither agree or disagree
- d. Agree
- e. Strongly agree

19. The avatar program seems less resource intensive than our current programs.

- a. Strongly disagree
- b. Disagree
- c. Neither agree or disagree
- d. Agree
- e. Strongly agree

20. [If Agree or Strongly agree to Q19] What resources do you think you would use less of? Please select all that apply.

- a. Class time
- b. Employees
- c. Cost
- d. Materials
- e. Other \_\_\_\_\_

21. The following questions will ask about nutrition and physical activity programs and how the avatar program compares to your organization's current

programs. For the following questions, please select to the extent you agree or disagree.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The avatar program aligns with my <b>organization's mission</b> to improve the health of children and families.					
The avatar program aligns with my <b>personal values</b> to about health and wellness.					
I believe the avatar program could be easily integrated into my organization's current health promotion practices.					
My organization may benefit from using this program.					

**Page break**

22. The avatar program seems easy to **use**.

- a. Strongly disagree
- b. Disagree
- c. Neither agree or disagree
- d. Agree
- e. Strongly agree

23. [If Disagree or Strongly disagree to Q22] If you selected disagree or strongly disagree to the questions above, what do you think could be challenging about using the program? \_\_\_\_\_ [open-ended response].

24. I believe the individuals (children/families) my organization serves would find the avatar program easy to **use**. Please note the avatar program will be available for free via the internet or smart phone in the future.

- a. Strongly disagree
- b. Disagree
- c. Neither agree or disagree
- d. Agree
- e. Strongly agree

25. [If Disagree or Strongly disagree to Q24] If you selected disagree or strongly disagree to the questions above, what do you think could be challenging about using the program? \_\_\_\_\_ [open-ended response]

**Page break**

26. What is your role(s) in facilitating the adoption of new technology-based programs within your organization? Please select all that apply.
- Influencer
  - Decision maker
  - Disseminator of information
  - None of the above
  - Other\_\_\_\_\_
27. How likely are you to adopt new technology before others?
- Very unlikely
  - Unlikely
  - Neutral
  - Likely
  - Very likely
28. How would you rate your organization's support to help you implement new programs and/or technology?
- Not supportive at all
  - Somewhat supportive
  - Neutral
  - Supportive
  - Very supportive
29. How do you get feedback from the individuals (families/children) your organization serves about the current health programs you provide? Please select all that apply.
- Survey (i.e., quality improvement survey, pre and/or post program survey)
  - Email
  - Informal verbal feedback
  - Focus groups (formal verbal feedback)
  - We currently don't collect feedback
30. How easy would it be to measure the impact of this program within your organization?
- Very difficult
  - Difficult
  - Neutral
  - Easy
  - Very easy
31. How would you promote using this program to the children and families your organization serves? Please select all that apply.
- Email
  - Newsletter
  - Posters or Flyers
  - Website
  - Social Media
  - Teachers, program staff
  - Other\_\_\_\_\_



32. What types of devices do the children and families your organization serves have access to? Please select all that apply.

- a. Computer/laptop
- b. Smartphone
- c. Tablet (Surface, iPad, Galaxy, Amazon Fire)
- d. e-Reader (i.e., Kindle)
- e. Computer gaming system with internet (i.e., Xbox)

33. Is there anything else about the avatar program that you would like to share with us? For example, what did you like most or least about the program?

\_\_\_\_\_ [open-ended response]

**Page break**

34. What county in North Carolina does your organization serve?

- 1, Alamance
- 2, Alexander
- 3, Alleghany
- 4, Anson
- 5, Ashe
- 6, Avery
- 7, Beaufort
- 8, Bertie
- 9, Bladen
- 10, Brunswick
- 11, Buncombe
- 12, Burke
- 13, Cabarrus
- 14, Caldwell
- 15, Camden
- 16, Carteret
- 17, Caswell
- 18, Catawba
- 19, Chatham
- 20, Cherokee
- 21, Chowan
- 22, Clay
- 23, Cleveland
- 24, Columbus
- 25, Craven
- 26, Cumberland
- 27, Currituck
- 28, Dare
- 29, Davidson
- 30, Davie
- 31, Duplin
- 32, Durham
- 33, Edgecombe

- 34, Forsyth
- 35, Franklin
- 36, Gaston
- 37, Gates
- 38, Graham
- 39, Granville
- 40, Greene
- 41, Guilford
- 42, Halifax
- 43, Harnett
- 44, Haywood
- 45, Henderson
- 46, Hertford
- 47, Hoke
- 48, Hyde
- 49, Iredell
- 50, Jackson
- 51, Johnston
- 52, Jones
- 53, Lee
- 54, Lenoir
- 55, Lincoln
- 56, Macon
- 57, Madison
- 58, Martin
- 59, McDowell
- 60, Mecklenburg
- 61, Mitchell
- 62, Montgomery
- 63, Moore
- 64, Nash
- 65, New Hanover
- 66, Northampton
- 67, Onslow
- 68, Orange
- 69, Pamlico
- 70, Pasquotank
- 71, Pender
- 72, Perquimans
- 73, Person
- 74, Pitt
- 75, Polk
- 76, Randolph
- 77, Richmond
- 78, Robeson
- 79, Rockingham
- 80, Rowan
- 81, Rutherford

- 82, Sampson
- 83, Scotland
- 84, Stanly
- 85, Stokes
- 86, Surry
- 87, Swain
- 88, Transylvania
- 89, Tyrrell
- 90, Union
- 91, Vance
- 92, Wake
- 93, Warren
- 94, Washington
- 95, Watauga
- 96, Wayne
- 97, Wilkes
- 98, Wilson
- 99, Yadkin
- 100, Yancey

35. If your organization serves multiple counties, please list the counties you serve. \_\_\_\_\_ [open-ended response]

## APPENDIX F: VR AVATAR PROGRAM ACCEPTABILITY AND USABILITY SURVEY

### Introduction:

Thank you for participating in today's research study. A team of researchers at the University of North Carolina Greensboro (UNCG) would like your feedback about a virtual reality avatar nutrition education program. Please complete this short survey that will take about 10 minutes.

If you would like to speak to our research team prior to completing the survey, please contact Basheerah Enahora or Jared McGuirt for more information.

Email: brenahor@uncg.edu  
Faculty Advisor: Jared McGuirt, jtmcguir@uncg.edu  
Phone: 336-355-6684

If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with participating in this project, please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

### Page Break

### Survey Questions:

1. Participant ID \_\_\_\_\_ [Assigned and completed by the research team]
2. What is your age? Please enter your age in years. \_\_\_\_\_
3. What is your gender?
  - a. Male
  - b. Female
  - c. Transgender/non-binary
  - d. Other or prefer not to say
4. What is your race?
  - a. Afro-Caribbean
  - b. American Indian or Alaska Native
  - c. Asian
  - d. Black or African American
  - e. Hispanic, Latino or Spanish Origin
  - f. Middle Eastern or North African
  - g. Mixed-race
  - h. Native Hawaiian or Pacific Islander
  - i. White
  - j. Other or prefer not to say
5. What technology do you have access to at home?
  - a. WIFI or internet
  - b. Desktop computer with internet

- c. Desktop computer without internet
  - d. Tablet (Surface, iPad, Galaxy, Amazon Fire)
  - e. Laptop computer with internet
  - f. Laptop computer without internet
  - g. Chromebook
  - h. Own a Smartphone (with WIFI or internet)
  - i. e-Reader (i.e., Kindle)
- Video gaming system with internet (i.e., Xbox)

6. How many servings of fruit do you usually eat per day? Think about a serving as a medium piece of fruit or the size of a baseball.
- a. 0 servings per day
  - b. 1 serving per day
  - c. 2 servings per day
  - d. 3 servings per day
  - e. 4 servings per day
  - f. 5 or more servings per day
7. How many servings of vegetables do you usually eat per day? Think about a serving as a medium piece of fruit or the size of a baseball.
- a. 0 servings per day
  - b. 1 serving per day
  - c. 2 servings per day
  - d. 3 servings per day
  - e. 4 servings per day
  - f. 5 or more servings per day

8. For the next questions, please think about how much you agree or disagree

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I look forward to playing with new digital games.					
I am the first of my friends to try a new digital game.					
I like to use avatars when playing digital games.					
The avatar program was fun to use.					
I enjoyed using the avatar program.					
I liked learning about healthy eating in the program.					
Moving through the sections of the avatar program was easy.					
I understood how to use the avatar program					
Overall, using the avatar program was easy.					

Using the avatar program helped me learn more about healthy eating.					
Regularly using the avatar program would increase my confidence to eat healthy snacks					
Regularly using the avatar program would make it easier for me to eat healthier.					
I think the avatar program would be useful in my daily life.					
I intent to use the avatar program when it becomes available.					
I would recommend the avatar program to a friend.					

## APPENDIX G: FOCUS GROUP AND IN-DEPTH INTERVIEWS YOUTH ASSENT AND ADULT

### CONSENT FORMS

#### ADOLESCENT FOCUS GROUPS

#### UNIVERSITY OF NORTH CAROLINA GREENSBORO]

#### PARENTAL CONSENT FOR A MINOR TO ACT AS A HUMAN PARTICIPANT

Project Title: Engaging African American adolescents in a virtual avatar-based nutrition education program

Principal Investigator and Faculty: Basheerah Enahora, RDN, LDN, MS, MBA and Jared McGuirt, MPH, PhD

Participant's Name: <sup>72</sup>

#### **What are some general things you should know about research studies?**

Your child is being asked to take part in a research study. Your child's participation in the study is voluntary. You may choose for your child not to join, or you may withdraw your consent for him/her to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. There may not be any direct benefit to your child for being in the research study. There also may be risks to being in research studies. However, the risks of this study are minimal. If you choose for your child not to be in the study or you choose for your child to leave the study before it is done, it will not affect your relationship or your child's relationship with the researcher or the University of North Carolina at Greensboro.

Details about this study are discussed in this consent form. It is important that you understand this information so that you can make an informed choice about your child being in this research study.

You will be given a copy of this consent form. If you have any questions about this study at any time, you should ask the researchers named in this consent form. Their contact information is below.

#### **What is the study about?**

This is a research project. Your child's participation in this project is voluntary. If you and your child agree to participate in this study, you and your child will join an online focus group to talk about your child's eating habits and provide your thoughts on a new nutrition education program. Parents and children will join the focus group together, however, there will be breakout rooms to talk with youth separately from parents.

#### **Why are you asking my child?**

You and your child are being asked to participate in this study as (1) you identify as Black or African American race, (2) your child is between the ages of eleven and fourteen years old, (3) qualify as federal benefit eligible, (4) speak English and (5) have access to a computer, smartphone or tablet with WIFI and video.

**What will you ask my child to do if I agree to let him or her be in the study?**

To participate in the study, your child will be part of a focus group conducted via online video. In the focus group your child will discuss their eating habits as well as provide their thoughts on a new nutrition education program. Focus groups will last about an hour long. Parents and children will join the focus group together, however, there will be breakout rooms to talk with youth separately from parents.

**Is there any audio/video recording of my child?**

Focus groups will be recorded to allow the researchers to later transcribe each focus group and accurately capture each participant's feedback. The recordings and transcripts will only be reviewed by members of the research team. Because your child's voice will be potentially identifiable by anyone who hears the tape, confidentiality for things said on the tape cannot be guaranteed. Although the researcher limit access to the tape as described below.

**What are the dangers to my child?**

The Institutional Review Board at the University of North Carolina at Greensboro has determined that participation in this study poses minimal risk to participants. You or your child may feel uncomfortable discussing nutrition habits in the focus group or providing personal opinions about our new nutrition education program. However, your child does not have to respond to any of the questions asked in the focus groups and you can discontinue your child's participation in the focus groups at any time without it affecting the ability to participate in future research. Also, your child's confidentiality cannot be guaranteed due to the format of a focus group. However, we will ask participants not to talk about what was discussed during the focus group outside of the focus group.

If you have questions, want more information or have suggestions, please contact, please contact Basheerah Enahora at [brenahor@uncg.edu](mailto:brenahor@uncg.edu) or Jared McGuirt, PhD [jtmcguir@uncg.edu](mailto:jtmcguir@uncg.edu) or call 336-448-3676 to ask anything about the study.

If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with being in this study please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

**Are there any benefits to society as a result of my child taking part in this research?**

Participants in this research study will help inform the development of a new nutrition education program that has the potential to help African American children and families eat well. Participation will help us to design a tailored program that may improve diet quality, social connectedness, nutrition knowledge and motivation, while helping reduce the risk of childhood obesity and associated poor health outcomes.

**Are there any benefits to *my child* as a result of participation in this research study?**

There are no direct benefits to participants in this study. However, participation will help us to develop a new nutrition education program that may benefit many children and families in the near future.

**Will my child get paid for being in the study? Will it cost me anything for my kid to be in**



**this study?**

Yes, you and your child will each receive \$25 for taking the time to participate in this study. You will each receive a \$25 electronic Amazon gift card for completing the study. The cards will be delivered electronically after the focus groups. You may use this gift card for any purchase on amazon.com. You must participate in the entire focus group to receive the gift card.

**How will my child’s information be kept confidential?**

All information obtained in this study is strictly confidential unless disclosure is required by law. Focus group recordings, transcripts, field notes and survey data will be stored on a secure UNCG server, for the duration of the study. To further protect participant confidentiality, each focus group participant will be given a unique ID number, which will be used in electronic data files. In addition, at the end of the study, adults will complete a short online survey about their child and their home access to technology. The survey will be collected on a secure UNCG server and no identifiable information will be collected in the survey. Hence, the electronic data files for this study will lack identifiable participant information. Participants will not be identified by name when the findings from this research study are disseminated. However, as described above, because your child’s voice will be potentially identifiable by anyone who hears the focus group recordings, confidentiality for things said in the recordings cannot be guaranteed. However, recordings will only be reviewed by the research team for data analysis purposes.

**Will my child’s de-identified data be used in future studies?**

You and your child’s de-identified data will be kept indefinitely and may be used for future research without your additional consent or your child’s additional consent.

**What if my child wants to leave the study or I want him/her to leave the study?**

You have the right to refuse to allow your child to participate or to withdraw him or her at any time, without penalty. If your child does withdraw, it will not affect you or your child in any way. If you or your child chooses to withdraw, you may request that any data which has been collected be destroyed unless it is in a de-identifiable state. The investigators also have the right to stop your child’s participation at any time. This could be because your child experienced emotional discomfort, failed to follow instructions, or because the entire study has been stopped.

**What about new information/changes in the study?**

If significant new information relating to the study becomes available which may relate to your willingness allow your child to continue to participate, this information will be provided to you.

**Voluntary Consent by Participant:**

By signing this consent form, you are agreeing that you have read it or it has been read to you, you fully understand the contents of this document and consent to your child taking part in this study. All of your questions concerning this study have been answered. By signing this form, you are agreeing that you are the legal parent or guardian of the child who wishes to participate in this study described to you by Basheerah Enahora, RDN, LDN, MS, MBA, Doctoral Candidate in Nutrition, UNCG.

Date: \_\_\_\_\_

\_\_\_\_\_  
Participant’s Parent/Legal Guardian’s Signature  
(Signature and date will be obtained in RedCap)

**ADOLESCENT FOCUS GROUPS**  
**UNIVERSITY OF NORTH CAROLINA GREENSBORO**  
**ASSENT FOR MINORS**

Project Title: Engaging African American adolescents in a virtual avatar-based nutrition education program  
Principal Investigator: Basheerah Enahora, RDN, LDN, MS, MBA and Jared McGuirt, MPH, PhD

**WHY AM I HERE?**

We want to tell you about a research study we are doing. Research studies are done to find better ways of helping and understanding people or to get information about how things work. In this study we want to get your thoughts on a new nutrition program to help youth and parents eat healthy. You are being asked to be in the study because you are a child eleven to fourteen years old of Black or African American race. In a research study, only people who want to take part are allowed to do so.

**WHAT WILL HAPPEN TO ME IN THIS RESEARCH STUDY?**

If it is okay with you and you agree to join this study, you will be asked to participate in an online focus group about your eating habits and thoughts on a nutrition education program. A focus group is a group interview. The focus group will last about one hour long and will be audio recorded. Parents and children will join the focus group together, however, there will be breakout rooms to talk with youth separately from parents.

**HOW LONG WILL I BE IN THE RESEARCH STUDY?**

You will be in this study for about one hour long.

**CAN ANYTHING BAD HAPPEN TO ME?**

You may feel uncomfortable discussing what you eat or sharing your general thoughts with a group of people. However, you do not have to share anything that you don't want to. Also, you do not have to answer any question that you do not want to. If you do not answer questions, or decide not to be in this study, this will not affect your ability to be in future research at the University of North Carolina Greensboro.

We don't expect that the questions we ask will seem strange or make you feel uncomfortable or sad. However, If anything hurts or you are uncomfortable with some of the questions, please let us know and we will stop and do whatever we can to make you feel better.

**CAN ANYTHING GOOD HAPPEN TO ME IN THIS RESEARCH STUDY?**

We do not know if you will be helped by being in this project. However, we may learn something that will help other children improve their eating habits and social connectedness. In addition, in the future our program may help improve motivation, and self-confidence to eat well.

**DO I HAVE OTHER CHOICES?**

You do not have to be in this study. If you decide not to be in this study, this will not affect your ability to participate in future research at the University of North Carolina Greensboro

**WHAT IF I DO NOT WANT TO BE IN THIS RESEARCH STUDY?**

You do not have to be part of this project. It is up to you. You can even say okay now, but change your mind later. All you have to do is tell us. No one will be mad at you if you change your mind.

**WHAT ABOUT MY CONFIDENTIALITY?**

We will do everything possible to make sure that your data and or records are kept confidential. Unless required by law, only the study team can look at your records. They are required to keep your personal information confidential.

**WILL I BE PAID FOR BEING IN THIS RESEARCH STUDY?**

You will be paid \$25 in the form of an electronic Amazon gift card for taking the time to be in this study and complete the focus group.

**DO MY PARENTS KNOW ABOUT THIS RESEARCH STUDY?**

This study has been explained to your parent/parents/guardian and they have given permission for you to be in it.

**WHAT IF I HAVE QUESTIONS?**

You can ask Basheerah Enahora at [brenahor@uncg.edu](mailto:brenahor@uncg.edu) or Jared McGuirt, PhD [jtmcguir@uncg.edu](mailto:jtmcguir@uncg.edu) or call 336-448-3676 to ask anything about the study. You may also call the Office of Research Integrity at UNCG toll-free at (855)-251-2351 or email the office at [ori@uncg.edu](mailto:ori@uncg.edu).

**ASSENT**

This study has been explained to me and I am willing to be in it.

\_\_\_\_\_  
Child's Name (printed) and Signature  
(dated signature will be obtained in RedCap)

\_\_\_\_\_  
Date

Check which applies below (after child submits, doctoral candidate will complete this section in RedCap)

The child is capable of reading and understanding the assent form and has signed above as documentation of assent to take part in this study.

The child is not capable of reading the assent form, but the information was verbally explained to him/her. The child signed above as documentation of assent to take part in this study.

\_\_\_\_\_  
Signature of Person Obtaining Assent  
(Doctoral candidate will sign and date in RedCap after adolescent has submitted via the Hidden-Survey action tag)

\_\_\_\_\_  
Date

## PARENT FOCUS GROUPS AND IN-DEPTH INTERVIEWS

### UNIVERSITY OF NORTH CAROLINA GREENSBORO

#### CONSENT TO ACT AS A HUMAN PARTICIPANT

Project Title: Engaging African American adolescents in a virtual avatar-based nutrition education program

Principal Investigator and Faculty: Basheerah Enahora, RDN, LDN, MS, MBA and Jared McGuirt, MPH, PhD

Participant's Name: \_\_\_\_\_

#### **What are some general things you should know about research studies?**

You are being asked to take part in a research study. Your participation in the study is voluntary. You may choose not to join, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. There may not be any direct benefit to you for being in the research study. There also may be risks to being in research studies. If you choose not to be in the study or leave the study before it is done, it will not affect your relationship with the researcher or the University of North Carolina at Greensboro.

Details about this study are discussed in this consent form. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. If you have any questions about this study at any time, you should ask the researchers named in this consent form. Their contact information is below.

#### **What is the study about?**

This is a research project. Your participation is voluntary. If you and your child agree to participate in this study, you and your child will join an online focus group to talk about your child's eating habits and provide your thoughts on a new digital nutrition education program. Parents and children will join the focus group together, however, there will be breakout rooms to talk with youth separately from parents.

#### **Why are you asking me?**

You and your child are being asked to participate in this study as (1) you identify as Black or African American race, (2) your child is between the ages of eleven and fourteen years old, (3) qualify as federal benefit eligible (4) speak English, and (5) have access to a computer, smartphone or tablet with WIFI and video.

#### **What will you ask me to do if I agree to be in the study?**

To participate in the study, you and your child will be part of a focus group conducted via online video. In the focus group your child will discuss their eating habits as well as provide their thoughts on a new nutrition education program. Adults/parents will also discuss their child's eating habits and provide their thoughts on a new nutrition education program. Focus groups

will last about an hour long. Parents and children will join the focus group together, however, there will be breakout rooms to talk with youth separately from parents.

**Is there any audio/video recording?**

Focus groups will be recorded to allow the researchers to later transcribe each focus group and accurately capture each participant's feedback. The recordings and transcripts will only be reviewed by members of the research team. Because your voice will be potentially identifiable by anyone who hears the tape, confidentiality for things said on the tape cannot be guaranteed. Although the researcher will limit access to the recording as described below.

**What are the risks to me?**

The Institutional Review Board at the University of North Carolina at Greensboro has determined that participation in this study poses minimal risk to participants. You or your child may feel uncomfortable discussing nutrition habits in the focus group or providing personal opinions about our new nutrition education program. However, you do not have to respond to any of the questions asked in the focus groups and you can discontinue your participation in the focus groups at any time without it affecting the ability to participate in future research. Also, your child's confidentiality cannot be guaranteed due to the format of a focus group, but we ask participants not to talk about what was discussed in the focus group outside of the focus group.

If you have questions, want more information or have suggestions, please contact, please contact Basheerah Enahora at [brenahor@uncg.edu](mailto:brenahor@uncg.edu) or Jared McGuirt, PhD [jtmcguir@uncg.edu](mailto:jtmcguir@uncg.edu) or call 336-448-3676 to ask anything about the study.

If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with being in this study please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

**Are there any benefits to society as a result of me taking part in this research?**

Participants in this research study will help inform the development of a new nutrition education program that has the potential to help African American children and families eat well. Participation will help us to design a tailored program that may improve diet quality, social connectedness, nutrition knowledge and motivation, while helping reduce the risk of childhood obesity and associated poor health outcomes.

**Are there any benefits to me for taking part in this research study?**

There are no direct benefits to participants in this study. However, participation will help us to develop a new nutrition education program that may benefit many children and families in the near future.

**Will I get paid for being in the study? Will it cost me anything?**

Yes, you and your child will each receive \$25 for taking the time to participate in this study. You will each receive a \$25 electronic Amazon gift card for completing the study. The cards will be delivered electronically after the focus groups. You may use this gift card for any purchase on amazon.com. You must participate in the entire focus group to receive the gift card.

**How will you keep my information confidential?**

All information obtained in this study is strictly confidential unless disclosure is required by law. Focus group recordings, transcripts, field notes and survey data will be stored on a secure UNCG server for the duration of the study. To further protect participant confidentiality, each focus group participant will be given a unique ID number, which will be used in electronic data

files. In addition, at the end of the study, adults will complete a short online survey about their child and their home access to technology. The survey will be collected on a secure UNCG server and no identifiable information will be collected in the survey. Hence, the electronic data files for this study will lack identifiable participant information. Participants will not be identified by name when the findings from this research study are disseminated. However, as described above, because of the nature of the focus groups, you and your child's voice will be potentially identifiable by anyone who hears the focus group recordings. Therefore, confidentiality cannot be guaranteed, but we will ask participants to not to talk about what was discussed in the focus group outside of the focus group. Also, focus group recordings will only be reviewed by the research team for data analysis purposes.

**Will my de-identified data be used in future studies?**

You and your child's de-identified data will be kept indefinitely and may be used for future research without your additional consent or your child's additional consent.

**What if I want to leave the study?**

You have the right to refuse to participate or to withdraw at any time, without penalty. If you do withdraw, it will not affect you in any way. If you choose to withdraw, you may request that any of your data which has been collected be destroyed unless it is in a de-identifiable state. The investigators also have the right to stop your participation at any time. This could be because you experienced emotional discomfort, failed to follow instructions, or because the entire study has been stopped.

**What about new information/changes in the study?**

If significant new information relating to the study becomes available which may relate to your willingness to continue to participate, this information will be provided to you.

**Voluntary Consent by Participant:**

By signing this consent form/completing this survey/activity you are agreeing that you read, or it has been read to you, and you fully understand the contents of this document and are openly willing consent to take part in this study. All of your questions concerning this study have been answered. By signing this form, you are agreeing that you are 18 years of age or older and are agreeing to participate, in this study described to you by Basheerah Enahora, RDN, LDN, MS, MBA, Doctoral Candidate in Nutrition, UNCG.

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

(Dated signature will be obtained in RedCap)

APPENDIX H: FORMATIVE PROCESS EVALUATION ASSENT AND CONSENT FORMS

**AVATAR FORMATIVE PROCESS EVALUATION**  
**UNIVERSITY OF NORTH CAROLINA GREENSBORO]**  
**ASSENT FOR MINORS**

Project Title: Engaging African American adolescents in a virtual avatar-based nutrition education program

Principal Investigator: Basheerah Enahora, RDN, LDN, MS, MBA and Jared McGuirt, MPH, PhD

**WHY AM I HERE?**

We want to tell you about a research study we are doing. Research studies are done to find better ways of helping and understanding people or to get information about how things work. In this study we want to see how well our digital nutrition program helps you eat well. You are being asked to be in the study because you are a child eight to fourteen years old of Black or African American race. In a research study, only people who want to take part are allowed to do so.

**WHAT WILL HAPPEN TO ME IN THIS RESEARCH STUDY?**

If it is okay with you and you agree to join this study, you will be asked to use or engage with our nutrition program, then complete a survey and recall what you ate over the past 24 hours. We will also obtain an approximate measure of how much fruits and vegetables you regularly eat with a device called a Veggie Meter. You place your finger in the Veggie Meter for a few seconds and it shines light through your finger to measure the amount of carotenoids in the skin. Carotenoids are yellow, red and orange substances that naturally occur and provide fruits and vegetables with their rich color. Your participation in this research study will last about forty-five minutes long.

**HOW LONG WILL I BE IN THE RESEARCH STUDY?**

You will be in this study for about forty-five minutes.

**CAN ANYTHING BAD HAPPEN TO ME?**

You may feel uncomfortable discussing what you eat or sharing your general thoughts with our research team. However, you do not have to share anything that you don't want to. Also, you do not have to answer any question in the survey that you do not want to. If you do not answer questions, or decide not to be in this study, this will not affect your ability to be in future research at the University of North Carolina Greensboro.

We don't expect that the questions we ask will seem strange or make you feel uncomfortable or sad. However, If anything hurts or you are uncomfortable with some of the questions, please let us know and we will stop and do whatever we can to make you feel better.

**CAN ANYTHING GOOD HAPPEN TO ME IN THIS RESEARCH STUDY?**

We do not know if you will be helped by being in this project. However, we may learn something that will help other children improve their eating habits and relationships with family

and friends. In addition, in the future our program may help improve motivation, and self-confidence to eat well.

**DO I HAVE OTHER CHOICES?**

You do not have to be in this study. If you decide not to be in this study, this will not affect your ability to participate in future research at the University of North Carolina Greensboro

**WHAT IF I DO NOT WANT TO BE IN THIS RESEARCH STUDY?**

You do not have to be part of this project. It is up to you. You can even say okay now, but change your mind later. All you have to do is tell us. No one will be mad at you if you change your mind.

**WHAT ABOUT MY CONFIDENTIALITY?**

We will do everything possible to make sure that your data and or records are kept confidential. Unless required by law, only the study team can look at your records. They are required to keep your personal information confidential.

**WILL I BE PAID FOR BEING IN THIS RESEARCH STUDY?**

You will be paid \$50 in the form of a Walmart or Amazon gift card for taking the time to use our digital nutrition program, complete the survey, recall what you ate yesterday and complete a Veggie Meter scan.

**DO MY PARENTS KNOW ABOUT THIS RESEARCH STUDY?**

This study has been explained to your parent/parents/guardian and they have given permission for you to be in it.

**WHAT IF I HAVE QUESTIONS?**

You can ask Basheerah Enahora at [brenahor@uncg.edu](mailto:brenahor@uncg.edu) or Jared McGuirt, PhD [jtmcguir@uncg.edu](mailto:jtmcguir@uncg.edu) or call 336-448-3676 to ask anything about the study. You may also call the Office of Research Integrity at UNCG toll-free at (855)-251-2351 or email the office at [ori@uncg.edu](mailto:ori@uncg.edu).

**ASSENT**

This study has been explained to me and I am willing to be in it.

Child's Name (printed) and Signature Date  
(dated signature will be obtained in RedCap. See below)

Check which applies below (after child submits, doctoral candidate will complete this section in RedCap)

The child is capable of reading and understanding the assent form and has signed above as documentation of assent to take part in this study.

The child is not capable of reading the assent form, but the information was verbally explained to him/her. The child signed above as documentation of assent to take part in this study.

Signature of Person Obtaining Assent Date  
(Doctoral candidate will sign and date in RedCap after adolescent has submitted via the Hidden-Survey action tag)



## AVATAR FORMATIVE PROCESS EVALUATION

### UNIVERSITY OF NORTH CAROLINA AT GREENSBORO]

#### PARENTAL CONSENT FOR A MINOR TO ACT AS A HUMAN PARTICIPANT

Project Title: Engaging African American adolescents in a virtual avatar-based nutrition education program

Principal Investigator and Faculty: Basheerah Enahora, RDN, LDN, MS, MBA and Jared McGuirt, MPH, PhD

Participant's Name: \_\_\_\_\_

#### **What are some general things you should know about research studies?**

Your child is being asked to take part in a research study. Your child's participation in the study is voluntary. You may choose for your child not to join, or you may withdraw your consent for him/her to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. There may not be any direct benefit to your child for being in the research study. There also may be risks to being in research studies. However, the risks of this study are minimal. If you choose for your child not to be in the study or you choose for your child to leave the study before it is done, it will not affect your relationship or your child's relationship with the researcher or the University of North Carolina at Greensboro.

Details about this study are discussed in this consent form. It is important that you understand this information so that you can make an informed choice about your child being in this research study.

You will be given a copy of this consent form. If you have any questions about this study at any time, you should ask the researchers named in this consent form. Their contact information is below.

#### **What is the study about?**

This is a research project to understand your child's usage and perception of a new digital nutrition program we are developing. Your child's participation in this project is voluntary. If you agree to have your child participate in this study, your child will use or engage with our digital nutrition program for about seven minutes, complete a survey about their experience (about fifteen minutes) and recall what they ate over the past 24 hours (about fifteen minutes). We will also measure your child's fruit and vegetable intake with a device called a Veggie Meter. Your child will place their finger in the Veggie Meter device for fifteen seconds. The Veggie Meter shines light through the finger to measure the amount of carotenoids in the skin. Carotenoids are yellow, red and orange pigments that naturally occur and provide fruits and vegetables with their rich color. The Veggie Meter reading. The Veggie Meter reading is a painless, non-invasive process.

#### **Why are you asking my child?**

Your child is being asked to participate in this study as (1) they identify as Black or African American race, (2) your child is between the ages of eight and fourteen years old, (3) qualifies as federal benefit eligible (free/reduced lunch) and (4) speaks English.

**What will you ask my child to do if I agree to let him or her be in the study?**

To participate in the study, your child will use or engage with our digital nutrition program for about seven minutes online on a UNCG laptop provided to them, complete a survey about their experience and recall what they ate over the past 24 hours. The survey will also ask about your child's age, gender, race and technology access at home. We will also measure your child's fruit and vegetable intake with a device called a Veggie Meter. Your child will place their finger in the Veggie Meter device for fifteen seconds. The Veggie Meter shines light through the finger to measure the amount of carotenoids in the skin. Carotenoids are yellow, red and orange pigments that naturally occur and provide fruits and vegetables with their rich color. The Veggie Meter reading. The Veggie Meter reading is a painless, non-invasive process. Your child's participation in this research study will last about forty-five minutes.

**Is there any audio/video recording of my child?**

No. Participation in this research study does not involve audio or video recordings.

**What are the dangers to my child?**

The Institutional Review Board at the University of North Carolina at Greensboro has determined that participation in this study poses minimal risk to participants. Your child may feel uncomfortable discussing some of the foods they like to eat or providing personal opinions about our new nutrition education program. However, your child does not have to respond to any of the questions asked while engaging in our digital nutrition program or completing the survey. In addition, you can discontinue your child's participation in this research at any time without it affecting the ability to participate in future research. Finally, while we ask general information about your child in the survey, such as age, gender and race, no information identifying your child will be documented in our study.

If you have questions, want more information or have suggestions, please contact, please contact Basheerah Enahora at [brenahor@uncg.edu](mailto:brenahor@uncg.edu) or Jared McGuirt, PhD [jtmcguir@uncg.edu](mailto:jtmcguir@uncg.edu) or call 336-448-3676 to ask anything about the study.

If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with being in this study please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

**Are there any benefits to society as a result of my child taking part in this research?**

Participants in this research study will help inform the development of a new nutrition education program that has the potential to help African American children and families eat well. Participation will help us to design a tailored program that may improve diet quality, social connectedness, nutrition knowledge and motivation, while helping reduce the risk of childhood obesity and associated poor health outcomes.

**Are there any benefits to *my child* as a result of participation in this research study?**

There are no direct benefits to participants in this study. However, participation will help us to develop a new nutrition education program that may benefit many children and families in the near future.

**Will my child get paid for being in the study? Will it cost me anything for my kid to be in this study?**

Your child will receive \$50 for taking the time to participate in this study via an electronic Amazon gift card. The gift card will be provided to the child after they complete all parts of the study. They may use this gift card for any purchase on amazon.com. They must complete the entire research study to receive the gift card.

**How will my child’s information be kept confidential?**

All information obtained in this study is strictly confidential unless disclosure is required by law. Survey data, 24-hour dietary recall data, nutrition program data, and field notes will be stored on a secure UNCG server for the duration of the study. To further protect participant confidentiality, each participant will be given a unique ID number, which will be used in electronic data files. In addition, the survey will be collected on a secure UNCG server, and no identifiable information will be collected in the survey. Hence, the electronic data files for this study will lack identifiable participant information. Participants will not be identified by name when the findings from this research study are disseminated. Data collected in this study will only be reviewed by the research team for data analysis purposes.

**Will my child’s de-identified data be used in future studies?**

Your child’s de-identified data will be kept indefinitely and may be used for future research without your additional consent or your child’s additional consent.

**What if my child wants to leave the study or I want him/her to leave the study?**

You have the right to refuse to allow your child to participate or to withdraw him or her at any time, without penalty. If your child does withdraw, it will not affect you or your child in any way. If you or your child chooses to withdraw, you may request that any data which has been collected be destroyed unless it is in a de-identifiable state. The investigators also have the right to stop your child’s participation at any time. This could be because your child experienced emotional discomfort, failed to follow instructions, or because the entire study has been stopped.

**What about new information/changes in the study?**

If significant new information relating to the study becomes available which may relate to your willingness allow your child to continue to participate, this information will be provided to you.

**Voluntary Consent by Participant:**

By signing this consent form, you are agreeing that you have read it or it has been read to you, you fully understand the contents of this document and consent to your child taking part in this study. All of your questions concerning this study have been answered. By signing this form, you are agreeing that you are the legal parent or guardian of the child who wishes to participate in this study described to you by Basheerah Enahora, RDN, LDN, MS, MBA, Doctoral Candidate in Nutrition, UNCG.

\_\_\_\_\_ Date: \_\_\_\_\_  
Participant’s Parent/Legal Guardian’s Signature (dated signature will be obtained in RedCap)

COMMUNITY AGENCY SURVEY RECRUITMENT FLYER



# WE NEED YOUR FEEDBACK ON AN INNOVATIVE NUTRITION EDUCATION PROGRAM!

A team of researchers at the University of North Carolina at Greensboro is wanting feedback about an online virtual reality nutrition education program.

By completing a quick online survey providing your thoughts on the virtual reality online nutrition education program, **you may be one of 10 participants selected to receive a \$25 gift card**. If you are interested in providing us with feedback on this program, please complete the online survey, which will take approximately 10 minutes to complete.

To be eligible, you must be 18 years old or older, read English, work for a community entity (government, private or non-profit) that provides nutrition education programs to families and children.

By completing the online survey, you are agreeing to participate. Please click this link to complete the survey or scan the QR code.

<https://redcap.uncg.edu/redcap/surveys/?s=MFLEXF8TRC>



For more information, please contact us at:

Email: [brenahor@uncg.edu](mailto:brenahor@uncg.edu)

Phone: 336-355-6684

## COMMUNITY AGENCY SURVEY EMAIL SCRIPT

Hello \_\_\_\_\_ (first name) \_\_\_\_\_ (last name)! I am sharing this email with you on behalf of the University of North Carolina Greensboro (UNCG).

Researchers at the University of North Carolina Greensboro are working on a research project to make nutrition education programs more accessible to families and children. We are looking for interested and eligible individuals to participate in helping us design an innovative, online virtual reality-based nutrition education program.

### **What is involved?**

Participating persons will complete a brief online electronic questionnaire, which will take approximately 10 minutes to complete.

Ten participants will have an opportunity earn a \$20 Amazon gift card for participating in this study. Data collection will occur September 2021-February 2022.

### **Who is eligible?**

Individuals (a) who are 18 years of age or older, (b) read English, (c) work for a healthcare organization or community entity (government, private, or non-profit) that provides nutrition programs or guidance and (d) has influence on or authority to provide nutrition education programs to end users (children and families).

### **What is next?**

By completing the online survey, you are agreeing to participate in this study.

**Please use this link to participate or scan the QR code in the attached flyer <https://redcap.uncg.edu/redcap/surveys/?s=MFLEXF8TRC>**

Also, could you please forward the attached flyer to other healthcare providers working with children and families in North Carolina? We would greatly appreciate your help with this important research.

Thank you,

Basheerah Enahora, MS, RD  
Department of Nutrition  
UNCG

Jared McGuirt, PhD, MPH  
Department of Nutrition  
UNCG



# **ARE YOU A PARENT WITH A CHILD BETWEEN THE AGES 11-14?**

A team of researchers at the University of North Carolina at Greensboro wants feedback about a new computer-based program aimed to help parents and children eat healthier.

You and your child between the age of 11-14 would participate in a focus group, lasting around 1 hour, where you would share your thoughts on the program. **You can each earn a \$25 gift card for participating.** If you are interested in providing us with feedback on this new nutrition program, please contact us as soon as possible at the email or phone number below.

To be eligible, you must speak English, have access to a computer, smartphone or tablet with WIFI and video, live in the Greensboro Triad area, be a parent or caregiver and a child between the ages of 11-14 and of Black or African American race who: (1) receives or is eligible to receive federal food assistance; and/or, (2) has a monthly household cash income that is at or below 200% of the Federal Poverty Level.

**Contact us for more information:**

**Email: [brenahor@uncg.edu](mailto:brenahor@uncg.edu) Phone: 336-448-3676**



# HELP US DESIGN A NEW DIGITAL NUTRITION PROGRAM

A team of researchers at the University of North Carolina at Greensboro needs help designing a new computer-based program aimed to help children eat healthier.

Your child between the age of 8-14 would spend about forty-five minutes engaging with our nutrition program and completing a short survey. We will also measure your child's fruit and vegetable intake with a device called a Veggie Meter. **Your child will earn a \$50 gift card for participating.** If you are interested in your child participating in our nutrition program, please contact us as soon as possible at the email or phone number below.

To be eligible, the child must speak English, live in the Triad area (Greensboro, High Point, Winston), be between the ages of 8-14 and of Black or African American race who: (1) receives or is eligible to receive free/reduced lunch/breakfast; and/or, (2) lives in a household with a monthly cash income that is at or below 200% of the Federal Poverty Level.

**Contact us for more information:**

**Email: [brenahor@uncg.edu](mailto:brenahor@uncg.edu) Phone: 336-448-3676**

## **Formative Process Evaluation Research Protocol**

Data collection will take place at Boys & Girls Clubs in the Greensboro Triad area. Please see the data collection schedule for the most update schedule:

<https://docs.google.com/document/d/1X2fEr2b1x8CpC8bwC4LkLvEsleakoj9iMPfRID5daVQ/edit?usp=sharing>

Upon arrival at each site, the lead researcher will set up and calibrate the Veggie Meter. After the Boys & Girls Club center director brings the participants to the data collection area, the lead researcher will review the assent statement with the children. The children will sit at a table in front of a laptop or iPad. A participant ID will be assigned to each child at the start of data collection. Use the same participant ID for the child throughout the study.

Each researcher will collect data in the following order:

### **Avatar Program Engagement (7-10 mins)**

Participants will engage with the avatar program on UNCG laptops for approximately 7-10 minutes. The program only runs on FireFox. Please download FireFox to your laptop and go through the program twice to ensure the program runs properly on your UNCG laptop.

Step 1: Access the Avatar program at <https://avastudy.uncg.edu/>

Click the bottom right double arrow to make the program full-screen

Step 2: Youth will enter their information (first name, address) for customized advise from the avatar.

Step 3: Youth will customize their avatar by clicking the right/left arrows to change the body type, hair, eyes, and clothing of the avatar.

Step 4: Let the child engage with the program on their own and observe. They will need to click next on each screen to continue through the program. They will stop at the screen that says "Thank you for spending time with me today. I would now like to speak to your parent or caregiver". Again, it will take about 7-10 minutes to get to this screen. Next, do a Veggie Meter® scan.

### **Veggie Meter® (2-3 mins)**

Each participant will complete a single Veggie Meter® scan.

Step 1: Participants will wash and dry their hands first. There should be a bathroom nearby at each Boys & Girls Club. It will probably make sense for one researcher to go with the youth to the bathroom and wait outside the door as they wash their hands. Alternatively, the lead researcher will bring wet wipes to each study site. Each child can wipe their fingers clean, then air dry them before inserting their finger into the Veggie Meter®.



Step 2: Enter participant info on the Veggie Meter® computer interface: Participant/study ID, gender, and left/right finger used.

Step 3: Ask the participant to insert her index finger into the cradle (note left/right on the display) Make sure pad of the finger covers the entire lens and ask the participant to be still; let the lid close down to apply pressure

Step 4: Click on "Single Scan"

Note: It is normal for reading to be 10% of average score

## ASA24 Data Collection Guide

A username (ID) and password have been created for each participant for the 24-hour dietary recall data collection on the ASA24 respondent website. Each researcher will be provided with the participant information for login on the day of data collection. A video showing how to enter data in ASA24 has been created to help you with the process and can be found in BOX via this link. <https://uncg.box.com/s/uihwarzdivt74j51t5yrd3t528o1uq3y>

### To enter participant data in ASA24:

Step 1: Go to <https://asa24.nci.nih.gov>

Step 2: Log in with the participant ID and password. Also, log in with the demo ID and password to practice. Demo ID: AvFPE\_DemoUser, PW: Demouser!

**We will also practice on each other once before the first data collection date. Please also practice as a demo user twice before the first data collection date.**

Step 3: Select if the child is a male or female, then guide the participant through entering each meal, snack, and beverage they ate within the past 24 hours. They will also enter the day (within 24 hours) and time of the eating occasion, where the meal/snack took place (i.e., at home or school,) and if they ate in the presence of others. Once the meal or snack has been entered, the participant will choose the portions they consumed. Visuals of portion sizes will be shown to participants. Choose cups for food and ounces for drinks as much as possible. It is probably easier for a child to provide portions of fruit as small/med/large size.

Note: Enter as much detail as the child can remember and ask clarifying questions to gather more information (i.e., what color was the pasta? Was it brown or light tan?).

Step 4: ASA24 will ask you if you have missed anything. For example, did you include all beverages and snacks? You will then have an opportunity to add additional snacks or meals. The final screen will ask if you want to review analytics data. Select yes, then enter the child's age. You don't need to provide this data to the child. You can let the child know that you are finished, and they will receive their \$50 electronic Amazon gift card in a few days.

Note: we must have the child's email or their parent's email to send the Amazon gift card. So, please make sure we have collected their email on this form: [https://docs.google.com/forms/d/e/1FAIpQLSfedYrUMSof 2-RqJTKvaU2mwBUfmHekbLaOGfI8tOX61MsQ/viewform?usp=sf\\_link](https://docs.google.com/forms/d/e/1FAIpQLSfedYrUMSof 2-RqJTKvaU2mwBUfmHekbLaOGfI8tOX61MsQ/viewform?usp=sf_link).

If an email address is not available, we will provide the child with a Walmart gift card. Record the gift card serial number, date, participant ID, and person issuing the gift card on the paper log sheet, then provide the gift card to the child.

Step 5: Prepare to collect 24-hour recall data on the next child