

***Acceptance, Adoption, and Adherence:
The 3 A's of Eating Behavior Change***

Suzannah Gerber, MA, MS

PhD Candidate

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Committee members:

Sean B. Cash, PhD. (Co-Chair)

Paul Jacques, PhD. (Co-Chair)

Susan Roberts, PhD.

Abstract

Background: Diet is the leading global cause of chronic illness, yet healthcare providers remain reluctant to recommend dietary approaches for prevention and treatment. In addition, food systems contribute roughly one-third of all human-generated greenhouse gas emissions (GHGs), along with deforestation, ocean habitat loss, zoonotic diseases, and environmental injustice. Modifiable diet choices, such as reducing animal-sourced foods (ASFs), are increasingly recommended by nutrition and climate scientists. However, promotion of plant-based foods (PBFs) and diets (PBDs) faces even greater resistance. Shifting toward plant-based diets requires identifying barriers and facilitators of food and diet acceptance, adoption, and adherence, and assessing the feasibility and effectiveness of sustained practice. Acceptance of PBFs and novel alternatives may promote PBD adoption, but long-term adherence must be specifically measured to determine drivers of sustained change.

Objective: To advance understanding of how acceptance, adoption, and adherence relate to strategies for reducing ASF intake to support healthy and sustainable dietary change.

Specific Aim 1: To investigate consumer acceptance of cultivated meat (CM) in a real-world setting examining attitudes, sensory experiences, and sociopolitical meaning-making at the first public CM tasting event in the world, using ethnographic and grounded theory methods.

Specific Aim 2: To develop and test a novel intervention designed to increase health with increasingly plant-forward diet behaviors and exercise, testing for adherence to goals, stage of change and change readiness, and weight change in a six-month pilot randomized control trial.

Specific Aim 3: To develop and test an adherence metric for popular diets that restrict ASFs among self-identified adopters, and associations with BMI, diet quality (HEI-2015), and diet duration.

Methods: Three studies explored acceptance, adoption, and adherence among American adults voluntarily pursuing diet change, independently, through novel food trial or coaching.

Study 1: An ethnography of the June 2024 UPSIDE Foods “Freedom of Food” pop-up in Miami—the world’s first public CM tasting—included semi-structured interviews (n=19), media interviews (n=17), field notes, and secondary media/social media analysis. Grounded Theory was used to analyze sensory feedback, attitudes about food technology, willingness to consume (WTC), and ethical and political alignment, with attention to pre-existing belief systems and veg*n identity.

Study 2: A pilot RCT enrolled older adults (n=20) at risk for diet-related NCDs in an intervention (1:1 with control) designed to provide education and support plant-forward change diet and other healthy lifestyle behaviors and to maintain those changes. Adherence and weight change in the intervention and control groups were measured at three timepoints over six months. Adherence to program goals, change readiness (Stage of Change), compatibility, engagement, and enjoyment of the program was evaluated in intervention groups (n=3) which were also assessed for fidelity.

Study 3: An online survey (n=1282) recruited American adults who self-identify as following a vegan, vegetarian, Paleo, or whole-food plant-based (WFPB) diet. Weight, height, lifestyle and demographic factors were gathered for participant characteristics. Diet was assessed using the Diet History Questionnaire II (DHQ-II) and used to calculate diet quality using HEI-2015 score.

Contributions: The results generated from this study can be used to design future interventions and nutrition education programs to increase acceptance and adoption and more accurately gauge adherence to alternative foods and diets. Individuals, clinical and public health professionals can support maintained adoption and increased adherence aligned with individual preferences and health goals in order to achieve health benefits while incrementally improving sustainability and health through frequent plant-based choices.

Abbreviations and Terms Definition:

ACEND: Accreditation Council for Education in Nutrition and Dietetics
 ADAPT: Adhering to Dietary Approaches for Personal Taste Study
 AI: Artificial Intelligence
 ASF: Animal-Sourced Foods
 BMI: Body mass index
 CDC: Centers for Disease Control and Prevention
 Cegan: Like vegan, but eating cultivated proteins
 COI: Community of Inquiry framework
 CM: Cultivated meat, made from cell-culturing animal cells from animals commonly used as food
 CVD: Cardiovascular Disease
 DASH: Dietary Approaches to Stop Hypertension
 DHQ: Diet History Questionnaire
 EAT: EAT Foundation (EAT-Lancet Commission)
 EPIC: European Prospective Investigation into Cancer and Nutrition
 ESG: Environmental, Social, and Governance
 FAIRR: Farm Animal Investment Risk & Return
 FDA: Food and Drug Administration
 FFQ: Food Frequency Questionnaire
 FNDDS: Food and Nutrient Database for Dietary Studies
 FPED: Food Patterns Equivalents Database
 GBD: Global Burden of Disease
 GHG: Greenhouse Gas Emissions
 GRAS: Generally Recognized as Safe
 HEI: Healthy Eating Index
 IPAQ: International Physical Activity Questionnaire
 IPCC: Intergovernmental Panel on Climate Change
 MAHA: Make America Healthy Again
 MVPA: Moderate to Vigorous Physical Activity
 NCD: Non-Communicable Disease
 OZEMPIC: Brand name of GLP-1 receptor agonist, Semaglutide medication
 PBMA: Plant-Based Meat Alternatives
 PDMDA: Plant-Derived Meat and Dairy Alternatives
 Pegan: Like vegan, but paleo-vegan
 NHANES: Nutrition and Health Examination and Study
 RCT: Randomized controlled trial
 ROI: Return on Investment
 SAVoReD: Scoring Adherence to Voluntary Restriction Diets
 SCT: Social Cognitive Theory
 SoC: Stages of Change
 TPB: Theory of Planned Behavior
 TTM: TransTheoretical Model
 UNCCC: United Nations Framework Convention on Climate Change
 USDA: United States Department of Agriculture
 UTAUT: Unified Theory of Acceptance and Use of Technology
 Veg*n: vegan and vegetarian, collectively
 WL: Weight Loss
 WWEIA: What We Eat In America

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Introduction and Background

Diet-related diseases are the most prevalent chronic non-communicable diseases (NCDs) in the world [1], but healthcare practitioners often hesitate to recommend dietary approaches for disease prevention, or as a first-line treatment [2]. Similarly, food systems are estimated to contribute over 1/3 of all human-generated greenhouse gas emissions [3] and otherwise greatly contribute to major negative environmental externalities such as contamination and overuse of water and land, destruction of ocean habitats, the rate and severity of foodborne and zoonotic diseases, and many forms of environmental injustice [4, 5]. Modifiable dietary choices, such as reducing consumption of animal-sourced foods (ASFs) through the adoption of increasingly plant-based diets (PBDs), have been frequently associated with improvements in both human and planetary health [4, 6, 7]. However, there is widespread reluctance to promote PBDs, in specific, alongside the overall hesitancy to rely on diet change as a solution to address these critical issues. These concerns largely center around perceptions about consumer acceptance for PBFs and PBDs and thus whether they are likely to be adopted among a significant proportion of the population, or that when adoption is attempted that it may not be sustained or truly adhered to in order to confer meaningful impacts [6, 8-10].

Individuals adopt diets, including PBDs, for a variety of reasons, with many factors known to influence eating behavior and behavior change [11-14]. Individuals often indicate that food and dietary adoption is motivated by multiple subjective priorities including health, sustainability, medical advice, cultural or social norms, personal or social identity, access and affordability, and perceptions of social desirability [11-13, 15-17]. While frequently discussed, the topic of reducing meat and ASFs, and vegan and vegetarian (collectively, veg*n) diets in particular, are often polarizing [18-20]; consequently, adoption often indicates association with a strong, reciprocally reinforcing dietary identity [14, 20, 21]. Individuals with a strong veg*n identity often experience internal and external pressures (from both within their dietary subculture and from without) to maintain perfect adherence to their dietary choices.

[17, 20-30] This pressured expectation is fraught by a food environment that presents challenges such as limited availability of convenient or affordable plant-based options, or foods suitable to meet preference, nutritional, or dietary needs. Additionally, social isolation from non-veg*n peers can further hinder adherence [31-34]. These factors separately and together contribute to higher rates of recidivism, can deter individuals from initiating and maintaining PBDs and lower adherence [9, 11, 13, 35-38]. Thus, motivating change towards PBD is somewhat more challenging than the already complex undertaking of healthy diet behavior change. Nonetheless, multiple priority areas for public health and environmental sustainability are well-served by increasing our understanding of the drivers of acceptance of these diets and the alternative foods that increase the ease of operating them. Methods to facilitate sustained shifts to plant-based, plant-forward or animal meat-reducing diets, and more specific measures of adherence to these behavioral goals may help identify avenues to increase their sustained and functional adoption.

Taster rating of PBFs tend to be positive, among both veg*ns and meat-eaters [39]. Indeed, a recent large, blind, taste test with nearly 2,700 participants found that while animal meat tends to score higher, many plant-based foods were rated equally high or higher than animal-sourced counterparts, suggesting that consumer biases and perceptions significantly influence taste preferences beyond actual flavor differences.[40] However, Van Loo et al. (2020)[41] and Slade et al. (2018)[42] found that even when priced similarly, only 21-23% of respondents would choose a PBF food despite indicating positive evaluations of taste or ethical priorities, and only 5-11% would choose cultivated meat (CM). Plant-based meat market shares tell a similar story, with retail shares estimated to be between 0.1-3% of all meat sold [41, 43]. Studies also indicate that a majority (>58%) of persons who reported consuming PBFs in the prior day also reported consuming ASFs the prior day [44], and that when pricing conditions are favorable for PBFs (and in choice experiments with price held constant), that plant-based meat would only expand to 12.1% of the market—6.9% from people who buy and eat animal-sourced meat, and 5.2% from persons not otherwise consuming meat at all [41]. These observations cast a rather pessimistic view on the ability

of PBFs to offset traditional ASFs, but the mixed adoption and range in mediating factors present opportunities for further examination.

A frequent report among former veg*ns, and some currently maintaining veg*n diets is that hedonic dissatisfaction with and/or difficulty in maintaining the diet due to access and availability of desirable alternatives is the biggest source of recidivism and non-adherence [22, 30, 31]. Another component impacting sustained adoption and adherence is price—despite PBDs being overall more affordable compared to the standard diet in many countries including the U.S.[45-47], commercial PBFs designed as alternatives to animal-sourced meat and dairy are often more expensive than the ASFs they emulate [46]. Determining which alternatives are rated as acceptable to consumers is thus an important area of investigation for supporting adoption of and adherence to these diets, as is evaluating levers to improve accessibility. Access is itself reflexively related to consumer acceptance, after all—in order for suitable products to be available and affordable they need to be produced at a large enough scale, which requires that more people adopt them.

How do we get people to adopt a healthy diet?

Adoption is a transitional phase where an accepted food or diet begins to be incorporated into an individual's lifestyle [48]. Accessibility, convenience, knowledge, motivational drivers, and hedonic satisfaction all play roles in successful adoption [49]. Adoption is time-variable in that there can be an initial adoption and a later rejection and that adoption and acceptance/rejection can change direction over time and with additional exposures to the behavior and to things like normative beliefs about the behavior [50-53]. Adoption typically requires positive experience(s) that develop acceptance to precede it and support continued adoption to translate into maintenance of the new behavior; in the case of diet adoption, this can also entail a reciprocal relationship with adherence which itself also varies over time. The Theory of Planned Behavior (TPB)[54-56] and Social Cognitive Theory (SCT)[57] emphasize the importance of perceived behavioral control, normative beliefs/social influences, and self-efficacy to

support adoption, illustrating how an individual moves from awareness and attitudes towards intention and action. However, these theories are unidirectional, presenting a theory of change that has only a forward progression. The Transtheoretical Model (TTM), which is structured as the Stages of Change (SoC), is often used in long-term interventions as a model that captures the variable nature of adoption, allowing forward, backward, and non-linear progression from pre-contemplation to maintenance [50-53]. Motivation, satisfaction, and ease are often considered critical determinants of adoption, which are processes of repeated choice and acceptance over time [48, 58, 59]. As a result, interventions stage-matched to SoC have been observed to better enable long-term adoption and greater adherence [53, 60-64].

Multiple intervention programs have been created to support healthy diet adoption and adherence [49, 61, 65-69]. However, only one is promoted by the CDC: The Diabetes Prevention Program (DPP) [49, 70-72]. While initial studies by the program's designers reported strong results, many subsequent studies and versions of the DPP failed to achieve the same effects [72, 73]. Adaptation for specific populations and fidelity to program materials are often described as process-based limitations of DPP interventions [52, 74-76], which suggests that tailoring programs to participants while also using standardized materials could better support healthy lifestyle change, including initial diet adoption, sustained adoption (maintenance), and adherence to program recommendations associated with improved health outcomes [66, 73, 77, 78]. Affecting behavior change in an intervention program is itself a major step towards improving clinical outcomes. However, for meaningful and long-lasting improvement in public health and environmental sustainability, changes need not only be adopted during program enrollment but also adhered to and sustained thereafter. Despite great need, our understanding of true levels of adherence and methods for increasing it is limited. Adherence is also often conflated with duration, which further necessitates the development of tools that can assess and compare these behavioral constructs to each other and with clinical and ecological metrics in order to inform approaches for healthy sustainable diets.

Understanding adherence to diet

Adherence is critical to the success of healthy diets, largely relating to the dose of exposure. Dietary adherence may refer to following clinical recommendations, but most commonly refers to following the rules of a given diet plan or structure [9, 79], sometimes referred to as compliance or concordance [80]. Individuals often hold varying beliefs about health relevant to food and diet [81], and many voluntarily initiate the adoption of popular diets without input from healthcare providers or enrollment in intervention programs. Although a growing body of research explores motivation for diet adoption [11, 12], patterns of diet maintenance [16], and the diet quality of various PBDs [82], the study of adherence itself remains inconsistent. Researchers frequently use heterogeneous definitions of diet types, dietary assessment methods, and metrics limited in their ability to quantify and categorize adherence—often conflating the constructs of adoption, maintenance, and ‘compliance’.

This inconsistency is particularly problematic given the nature of chronic diet-related diseases, such as cardiovascular disease and type 2 diabetes, which typically develop over decades but can show clinically meaningful improvement in biomarkers within months or even weeks of significant dietary change [83-89]. Without a clear understanding of adherence level, diet-specific adherence patterns, and the duration of adherence—collectively, the “diet dose”—it is difficult to determine which dietary approaches offer the greatest potential for improving population or individual health outcomes.

Most often, dietary adherence is assessed using a single-item subjective measure, such as ‘How closely do you follow your diet?’[90] or ‘How important is following your diet?’[91] More robust, diet-specific adherence scores have also been constructed for the Healthy Mediterranean Diet [92], the Dietary Approaches to Stop Hypertension (DASH) Diet [93], and indices like the Healthy Eating Index (HEI) that capture adherence to the Dietary Guidelines for Americans (DGAs) [94]. There is a notable absence of validated tools to measure the degree of adherence to popular ASF-reducing diets—especially those voluntarily adopted outside of clinical or research settings. Existing measures often rely on binary, self-

reported metrics that indicate either perfect adherence or non-adherence [18, 90] limiting their utility in capturing real-world variation. Furthermore, no known method currently allows for comparison across multiple diets, or that can compare adherence to these diets to the average dietary intakes of proximal peers using a nationally representative standardized reference.

The long latency and development periods for diet-related NCDs [2, 95, 96], paucity of data from long-term diet maintainers, and the variability in both the efficacy and time-to-effect of different interventions combined with inconsistent methods for reporting and categorizing dietary intake and adherence [97-100] means that the existing literature on diet-disease relationships may be omitting critical information about the dose of exposure. The lack of specificity for adherence levels may obscure dietary sub-components drive outcomes and more specific measures might better help describe not only -world adherence levels but also cut points associated with best net outcomes, weighing tradeoffs both clinical and personal. Such metric has the potential to help better inform individuals and health authorities about methods to address both human and planetary health and could be further applied to explore which traits, barriers, and bolsters accompany successful and unsuccessful adherence. The knowledge gained from such exploration could then be used to develop interventions optimized for improved adherence while better able to report associations between diet operation and both health and environmental outcomes, respectively. Additionally, isolating adherence into a standalone metric would also allow disambiguation from diet duration, allowing evaluation of how adherence might change throughout adoption, thus enabling more accurate assessment of the impact of these diets over time. Diet behavior-based solutions remain underutilized in clinical care and public policy, improved acceptability and access joined with better metrics to assess real-world ranges in dietary adherence may combine to better help promote utilization of diet change.

In the case of veg*ns and PBDs adoption itself may be internalized as an identity, especially where voluntary diet followers having motivations other than health or sustainability alone. Emerging research

focuses on the situated role of diet for veg*ns, how these volitional identities form and influence food choice—this intrinsic motivation stemming from identity may also confer greater diet quality through prolonged duration and adherence [17, 21, 22, 27-29]. Both veganism and vegetarianism are frequently referred to as “lifestyles,” representing a wider ethical belief system in which diet is just one part of a larger identity. Thus, for those who identify, the intent of adoption may be to sustain it lifelong, rather than as an experiment for health, a trend, or a short-term goal, such as weight loss [21]. While diet identity for veg*ns has been described, and linked to adoption, maintenance, and to some extent to adherence, self-identification does not seem to perfectly safeguard against recidivism. Some studies report that over 50% of veg*ns abandon their diet within the first trial year of adoption, [31] a time period consistent with challenges converting from action to maintenance in major behavior change models like the TTM [63]. Reports of duration for Paleo diet followers seem even shorter, with average follow periods of 5-6 weeks [101]. However, there are long-term maintainers for multiple PBDs and Paleo diets alike. Research evaluating the possible sources or predictors of recidivism cite satisfaction/boredom with diet, food access, and social acceptance as key determinants of maintenance versus recidivism, with parallels to adherence [31]. Altogether, research indicates that personal and popular opinions of foods and diets interrelates with the choice to adopt a diet even when taste enjoyment, ethical values, and health beliefs, and the price point are aligned. However, there remain many significant gaps in our understanding of what is most effective for supporting higher adherence and longer maintenance and how to translate insights to promote acceptance and adoption for the next several waves of optimized products and evidence-based recommendations.

Acceptance of alternative foods and their role in adoption and adherence

Acceptance is a broad term that encompasses several behavioral constructs and is reflexively updated (both positively and negatively) by adherence and adoption experiences. For example, evaluating the acceptability of an intervention commonly includes determining whether a program is “favorable,

agreeable, or satisfactory”, and indeed what qualities impact acceptability, who finds it acceptable, and whether the acceptability impacts protocol adherence and/or participation [102]. For consumer food and diet behaviors, acceptance may refer to willingness to try or consume regularly, but it is also significantly influenced by taste preferences, attitudes, normative beliefs, cultural background, and often perceived health benefits [13, 48, 58].

Much like the many motivations to adopt a diet, perceptions and preferences for foods also impact acceptance. For example, even for someone with low price sensitivity (willing to pay more for preferred foods) and a positive taste evaluation, PBFs may be regarded as inferior for health by some due to beliefs about processing or naturalness. Alternatively, some veg*ns may have negative health beliefs about ASFs, and/or emotional, and/or hedonic aversions to them which could also result in a transference of that aversion to more realistic novel alternatives, compared to traditional ones like tofu, falafel, or black bean burgers [39, 103].

Acceptance is like a gateway to dietary change—without it, the subsequent stages of adoption and adherence are unlikely to occur [58, 104-107]. The acceptance stage parallels the early stages of behavior change models like the Health Belief Model (HBM) and the TTM, where an individual's awareness and contemplation of a behavior are the foundation for future action [61-64]. However, in the case of cultivated meat (CM), acceptance may also relate to individual beliefs and interest in technology, and food technology versus naturalness in specific. Specific combinations of models like the Unified Theory of Acceptance and Use of Technology [108, 109], and constructs like Food Techneophobia [58, 110, 111] and Meat Avoidance [112] may better describe the complex factors in the acceptance technology-based solutions to the multi-fold externalities of ASFs.

Interrelationships between the three A's in prior literature

The existing literature on diet-related behavior change highlights the interconnectedness of acceptance, adoption, and adherence in major theories like HBM, SCT, TPB, and TTM [54-57, 61-64, 113,

114]. These theories emphasize the importance of attitude in the initial stages of behavior change, where acceptance and adoption are strongly influenced by an individual's beliefs, change readiness, and perceived control over a change. Factors like knowledge, access, satisfaction, and social norms are all known to influence food and diet acceptance, adoption, and dietary adherence [11, 12, 15, 16, 38, 82]. As mentioned above, adherence is also often conflated with adoption and maintenance in research which can obscure both time-variable factors and sub-components and internal factors that influence sustainable adherence [90, 115-117].

It is hypothesized that if a significant portion of people voluntarily change their behavior towards healthful PBDs that there would be significant personal, economic, and environmental benefits [118]. However, it is unclear how, or if, it is possible to facilitate greater acceptance of ASF alternative foods, to increase the adoption of ASF-reducing diets, or indeed if those following veg*n diets are meaningfully adherent. Further research is needed to increase our understanding of how these interrelate so public health guidance can best support behaviors that correspond to greatest net benefit.

Conceptual Framework: Food and Diet Acceptance, Adoption, and Adherence

Diets Reducing Animal-Sourced Foods

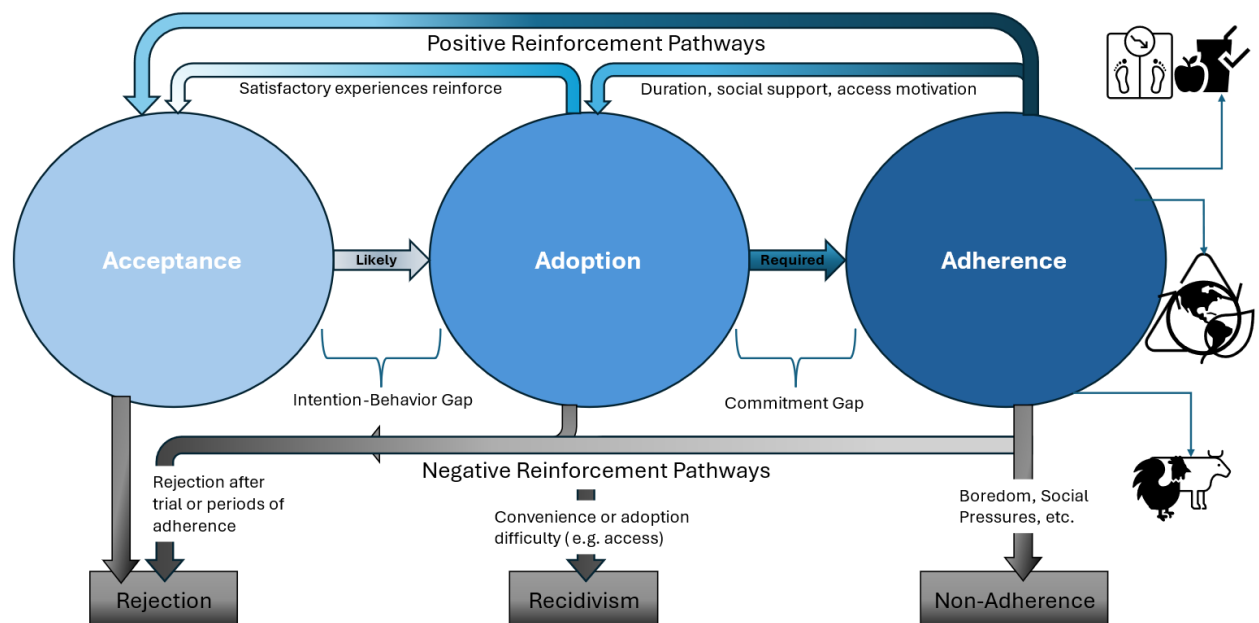


Figure 1. Conceptual Framework Showing the Relationship Between Acceptance, Adoption, and Adherence and Positive and Negative Feedback Loops for Diets Seeking to Reduce Animal-Sourced Foods or Foods Developed as Alternatives. The conceptual framework visually represents the stages and reinforcement pathways involved in reducing animal-sourced foods through alternative foods and dietary patterns. Acceptance is the initial stage, influenced by taste, cultural norms, and social factors, where individuals decide whether to try a new food or diet. Successful acceptance can lead to adoption, where the food or diet is incorporated into routine life choices, facilitated by factors like accessibility and support systems. Moving from acceptance to adoption involves crossing the "intention-behavior gap" whereas moving from adoption to adherence crosses the "commitment gap". Positive reinforcement pathways, such as diet satisfaction and social support facilitate continued acceptance and adoption. Conversely, negative experiences can lead to rejection, recidivism, or non-adherence.

Figure 1 illustrates how acceptance, adoption, and adherence are sequential and interrelated, with each dependent on the success of the previous stage as well as being shaped by a complex interplay of psychological, social, and environmental factors and feedback loops between stages. Acceptance of a diet or alternative food progresses to adoption, with higher acceptance contributing to the likelihood of adoption. Adherence follows from adoption in that adherence requires adoption to be considered, but unlike mere adoption, adherence considers both the density and frequency of choices (e.g. adherence in a given meal, day, week, over time and possibly compared to in-group others or normative populations). While the term adherence is used heterogeneously to mean 'rule compliance' or 'length of diet duration', here, rather than considering time as part of adherence, adherence level is isolated in order to enable comparison to duration following one's diet. This isolation not only enables evaluation of adherence over time but also allows investigation into the feedback loop between adherence and adoption.

Sustained adoption of a healthy diet may confer benefits independent of perfect adherence. Identifying dimensions most associated with diet maintenance longevity and outcome maximization hold potential for redefining feasibility for veg*n diets, meriting further exploration to identify thresholds of adherence and maintenance for relevant health outcomes and environmental impact. While individuals may be personally motivated and value-aligned towards adopting plant-based diets, various factors can break down acceptance. These include limited access to affordable PBFs, low self-efficacy in cooking skills, and a social environment that challenges benefits or acceptability [33, 119, 120]. Such barriers can lead

to increased recidivism and can even result in radical flips in sentiment. In the case of ex-vegans and “anti-vegans”, the clash in social and informational pressures may result in a counter-formation in which other diets/foods come to be seen as superior, leading to a potentially intense rejection of previously endorsed beliefs, behaviors, identities, and preferences [20, 23, 25, 26, 31].

Statement of Aims and Hypotheses

Aim 1: To explore consumer acceptance of cultivated meat (CM), in a real-world social and political context, focusing on how sensory experience, ethical priorities, identity, and sociopolitical beliefs interact to shape consumer perceptions and willingness to consume CM.

Hypothesis 1a: Acceptance of CM is influenced by complex interactions between social and sensory factors. Individuals will socially process sensory experiences in real-time, including comparisons to ASFs and PBFs, expectations of verisimilitude, and reactions to event primes.

Hypothesis 1b: Consumers will be more likely to accept CM when it is perceived as ethically aligned with values, and will be more likely to reject when those are doubted or violated.

Hypothesis 1c: Perceived threats to values and identity motivate voluntary action in favor of CM, defying traditional political or social affiliations.

Specific Aim 2: Develop and pilot a modification of the Diabetes Prevention Program (DPP) designed to facilitate diet and exercise behavior adoption among older adults, compared to a waitlisted control while evaluating program fidelity, acceptability, and adherence.

Hypothesis 2a: Participants in the intervention will lose more weight than among controls.

Hypothesis 2b: Weight loss will be associated with high adherence and change readiness.

Hypothesis 2c: Targeted programs can enhance acceptance and adoption of healthy lifestyle for older adults and can bolster adherence that can be maintained over 6 months.

Specific Aim 3: To develop and test a novel adherence metric in voluntary adopters of four ASF-restricting diets, and the associations between adherence and BMI, diet quality (HEI-2015), and duration following one's diet.

Hypothesis 2a: Voluntary adoption to ASF-restricting diets will not result in perfect adherence.

Hypothesis 2b: The diets will differ in mean adherence and health outcomes. Greater adherence to a more PBD will be associated with a higher HEI-2015 score and healthier BMI.

Hypothesis 2c: Adherence and duration will be independent and additively associated with BMI.

The studies described herein aim to provide further understanding of how ASF-reducing diets and foods that may support meat-reduction diet behavior are accepted, adopted, or adhered to by individuals with varying goals and personal motivations. Aim one observes reactions to a public tasting and the early social co-construction of meaning for the newest type of meat alternative—cultivated meat (CM). Aim two develops a program designed to encourage multiple healthy lifestyle shifts, including increasingly plant-forward diets in a population of older adults at risk for cognitive decline and diabetes. Aim three assessed adherence among several ASF-reducing diets being voluntarily followed among free-living adults, and examines associations between adherence and BMI, diet quality, and diet duration.

Together, this research aims to generate insights about the suitability of different approaches to meat reduction by: (1) examining the acceptance of innovative techno-food meat alternatives; (2) designing, implementing and evaluating technology tailored, peer-driven, group-based intervention programs that support diet change through acceptance, adoption, and the measurement of adherence, social compatibility, and program efficacy; and (3) developing and testing a novel metric to assess adherence to popular animal-source food (ASF)-restricting diets. This new metric enables comparisons across diet types by relating adherence levels to established healthfulness indicators such as the Healthy Eating Index (HEI) [94], the Healthy Plant-Based Dietary Index [82], or the Healthy Mediterranean Diet Score [93]) across varying durations of dietary maintenance.

Lasting consumer behavior change requires a multi-pronged approach: the availability of acceptable food alternatives, systems that support both adoption and social acceptance of healthy and sustainable diets, and a social and public health infrastructure to encourage long-term adherence commensurate with benefits. With over 72% of global greenhouse gas emissions originating from household-level activities in the Global North [118], and consuming ASFs identified as the second most impactful modifiable behavior, there is a pressing need to identify strategies that can foster sustained dietary change for people, the planet, and the animals. These combined studies may help advance our understanding of how individual-level change can be better supported—and how to maximize impact within constraints of limited attention and resources. Insights gained can help identify leverage points for future interventions and inform public health programming to explore avenues for sustained diet change at scale.

Chapter 1: Publicly Tasting Cultivated Meat and Socially Constructing Perceived Value, Politics, and Identity

Suzannah Gerber, Hyeryeon Bae, Isabella Ramirez, Sean B. Cash

Abstract: Cultivated meat (CM), derived from animal cells without traditional animal agriculture, offers potential to reduce environmental and ethical impacts of meat production. However, CM faces challenges from consumer skepticism toward food technologies, mixed success of plant-based alternatives, regulatory hurdles, and bans in some U.S. and European states. Acceptance, sensorial evaluation, and political alignment is a large gap in our understanding and existing research relies on hypothetical or lab-based evaluations. This is the first study to observe consumer acceptance in a public food tasting of CM. We conducted a multicomponent ethnographic analysis exploring CM acceptance, combining semi-structured interviews among 19 event attendees, detailed field observations, and secondary data from media and social media including 17 additional interviews. Using Grounded Theory, we identified key themes—American identity, verisimilitude, and the role of government—that informed theoretical pathways for CM acceptance. Our results reveal the importance of aligning CM with ethical priorities for animal welfare, sustainability, and health while meeting sensory and transparency expectations to foster consumer trust. To address skepticism and social needs, CM must be perceived as a valuable alternative to conventional meat. Our insights reveal that widespread adoption could require ongoing innovation, evidence-based communication, and consumer inclusion.

Keywords: Cultivated Meat, Cellular Agriculture, Sustainability, Protein Diversification, Consumer Acceptance, Sensory Evaluation, Ethnography, Political Activism, American Identity

Introduction

“We Don’t Ban Foods in America. It’s Not Who We Are.”

-event participant

Cultivated meat (CM), also known as cell-cultivated, or cultured meat, is an alternative to animal-sourced foods (ASFs) produced by culturing animal cells in a controlled environment (often within a food-grade bioreactor like those used to process dairy).[121] Development of CM has been described and explored for over 100 years in various scientific fields, with a technological origin in tissue engineering used in stem-cell therapy and skin graft transplantation.[122] The rationale for CM, according to scientific and industry leaders, is to create a sustainable alternative or complement to conventional livestock farming that addresses the rising demand for protein foods while also offering solutions for food security,[123, 124] national food sovereignty, and minimizes negative externalities of animal agriculture on the environment, human health, and animal welfare.[125-128] In 2023, the U.S. approved the sale of CM for the first time.[122] For a brief time, two companies, UPSIDE Foods and GOOD Meat, Inc. provided CM to two unconnected fine dining restaurants that each sold CM to U.S. consumers on high priced tasting menus in which CM was a small component; each restaurant served less than an estimated 100 servings before discontinuing these options.[129-131] Aside from these limited opportunities, the U.S. public has no routine way to acquire or taste these novel foods.

Despite federal approval of these initial products, some U.S. states have moved to ban CM or otherwise pass legislation to mandate censorship and restrictive naming requirements on food labels.[132, 133] In May 2024, Florida and then Alabama passed bans taking effect in July and October, 2024 respectively[132, 133]; the Tennessee House proposed a bill which was introduced in the Senate, deferred for a later session, and is now inactive[134]; and the Arizona House passed a bill, which later

failed in the Senate.[135] Historically, the Food and Drug Administration (FDA) has taken a permissive approach to food approvals, and while federal food ingredient bans do occur, they typically occur after approval after strong evidence of harm is demonstrated.[136] Recently, ingredients such as partially-hydrogenated oils (trans fats), certain food colorings,[137, 138] and some high-profile food safety incidents[139-141] have called into question both the process of approval and removal. State-level food bans are more rare, and despite criticisms and trade complications, proponents of state-level bans argue that they influence FDA re-evaluation.[142, 143] This, along with popular discourse deliberating the safety of food additives, genetically modified organisms (GMOs),[144, 145] and a lack of scientific consensus around the risks and definitions of processed foods have fueled consumer wariness[146-149] and become a point of political tension. UPSIDE Foods, the first company to receive market approval to sell CM in the United States, hosted the world's first, free and open to the public tasting of CM in Miami, Florida, on June 27, 2024—announced two weeks before, and hosted just four days before the first U.S. state-level ban on CM would take effect in Florida.[150] The event was framed as a way to allow consumers to taste and examine CM for themselves while also soliciting activism and advocacy for the “Freedom of Food”.[150] The historic event provided a unique opportunity to conduct a natural history ethnographic event study, enabling analysis of real-world consumer perceptions of an actual CM product without researcher-imposed experiments, controlled settings, targeted recruitment, or facilitation. At an event, interviews can elicit faithful and spontaneous inquiry into attendees’ underlying beliefs, sensory experience, political perspectives, and impressions of the company, industry and event could be explored among individuals with a range of prior experience and beliefs who voluntarily chose to attend without external incentive.

In this fraught political context, relatively little is understood about public desire for and acceptance of CM. At the time of the event, four U.S. states – Alabama, Arizona, Florida, and Tennessee –had fielded bills banning CM; by November 2024, another four states, Michigan, New York, Pennsylvania,

and Illinois introduced similar bills. Consumer acceptance of CM has been explored in multiple studies, including hypothetical choice modeling, sensory evaluation, and attitudinal surveys. Prior research has identified key factors influencing acceptance, including perceived naturalness, food safety concerns, and ethical considerations [151-153]. Other studies have explored consumer attitudes towards naming and framing of CM compared to other foods designed as alternatives to animal foods [154]. These studies identify important constructs underlying presumed acceptance of this novel food that can be probed when encountering CM in tasting opportunities. This study builds on the existing research by examining how consumers engage with CM at a tasting event, allowing for the observation of unstructured, socially influenced acceptance processes.[155] Given that CM is not available for purchase, consumers have no reliable access to CM and few individuals outside of relevant industry and research circles have tried it.[147, 154-160] As a result, much published research on CM acceptance attempts to predict acceptance based on thought experiments[161, 162] and the rare studies on sensory evaluations are in the context of experiments. These sensory studies include isolated evaluation of smell,[163] or manipulating taste ratings in response to information treatments,[164] or recruiting interested participants to compare CM to familiar foods at a local butcher shop.[165] While these offer insights about possible consumer acceptance, they do not capture the reflexive processes of acceptance and adoption likely to manifest within open-choice and socially complex settings, such as when wider availability and distribution of CM occurs. There are no known studies that have studied individuals freely seeking out CM in order to understand their background, baseline opinions, and political alignment alongside sensory evaluations, nor any examining the complex social environment of a public event. Immersive ethnography can offer rich insights situated in a complex social environment, observing consumer experiences within family and other social dynamics as they naturally unfold, and witnessing how consumers co-create social meaning for CM without manipulation or incentives to attend and try the food.[166]

Media coverage about food technology has stoked consumer wariness and preferences for familiar, traditional, and "natural" foods.[81] Perception of food technology has a complex history in the modern foodscape,[167, 168] and naturalness is often perceived as safer and wholesome, laden with nostalgic or even romantic ideals about culture and nature.[81, 169-172] Frequently, introduction of novel food processing and agricultural technology is met with consumer aversion, in large part due to innate preferences for naturalness.[173, 174] Advances in food technology offer a range of societal benefits and harms, but resistance is usually untethered to demonstrated evidence.[173, 174] Importantly, acceptance and rejection patterns for food technology are heavily shaped by cultural and social factors as well as media messaging which echoes popular fluctuations in public trust of science and food safety regulation.[166-168, 175-179] This suggests that consumer perception of naturalness and novel food technology may be largely symbolic and that resistance may be primarily due to cultural beliefs and the identity threats that novel technologies may signal to both consumers and producers.[180-182] Indeed, farmers and farms themselves are often described as stewards of nature, and thus as symbols of naturalness and health, indicating that a departure from these traditions may itself provoke existential anxiety.[182, 183]

No prior ethnographies of public encounters with CM exist, but some have investigated other once-novel, now prevalent and politically charged food technologies including GMOs[184, 185] and the paradoxical acceptance and aversion to concentrated animal feeding operations (CAFOs), also known as factory farms.[186-190] Event-based ethnography offers a unique opportunity to simultaneously investigate social norms, anxieties, power dynamics, political culture, expended effort, sensory dynamics and the reflexive interactions between these dynamics both voluntarily and spontaneously.[191][192] Event studies allow for an ethnography of a certain group of people at a specific time and place where researchers can observe the natural unfolding of events. Anthropologist Penny van Esterik describes the ethnography of taste events as a crucial complement to lab-based sensory research because it is more

sensitive to the social and cultural dynamics that influence true and complex tastes and the socialization of food habits.[193] Ethnography of food has a long history, predominantly exploring the cultural significance of social food practices in communities, often tied to specific regions.[166] Much literature describes immersive field research for food preparation, consumption, political activism, and social/religious rituals,[194-198] but less work examines public tasting events beyond juried events with premium entry fees.[199-201] Nonetheless, food tasting events have long been used to advocate for ethical food and agriculture practices like the environmentalist “locavore” movement, “Slow Food” movement, and the vegan movement; each co-locating food within personal and political spheres.^{7,62,63,71-}

⁷⁴ For these sociopolitical movements, taste events are powerful tools to galvanize and concentrate support, demonstrate the sensory value of ethical foods, spread messaging, imprint favorable impressions, and allow attendees to bond over shared visions of food futures.[166, 184, 185, 202-205]

Our objective is to conduct an ethnographic analysis of the reception of this novel technology among members of the general public who voluntarily chose to attend a tasting event of CM. We aimed to document the ways that companies, cultures, and communities encounter, interact with, adapt to, reject, and grapple with acceptance of CM including how stakeholders may solicit political action in support of or against it.[185, 192, 206, 207] As modern food solutions are developed to help address growing resource demands, analyzing social environments in which novel foods are tried can help identify successful means of democratizing suitable solutions,[206] enabling society to co-create better food systems and food cultures of the future.[166, 207]



Figure 1 Freedom of Food Pop-Up Logo, Used By UPSIDE Foods

Results

Pre-Event Media Analysis

Company Promotion of the Event

The company used social media platforms including Instagram and Linked In to promote the event, known as the "Freedom of Food Pop-Up" with a red, heart-shaped logo bearing that name superimposed over an American flag which was often surrounded by Florida's famous palm trees. (Figure 1) The campaign emphasized the urgency, highlighting that it was the "first and last chance" and/or "the ONLY chance" for Floridians to taste CM before the Florida state ban on July 1, 2024. Posts were strategically timed, with the event location only revealed the day before— prior to that, would-be attendees needed to contact the company to attend. The messaging invoked activism in support of protecting the American values of "freedom" and a sense of historical importance by urging people to "make history" by attending.[150]

Posts had user comments which tended to show strong interest, with many eager to attend or requesting that a similar event come to their city. Many comments also expressed political frustration, with some criticizing the ban as "sad," or voicing opposition to the politician who introduced the ban: "Ron DeSantis and the Florida Republicans are Un-American anti-capitalists." Comments sometimes led to larger discussions about free market principles, government roles, and American identity, with one user stating, "Passing policies based on political ideals leads to what's best for the political class, not for Americans. Only the free market can do that."

Interestingly, the company website lacked prominent information about the event. To find information, users needed to search directly through an external search engine. By contrast, information about the Florida and Alabama state bans, and a call to sign a petition against them, were featured prominently on the company webpage. Searching directly, the event page also featured information about the bans, with

an image of a family gathered around a dinner table with a homemade meal. This was juxtaposed with a call to action:

“Florida and Alabama criminalized cultivated meat. These laws do not protect consumers. It is ‘food policing’ to protect entrenched interests, defying free market principles and limiting consumer autonomy for a product the food safety experts at USDA and FDA have deemed safe. Fight back: SIGN THE PETITION.”

(Appendix 1 - Supplemental Figure 2)

Similarly to other announcements about the event, the page emphasized the urgency and exclusivity of the event as the "first- and last- chance to taste cultivated meat in Florida" before the ban, and as first-come, first-served, with limited quantities, encouraging early arrival. The bottom of the page included disclaimers about limited supply, liability, photography consent, and event rules, which included a requirement to sign the petition against the bans. This framing combined urgency with a sense of civic duty, tying the tasting experience directly to broader political and social issues of food freedom.

The company promotion of the "Freedom of Food Pop-Up" emphasized the following themes (Table 1):

Table 1. Company Pre-Event Messaging Analysis

Theme	Sub-Theme	Description
Identity and Freedom	American Identity	American symbols like the flag were used in promotions, with the flag modified into the "Freedom of Food Pop-Up" logo bearing company statements like "come make history" linked the event to values like patriotism.
	Freedom of Choice	Framed as a fight for consumer freedom, suggesting the ban limited personal choice. Statements like "It's about giving people freedom of choice" emphasized a vision for a "better food future."
Opposition to Government Intervention	Critique of Government	Company messaging criticized the ban as "clucked up," accusing politicians of hypocrisy and selective "food policing."
	Free Market Advocacy	Promoted as a free market issue, arguing that the ban represented government overreach and protection of entrenched interests, limiting consumer autonomy.

Theme	Sub-Theme	Description
Time Urgency and Exclusivity	Scarcity and Urgency	Presented as a "first- and last-chance" event with limited supply and "first-come, first-served" access, creating urgency.
	Exclusivity	Framed as a unique, historical event with limited quantities and undisclosed location to increase exclusivity.
Health and Safety Concerns	Health and Safety	Company messaging highlighted product safety and regulatory approvals (USDA, FDA). However, comments such as "Frankenstein meat" from users on LinkedIn showed continued skepticism, especially among potential attendees, similar to skepticism expressed by Florida lawmakers.
Political Positioning	Political Statements	Posts and comments criticized Ron DeSantis and related political ideologies, challenging the "protectionist" framing used by ban supporters.
	Civic Engagement	Included calls to action, such as signing a petition against the ban and attending as a form of protest.
Community and Social Appeal	Social Interaction	The event was promoted as a social occasion, described as a "happy hour" and encouraging group attendance. Comments reflected a focus on community and shared experience.
	Local Engagement	Promotions referenced Miami, local neighborhoods like Wynwood, and hashtags like #bestfoodMiami to appeal to local pride and identity.
Marketing and Brand Positioning	Brand Identity	The UPSIDE logo with a heart replaced the stars on the flag, symbolizing the brand as an American innovator standing against restrictions to freedom.
	Appeal to Hedonics	Designed as socially desirable with a high-profile chef and the tagline "tasting is believing," to create appeal through sensory experience and exclusivity.

Overall, the company positioned itself as a champion of consumer rights and freedom, and the food as a symbol of those rights in need of protection. The event was situated within the broader political context and sought to solicit and galvanize support and maybe recruit the first wave of CM early adopters.

Media Promotion of the Event

Media coverage before the event largely matched the messaging in the company's press release,[150] but emphasized the event as both a culinary experience (like a product launch or tasting) and also a gathering to rally activism to challenge the regulatory barriers created by Florida politicians. The media promotion occurred in outlets that largely focus on the food industry, or on alternative proteins like cultivated and

plant-based foods (PBFs) specifically, and similarly focused on themes of urgency, freedom of choice, and the promises of CM[150, 208-210] (Appendix 1 - Supplemental Figure 1). The event was described as a historic, one-night-only opportunity to taste CM before the Florida ban and positioned the company as a pioneer, with clearance from the FDA and the United States Department of Agriculture (USDA). Statements like the "right to choose what meat to eat," framed the event as a celebration of food freedom and a protest, while the ban was depicted as a setback for innovation and consumer autonomy by multiple stakeholders. Articles included perspectives from local celebrity Chef and business-owner Mika Leon to emphasize the culinary value of CM as well as from the science and technology real estate firm Brick and Timber Collective (also the host of the event) to emphasize the economic importance of CM.[143, 208, 209] These perspectives added credibility and appeal to the event, while reinforcing the high political and economic stakes involved.

Themes were similar to those in company messages, although the emphasis was more focused on Miami local framing and the hedonic experiences to come with frequent references to Chef Mika Leon, mixologist Gio Gutierrez, and descriptions of the cultivated "chicken filet in a Cuban-style,"[209] alongside enticing images of CM foods. Articles used stronger language in opposition to the ban, referring to it as an "authoritarian policy by Governor DeSantis".[210] Articles also included the contrasting language from DeSantis, describing the ban as "fighting back against the global elite" which allowed the media to dramatically frame the event within the broader narrative of the American culture wars,[210] and to proposed or pending bans in other states, highlighting the growing political battle over CM.

Ethnography

Scene

The event had a high-end appearance and an exclusive atmosphere marked by a vibrant yet tense energy. Outside, a protest van with a large LED screen criticizing "lab-grown" meat blocked the view to the entrance (Appendix 1 - Supplemental Figure 3a and 3b), imposing a confrontational tone before attendees

reached the more festive party atmosphere on the rooftop. To get inside, attendees lined up along a red-velvet rope, moved past several large security guards, and were checked in at a desk by an UPSIDE Foods employee with a guest list creating an air of exclusivity even though the event was open to the public. Signs describing event rules and the requirement to sign the petition were posted throughout (Appendix 1 - Supplemental Figure 4). On the rooftop, the mood shifted as people entered a more polished, upscale, party environment. The party started sun-filled, on a rooftop in Miami with an expansive view of an artsy neighborhood and was decorated with tropical plants throughout. Additional decorations used the brand's colors (white and red), giving it the feel of a luxury food product launch with a prominent, central cooking station, a decadent buffet, two open bars, and colorful lighting over a dance floor. There was also a party photobooth set up with props intended to capture live reactions of "first bites".

Even before it was served, the focus of the crowd was on the cultivated chicken. However, it would not make an appearance until about 1.5 hours into the event, something that stoked quite a bit of anticipation and tension among guests. After grazing on the buffet and drinks (Appendix 1 - Supplemental Figure 5), guests vocally expressed confusion and frustration about waiting for the main attraction. Then, Dr. Uma Valeti, the CEO and Co-founder of UPSIDE Foods, delivered a long and passionate speech about the innovation and challenges of CM, and primed the audience to expect the food to "taste just like chicken, because it is chicken". After his speech, Chef Mika Leon described her appreciation for the food and company and began preparing the dishes. She also offered many sensorial primes, such as instructing the audience to listen for the sound of the sizzle and to smell the cooking. Attendees demonstrated eagerness to observe these sensorial qualities, and to see how the food looked while cooking. Once cooking commenced, many charged forward and pulled out phones or professional cameras to document the experience, often remarking aloud about wanting to taste the product. One by one, samples were assembled and attendees tasted the food while carefully observing the reactions of others around them.

Crowd

The crowd was diverse, with attendees of all ages, including small children with their families, young and old couples, and adults into their 60s. The majority of the crowd appeared affluent, seemed to understand how to comport in such a luxurious party environment, and many wore designer, albeit casual, clothing. Most attendees appeared to be white and/or Latine—however, people from other racial and ethnic backgrounds were present. There was a slightly higher proportion of men, roughly two thirds of the crowd, and the crowd appeared to have a healthier weight status than a standard cross section of 100 Americans. The media presence was palpable, including many professional photographers with cameras on tripods. The media and other industry stakeholders outnumbered attendees.

Food

Next to the cooking station was a large screen showing an overhead view of the CM cooking – this spectacle was part of the main attraction. On the screen, attendees could see bubbling juices swirling around the heavily seasoned meat. The samples themselves were small, amorphous cutlets and that developed randomly distributed red and browning rivulets as they cooked, indicative of a composite texture. The cooking station had two frying pans surrounded by seasonings in jars, with one labeled *Tajin*, a popular seasoning that is highly aromatic and likely added to the color in both the oil and on the cutlet. Many in the crowd asked the chef technical questions about cooking CM, and she discussed the similarity of cooking it to conventional chicken, indicating one difference: CM cooks faster.

Samples were served on small, compostable, square party plates. The menu described the dish as a tostada, layered up from the bottom starting with a small, fried, round cut tortilla, topped with guacamole, spices, CM chicken, chipotle aioli, and beet sprouts (Appendix 1 - Supplemental Figure 6). According to discussions with the company and one media outlet reporting, 75 samples would be made,[209] and according to communications with the company, not all samples were consumed by the end. Watching onlookers, some faces displayed skepticism or hesitation when going to take their first bite,

while others ate it quickly and without much consideration. People seemed to want to linger after trying; however, the samples were distributed between 8:15-8:45pm on a Thursday evening, and the event ended just after 9pm.

Interviews

The tasting event brought together a diverse group of attendees. Nineteen respondents agreed to be interviewed; respondent characteristics are summarized in Table 2. While some had prior exposure or positive support for CM, most came to the event curious, and some even skeptical. Attendees indicated that they were motivated to attend because of political, ethical, or environmental concerns. However, despite interest in the promise(s) of CM, some expressed optimism for the future of CM and others had clear skepticism about the product and its feasibility. The event offered multiple opportunities for attendees to model and observe the tasting experiences of others. As a result, interviews often offered both personal perspectives, as well as explicit awareness and discussion of others' opinions. Rates of responses to questions on these matters are summarized in Table 3.

Table 2. Interview Respondent Characteristics

	Interviewed	Tasting
N	19	15
Age (Mean, SD)*	39.7(+13.5)	40.5(+13.4)
Race/Ethnicity		
Black/African-American	1	1
Hispanic/Latine	7	6
Asian	0	0
White	13	10
Middle Eastern/Jewish	2	2
Gender		
Man	11	9
Woman	8	6
Diet Type		
Vegan	5	5
Vegetarian	1	1
Flexitarian	1	0
None (Omnivore)	12	9
Former Vegan or Vegetarian (veg*n)*	3	2
Political Affiliation		
Democrat/Liberal/"Left Leaning"	7	5
Republican/Conservative/"Right Leaning"	1	1

Libertarian	4	4
Independent/Undecided/PNR	7	5
Educational Attainment		
Some College	1	1
Bachelor's Degree	6	3
Master's Degree	7	6
Law Degree	4	4
Unknown	1	1
Prior Knowledge of Cultivated Meat		
No prior knowledge of cultivated meat	3	2
Prior interaction with cultivated meat industry	3	2
Previously eaten cultivated meat	2	2
Opinion of Cultivated Meat on Arrival		
Positive	11	10
Neutral	6	3
Negative	2	2
Distance Traveled to Attend		
Local (<1 hour drive)	14	11
Regional (>1 hour drive)	2	1
Visitor (Traveled By Plane)	3	3
Race/Ethnicity: 4 respondents indicated being of mixed race 1) one respondent self-identified as Middle Eastern and Hispanic, 2) self-identified as Black and White, 3) self-identified as being of Middle eastern Jewish descent and White, and 4) self-identified as Hispanic and White. Diet Type: Former vegan/vegetarian category is non-exclusive, 1) one respondent self-identified as flexitarian and a former vegan, and 2 others self-identified as not currently following a special diet while being a former vegan or vegetarian (veg*n).		

Table 3. Details From Interviews

How they heard about the event	n(%)
Friend/Family	6(32)
Professional	6(32)
Vegan Online Group	4(21)
Media/Social Media	3(16)
Who they came with	
Alone	7(37)
Friend	3(16)
As a couple	4(21)
Parent- Adult Child	5(26)
Intend to try	
Yes	19(100)
No	0
Interviewed after Tasting	
Yes	15(79)
No	4(21)
Enjoyed tasting	
Yes	11(58)
No	2(11)
Mixed	2(11)
Unknown	3(20)

Tasters Requesting Sensory or Product Improvements	
Yes	11(73)
No	4(27)
Willing to consume	
Only Try again	5(26)
Consume/Purchase	
Regularly	6(32)
Only on Special Occasions	1(5)
No	3(16)
Unknown	4(21)
Ban	
Knew About it	13(68)
Signed Petition	5(26)
Would Sign/Take Action to	
Oppose	19(100)
Would Vote Against it	19(100)

Thematic Analysis of Interviews

A predominant theme in the interviews was the belief in the importance of American freedom and consumer choice. Many respondents voiced strong opposition for government bans and advocated for the right for individuals to choose what they eat:

"The ban is about politics and about protecting certain industries, but it's a conflict for me because they put the science second. I support innovation and I'm usually a big DeSantis supporter. But I don't support him on this. I would vote against the ban."

Many respondents, particularly those who were currently vegan or vegetarian (collectively, "veg*n"; n=6) or previously veg*n (n=3), expressed great enthusiasm and curiosity about CM—but some had strong and unexpected reactions to the "realness" of the sensory qualities they experienced:

"The aftertaste was of real chicken, it was *too* real. I had forgotten about that taste. It isn't something you get in plant-based chicken and knocked me off guard. It wasn't a chemical taste; it was REAL CHICKEN."

Many expressed disappointment about the lack of information provided at the event and wished to learn more about production methods and to see concrete, evidence-based demonstrations of ethical claims relevant to health (safety, but most especially nutrition), the environment, and often for animal welfare:

"The whole activity lacks credibility. Who can tell you that that chicken wasn't bought at Walmart this morning? They didn't present anything. They didn't show you anything of the process. We don't know anything. We just have to believe that they did it in a lab. How do they [make] these meats? How do you get from a cell to a piece of meat? With regular meat they show you how they feed them, how they kill them, how they prepare them, the show more than just bringing you a piece of chicken that you don't know where it came from. "

Attendees described the event itself as an important way to increase awareness and acceptance of CM, offering the crowd the ability to discover how well supported CM is by others. Curiously, many had come to the event believing CM was unknown, with only niche interest, "We were expecting everybody here to be vegan. So, the fact that there are a lot of people who aren't just vegan or vegetarian feels cool to see." Most attendees indicated an expectation of small crowds of highly similar people and were excited to find such a large and diverse crowd. "I didn't think anyone else was interested in cultivated meat in Miami."

The event was not uniformly effective in alleviating concerns or skepticism about CM, especially about whether the product was mature enough for the market. For some it inspired moderate hope:

"I'm not saying people will stop eating real meat or anything but everything [is] consumed with criteria...I'm confident now after coming here and seeing all the support that it's a very valid way to eat meat in the future."

However, others would need substantial continued product development:

"This was like product day 1. I wanna see where we are on day 10, or day 100.

You haven't lost me yet; I'll try it again around day 10, or after. I want to see a little bit more growth...I'll buy it when its a much more developed product."

Taste evaluations were mixed; some praised the flavor and texture as comparable to conventional meat, while others described the texture as "rubbery" or in other ways differing from expectations that would authenticate it as "true chicken":

"It had a little bit of rubbery texture. A little bit like a fish fillet. Like when you bite fish and when it comes apart like that. You can actually feel the little pieces like coming apart. Except this didn't come apart."

The most common comparator was plant-based meat alternatives. For many respondents, the CM chicken was considered similar in taste or texture to PBFs, "Its tastes good, as good as any plant-based food but not particularly different." Only a few endorsed it as a superior alternative, "the biggest difference between this and plant-based is the texture for me, because this actually has the texture of meat;" but, three described it as worse in flavor and texture to available alternatives, "I would say some of the plant-based foods that I've tried tasted more like chicken, honestly." Vegans, in particular, expressed a unique kind of ambivalence in sensorial evaluations of CM, and were often reluctant to compare it to "real meat" since it had been "so long" since they had last consumed it, some over five years and some over ten. Vegans tended to compare CM to plant-based alternatives, simultaneously enjoying it and experiencing an uncanniness about its "realness." This uncanniness was described as an "aftertaste" that was so real as to be disturbing or having a texture that was "so much like chicken that it was overwhelming."

The level and type of seasoning, and the highly composed nature of the dish were very frequently discussed. "The seasoning was so strong it was hard to taste the chicken itself." This conveyed a prevalent uncertainty about the "true taste" of the food, with many describing that they made a concerted effort

to remove seasoning and layers of the tostada in order to taste the CM directly, "I tried it with like all the sauce on it and that tastes really good. And then I tried it again to try the meat by itself...I would want to try it with different styles of cooking." Despite varied sensorial responses and evaluations of product maturity, all but one respondent had a positive view of the future potential for the product—but all but one who tasted the food believed it needed substantial further sensorial improvement for maturity:

"It needs some honest improvement, like in general with the product...Plant-based foods have tasted more like chicken and stuff, honestly...but I think this would get better. Back then, five or more years ago, there weren't that many mock meats that tasted good; nowadays, I've had chicken nuggets that tastes just like where you can't tell the difference."

Summary of Deductive Codes

Sensory Evaluations. Some found CM indistinguishable from conventional meat, while others found it similar or inferior to plant-based alternatives. Acceptance was fairly divided; although most endorsed willingness to try again, few were ready to endorse consuming regularly, pending future product development. Texture played a crucial role in acceptance of the product. More positive and negative evaluations tended to track alongside texture evaluations, with positive evaluations being about identifying a grain or a bite, "Seeing it sliced, it sliced just like conventional chicken, having the same kind of muscle fiber and structure as conventional chicken. It looked delicious"; and negative evaluations described it as "rubbery" or like "minced meat" specifically identifying a lack of that fiber or grain, "The fibers of the chicken breast weren't there; it felt a bit more like minced meat put together into a nugget. A little bit rubbery, tougher, rougher, muscle cut up chicken than regular white meat piece."

Many respondents expressed a strong desire to try the CM in other formats, or to be able to cook it for themselves:

"I would cook it at a higher temperature to get the skin crispy. They should have shown two or three different ways to cook this chicken... and they should give some samples that people can take home with you to try."

The skill of a celebrity chef cooking the food was highly salient for respondents and led to caution or hesitation when answering whether what they tried would influence future food decisions, "this was definitely cooked by someone who knew what they were doing". Interviewee reactions to the professionally designed dish and requests to be able to try it in other and more familiar forms such "as a sandwich or a regular meal" added to the feedback that the food under-performed, or was more like a nugget than the expected chicken breast.

Political Position. Many respondents rejected the Florida government decision to ban CM, "I feel like the ban is an interesting choice for a state that allegedly supports smaller government". This position was consistent regardless of political affiliation and was often framed in terms of free-market principles, consumer rights, and American values:

"Banning cultivated meat sets a really terrible precedent in this country... Completely based on scare tactics and political nonsense. We don't ban foods in America. That's not who we are, that's just not what we do. This isn't Four Loko. There's no science behind the ban. It's nonsense."

This divergence from traditional party positions, particularly for those identifying as Democratic/Liberal, who typically do not oppose government intervention, suggests that CM might create new political fault lines defying traditional party stances. This was also evident among the several respondents who blurred

their own political self-identification, "I am towards a Democrat. A liberal. Actually, more like a Libertarian" and "I think Republicans are stupid. I'm like the complete opposite. A Liberal. Well actually libertarian may be closer to my thinking."

Prior Beliefs. Attendees expressed a range of beliefs about CM, such as benefits to society, "People have done research, published papers that show that it is more sustainable at scale". Others arrived with strong beliefs—right and wrong—about methods of creation:

"It's obviously grown and produced without hormones, without antibiotics in a humane way, using less water, using less land, using less energy. It offers so much promise..."

Some mistaken beliefs about the product created striking and sudden reversals from acceptance to rejection when the truth became known:

"I wish I'd known they use animal ingredients. If I had known I wouldn't have tried it. I wouldn't have eaten it. I would have spent my time advocating that the company change their process. We feel duped. I couldn't give informed consent to try the food. What if this was made using factory farmed animal inputs? Is it GMO? If they would mislead us about this, what else are they misleading us about? Doing things the right way is so important, transparency is everything. Going forward I will only support EAT JUST."

Attendees, including non-veg*ns, came with strong negative impressions of animal-sourced meat as well, "there was even rope in corned beef back in the day...regular chicken meat has become very different from what it was. If we're gonna compare chicken with lab chicken, I would say maybe the lab chicken is even healthier."

In many cases, prior knowledge, accurate or otherwise, described moral superiority beliefs for CM compared to ASFs, and in some cases a belief in superiority or equivalence to PBFs. Respondents indicated that CM was a better alternative to ASFs for animal welfare and food processing, "do you know what they put in sausages? You know what they put in, in the chicken nuggets? You know, the nails go there and the beaks and the whole thing" or otherwise favored CM compared to PBFs:

"I don't support plant-based meat substitutes. I think if you wanna eat plants and vegetables, I'd rather have like a real vegetable, the real plant or plant-based foods done with vegetables. What goes into plant-based meat substitutes, it's more processed more chemicals, you don't know what you're eating...but this is real meat. It's just that instead of being grown in an animal, it's grown in a vessel, but chemically and genetically, it's real meat."

Ethics. Ethical considerations like animal welfare were significant for many, "I support anything that would reduce the need to slaughter animals" and, "Well, you know, they are still using animal cells, but the amount of animal suffering is diminished to next to very little, you know...You have to take your wins where you can." Nearly all described a desire for this to alleviate environmental impacts, including concepts of food system resilience:

"We can't take the entire Western Hemisphere, North and South America, to raise cattle and other livestock...We can't wait 26 years and till we're desperate and facing a crisis and solve it then. I think it's probably a good idea to work on problems when you still have choices."

However, this was nearly always accompanied by a demand for greater proof and transparency:

"Right now, I believe that these are not GMOs, and that for environmental health, animal welfare, societal benefit, and naturalness that cultivated meat is better than chicken, but there is not enough definitive information about the health benefits, and I am looking for more objective information that scientifically demonstrates that."

Many attendees mentioned some knowledge of "reports", "studies", or "science" indicating safety, such as federal approval, and early evidence of reduced environmental impact. However, many expressed a keen awareness that these did not translate to healthfulness and expressed a great need for demonstrated downstream effects for personal and planetary health, "obviously long-term studies are needed". As a result, some respondents who arrived eager to embrace CM left skeptical due to this lack of disclosure.

Consumer Willingness. Attendees started out highly willing to try the food. According to most, it was the reason they came, "I'm trying it while I can". Some endorsed a willingness to pay more, "sometimes you have to pay for better quality" and, "I think if it raises the price of the meat by whatever sense, that's okay because then you have the validity that it went through a lab." While others characterized it as "for a

special occasion...not something I would eat everyday”, or that they would buy it “if it were as accessible and affordable as chicken in the marketplace.”

There was an observed divergent pattern in market segmentation between those who see CM as a superior/premium product and those who need more convincing of superiority/suitability through product innovation and disclosure. Perceived value[211, 212] seemed to be described among enthusiastic tasters who described CM as “fresh and high in quality” or able to create an abundance of high-quality food options that are normally rare or resource intensive, like “Wagyu”, or otherwise able to be “optimized” for specific nutritional or athletic goals like supporting better muscle hypertrophy than conventional meat. Others indicated waiting for price parity and ethical alignment such as removal of animal inputs, described above.

Most indicated that they would be willing to recommend CM to others, especially as a replacement for ASFs. These respondents often came across as cautious optimists, expressing conditional willingness to try again, pending substantive product re-formulation for sensory qualities, and largely believed this was possible. For these tasters, they may consider CM in the current form suitable for some, but not most, “It's a good vegan alternative for the vegans that are looking for that...Yeah, that's it, it's okay.”

Three respondents ultimately rejected the cultivated chicken. One rejected it due to poor sensorial experience:

“it looked more like a muscle, but the texture was just rubber. Not chicken, not a nugget, just rubber. A piece of rubber. I mean, for me complete failure. will not eat it again will not buy it.”

Two others began as conditional adopters (willing to consume on special occasions) ultimately rejected the product despite enjoying the taste when they learned about the use of bovine serum and expressed concern that the event had been marketed to vegans, but the use of animal-based serum was not disclosed.

Network. Six respondents indicated some prior exposure to the CM industry. These were primarily lawyers; another worked in PBF marketing; another had previously written about the passing of the Florida ban; and one was a former employee of an investment firm that was an early investor in CM. Many also indicated that personal and professional contacts had invited them to attend. Interestingly, many of the vegans at the event reported that the event was directly promoted within local, online, vegan groups (e.g. Miami Vegan Facebook group), suggesting that event promoters may consider vegans a key target for these products. Others indicated that they were fans of the celebrity chef or active in the Miami food scene, broadly.

Event and Company Evaluations. Overall, respondents viewed the event as effective in increasing acceptance and trust. Particularly that the event enabled a setting in which supporters could validate their beliefs and witness broader social acceptance:

"I really do think it's important that consumers have the opportunity to try this. I think if they did a lot of them who are squeamish about the idea of cultivated meat would probably change their mind."

Others described that being able to see the crowd communicated hope for the future viability of CM products and the industry, "I'm confident now after coming here and seeing all the support that it's a very valid way to do I eat meats in the future."

Many were impressed by the event ambiance, noting the high energy, diverse turnout, and curated presentation of food. Respondents described the engaging atmosphere, the “gorgeous space” and festive environment. However, for some this was seen as smoke-and-mirrors, “I’ve been eating Manchego Cheese and drinking Heineken beer, so nothing new.” Nonetheless, many commented that the event provided a space for social interaction and the normalization of CM, allowing attendees to “confirm that others also appreciate the brand and the food.”

Many described the company as an innovative leader in the field. Others expressed concern about the lack of information and felt that the company needed to do more to earn their trust. Some trust components overlap with concepts of perceived value and product quality and safety, including a desire for details about product provenance and pharmaceutical standards discussed above.

Emerging Themes

Five major themes emerged from interviews, summarized in Table 4 and described in more detail below. Themes emerged through consideration of multiple participant responses and often axially joined deductive codes. By comparing and integrating responses across different contexts, these themes and sub-themes contribute to a deeper understanding of participant perspectives and suggest possible theoretical determinants of a synthesized theory of influences on the consumer acceptance of CM.

Table 4. Emerging Themes

Americanness	Role of Government Freedom, freedom of choice, consumer freedom American identity
Social Awareness	Beliefs about what others think Beliefs about what others will or won't do Social dynamics in taste experiences
Need for Education or Development	Fear or distrust of science, food industry, or government Need for further information (e.g. evidence on health, sustainability, inputs) Need for further product innovation to address consumer needs

Time Urgency	Time pressure to try (last or only chance) Long waiting period at the event
Verisimilitude	Interrogating proximity and distinction from “the real” How real is real for cultivated meat, enough to be 'normal' or 'regular' Vegans and vegetarians (veg*ns) processing eating “real” meat

1. **Americanness:** Respondents referenced their perceived conflict between American identity and government intervention in the context of the CM ban. Respondents endorsed valuing freedom, "I'm against any ban that bans people from trying to work or make their business, especially when it comes to good food." Respondents also had high support for business innovation, and market-driven progress, and concerns about corruption, government overreach, and protectionism of some interests over others:

"I think it's an affront to the notion that our country has a common economic market and that states can't enact bans on out of state products just to protect in-state agricultural interests. I think it's an affront to the notion of supremacy of federal law over state laws that conflict with it. And I think it's just an outrageous interference with individual liberty."

Respondent reactions to the ban were rooted in broader beliefs about what it means to be American, and the integrity of the free market system, "Small businesses, family groups...deserves any chance to let their business prosper in any state, especially in America" and "this is free country [sic] and [the ban] is just weird to me". The ban was thus interpreted not just as a policy issue but as a symbolic battleground for competing visions of America's future.

The freedom to start a business and have a fair shot on the marketplace was joined by concepts of consumer freedom of choice and specific ideas about the role of government, "The ban pisses me off.

Companies, especially small companies working for good, should have the ability to freely market their foods". Nearly all expressed the belief that policies should not restrict consumer choice without strong scientific justification, and to do otherwise was 'not American':

"Bans should be because of more direct harms...if it's something that's dangerous to your health...like if it's something that's going to harm you, then yeah, there should be a ban, or law against it or whatever. But I haven't seen any reason for that for this."

The ban was frequently characterized as government overreach, "There's no science behind the reason for a ban. It's nonsense...This is an authoritarian government telling people what they can put in their bodies and feed their families". Respondents did however maintain that consumer freedoms need to be in place so consumers can decide in both directions, "There're a lot of people that don't want to try it, but that doesn't mean that it should be banned".

This theme goes beyond political positions on support for novel foods or how they should be approved and begins to suggest that actions like the Florida ban add to a growing distrust in government intervention and how patchwork legislation undermines trust in government at multiple levels.[175-177, 213] These participants distinguished regulatory oversight, which they support, from outright bans, which they oppose. Their desired regulation is framed around consumer protection, rather than stifling innovation and relates to a pervasive concern about the political motives for the ban having commercial interests, rather than public safety, in mind. Respondents reported wanting reliable government oversight so they can trust in the safety of foods—for them, this was often conveyed with descriptions of robust

long-term health and environmental surveillance above and beyond that which is currently required for foods on the market:

"Cultivated meats should definitely have the same kinds of testing that pharmaceuticals have, because it's very related in a way, all lab produced. If not pharmaceutical, then something more regulated by the FDA".

2. **Social Awareness:** The social dynamics of the tasting event and the broader cultural acceptance of CM were noted by nearly all interviewed. Respondents often detailed beliefs about what others might think or do when encountering CM. This suggests that the success of CM will depend not only on sensory qualities, and government oversight, but also by how it is situated and diffused within social and cultural contexts. The event enabled many to see the wider appeal of CM, but also elicited statements that others "would never switch" away from eating conventional meat, or that they know "a lot of people don't want to try it." However, some indicated a belief that if people were given the right information, such as "learning the truth about factory farms, they would run away from those foods and would welcome [CM] with open arms". Others mused that the public needs more chances to encounter CM before the media makes their mind up for them, referencing "events like this" that enable the public to try it as key, because "all that trepidation, all that fear goes away when you realize that it tastes great" and "I think it's important that consumers have the opportunity to try this. I think if they did a lot of them who are squeamish about the idea of cultivated meat would probably change their mind".

A common assumption among respondents was that there is a lack of public awareness of CM, "I'm really happy to see they're hosting events like this to get it out into the public so people can know what it is and make more informed decisions about it." This was evident in the previously described

expectation that the event would be small or not well-attended but was joined by comments like, "I don't know what the public perception of this stuff is compared to plant-based food" and, "I didn't even know that this kind of food existed. Genetically made food."

Responses suggested that mainstreaming through social modeling may be particularly influential at this stage in the development of these novel foods. Attendees could be seen scanning the room to assess reactions of other attendees, eagerly sharing their feedback with one another, and conferring with other attendees. Dyads in particular were common at the event (e.g. couples and adult parent-child groups) and these units displayed unique social processing. Out of four dyads interviewed, the most negative feedback about CM came from 3 dyads, one couple and two parent-child pairs, with the remaining couple dyad being more neutral. Among dyads, opinions tended to merge, with more subtle than overt differences in opinion, which were often partially or entirely incorporating views of the partner who spoke first, "My mom was saying that it felt a little bit like a fish fillet. Like when you bite fish and when it comes apart like that. You can actually feel the little pieces like coming apart. Except this didn't come apart, " and "that goes to my Dad's point about it being rubbery...I kind of hate to agree with him, but it was a little bit rubbery, that skin".

Aside from the co-constructed social interpretations of dyads, there were other kinds of social dynamics visible, including those attempting to imagine the self-efficacy needed to adopt these foods by watching and asking the chef questions about cooking the CM, "I was watching the chef and making sure it cooked the same way. She said that it cooks pretty much the same" and "It looked good, watching it cook was really interesting."

3. **Need for Education and Development.** Across multiple interviews, participants expressed a belief that the public needed to be better informed, “there's still a lot of misinformation and miseducation about what cultivated meat is,” a parallel to their own desire for more information about how CM is made, “I wish they had shown a lot of research and science behind it” and “I don't know what are their process [sic] to actually cultivate this meat, but I imagine it's way less than regular meat.”

Attendees noted the absence of information at the event, and this exacerbated a level of uncertainty in the ability to trust CM:

“Trust is important, and very delicate and they only have 1 shot to do it the right way and that means they need to do it the best that they can...like show me that you have nothing to hide.”

Enthusiasm and disappointment for taste and texture were central to many evaluations, but even among enthusiastic responses, nearly all said the product required improvement. This included understanding that “the technology needs support in order to advance” with many calls to remove remaining animal inputs, or otherwise for personal and environmental reasons:

“I wouldn't personally use them if they use FBS [animal-based growth media] or gelatin. I'd still want them to keep going and move forward because it still decreases animal suffering. The more money they get...the more development, the less you have to rely on these kind of animal derived components. So, it's really only a matter of time and money before you eliminate them completely...a few companies don't use them at all. They have found ways around it.”

As described above, the lack of structure that would present whole cuts rather than composite foods (i.e. breast versus nugget) or other textural anomalies were often discussed as a component where additional innovation was needed. While some considered this within a hopeful framing, such as eventually being able to offer Wagyu, others also discussed overrepresentation of some types of products like burgers or white chicken meat:

"When you eat chicken you have different parts of the chicken, like white meats or dark meats, like thighs and everything. I think down the road, they'll be able to develop specific types of cuts, some that resemble breast, like the one we had today and maybe someday resemble a thigh or other."

Responses indicated interest and optimism, but may also suggest that some consumer needs aren't being met with current offerings, underscoring the importance of routine public engagement to achieve acceptance of CM.[214-216]

4. **Time Urgency.** Echoing the promotional messaging, many indicated a sense of urgency to come to the event and try the food, saying that this was "their last chance" or that they had "waited a long time" to try it. This might suggest that some attendees may not have otherwise made the effort to come if not for the urgency of the impending ban, even though they otherwise endorsed a desire to try. The event itself also provoked urgency by building anticipation waiting to serve the CM late into the event. This anticipation resulted in frustration, excitement, and filling up on other foods which all might impact reported acceptance, including possibly reducing positive sensory evaluations.[217, 218]

5. **Verisimilitude.** Verisimilitude refers to whether something has the appearance of being real or true; at this tasting event, a common occurrence was to evaluate whether or not they were eating 'real' meat, a close imitation, or some new thing that while reminiscent of meat, was itself novel without an original.[219, 220] Participants didn't just come to try CM, they came with expectations that CM chicken would be identical to conventional, with messages from the press that it could "help meet the world's growing demand for meat"[210]; from the CEO's speech at the event, "that is the most *chicken* chicken [sic] I have ever tasted," that "tasting is believing,"; and the chef herself saying that "it sizzles and it cooks like chicken, and it tastes like chicken because it is chicken...which is the most exciting part to me as a chef" before handing out samples. Attendees were well-primed to evaluate not just the social atmosphere and personal enjoyment of eating CM, but specifically for verisimilitude. For some, the product met the desired level of realness—indistinguishability—for others it had the opposite effect. This internal verisimilitude evaluation was evident in language structures used to convey comparisons between CM and conventional chicken, which were both referred to by many names all of which were indicators of difference and distinction for CM and realness or authenticity compared to conventional chicken (see additional presentation of semantic thematic analysis below, and in Table 7). Statements that, "this was just like real chicken" and "it actually looks, smells, and tastes kind of like real meat" show milder distance in evaluation, but these were often joined by specific critiques when sensorial differences in texture or appearance observed, "The texture was more like plant-based". Many put forth their criteria for determining 'realness', such as grain and muscle fiber or appearance, "It looks different uncooked. But once it is cooked it looks the same", and function, "When cooking saucy dishes, like Chicken Marsala, I bet this would absorb the sauces and flavors better."

Verisimilitude considerations for CM tended to head in a metaphysical direction, especially among veg*ns who grappled with the internal significance of consuming “real meat” again, “I realized on my way here that I was on the way to actually eat real meat. I haven’t eaten meat in over 10 years. It was a strange realization”. These respondents often displayed active emotional processing alongside intellectual processing, “It’s been a little over 5 years since I last had a chicken. It was interesting, a little kind of overwhelming, in a sense, you know, mainly because of the texture. But it tastes good” and, similarly, “It was too real; it was very real chicken. I think I am happier with the Daring chicken [a soy-based chicken alternative] I regularly eat.”

Overall, in many ways priming attendees for verisimilitude evaluations may have resulted in more critical appraisals, even among consumers who otherwise enjoyed eating CM.

The CEO’s Speech at the Event

Approximately 1.5 hours into the event, the CEO, Dr. Uma Valeti, gave a speech. The speech emphasized key themes that were similar but more detailed than messages in the promotion and media before the event. The speech highlighted that CM offers people a way to preserve food traditions and freedom, letting the world still be able to eat “the foods we love,” and protects the development of a robust food system able to reliably feed the world, now optimized for ethical and societal benefit:

“We are here to talk about how this...is really good for Floridians, Americans, and also for the global stage. We cannot take what comes to the table for granted, we also cannot take the geopolitical crises that have threatened our food supply, the climate crises that are threatening our food supply as well as the multiple public health challenges including pandemics or COVID that are threatening our food supply as well as the supply chain disruptions that happen globally anytime there

is an event. Therefore, diversification of how we bring food to the table, the foods we love, is just table stakes and having options on the table is what being an American is all about—being a citizen, we want to be able to preserve the freedom of food.”

The ability for innovation to enable consumers to continue to eat foods of preference with newly improved ethical profiles found strong support among attendees, garnering strong applause. Safeguarding innovation and scientific progress were central to the speech, which positioned CM as an obvious and preferred alternative to factory farming, and the associated negative externalities including antibiotic resistance and climate change, but not as a replacement of animal agriculture, but rather as a complement to it. This was referred to by Dr. Valeti as his “Big Tent” vision for CM, a sentiment that was well-received by attendees and even directly referenced in some interviews, “I feel like the public perception is that this is gonna come out and people are just gonna switch to it and leave the animal agriculture behind...but that's kind of ridiculous”. This set up key points of collaboration and economic opportunity, with the CEO describing that UPSIDE Foods works with local farmers to create a just farm transition,[221] “we are proud to work alongside farmers in Florida and bring in a new generation of farmers here, and bring in economic opportunities.” The speech also included a strong social acceptance message, with the CEO describing how much people have loved the food in past tastings repeating the phrase “tasting is believing” multiple times and included a specific description of what he termed, “the chicken nod”, a smile-and-nod gesture with a full mouth that, according to Dr. Valeti, demonstrates that people both hedonically appreciate the food and experience it as being, in fact, real chicken. Dr. Valeti encouraged the crowd to look for, and perhaps to show off, their chicken nod.

Media Analysis and Triangulation

Comparing the CEO's Speech to Respondent Themes

Many interviews included elements that closely resembled the speech. The desire for better alternatives to ASFs and a strong commitment to the advancement of scientific innovation were highly similar. The emphasis on cultural preservation and the freedom to choose what foods to consume (like the above emerging theme of Americanness) resonated deeply with many attendees, whether self-identifying as Democrat, Republican, Libertarian, Independent, multiple, or other. Interviews also echoed the CEO's call for resistance to restrictive regulation, framing CM as both a breakthrough and a solution to global challenges:

“I really liked the CEO speech that he just gave, and he brought up a lot of good points that just having diversity especially when catastrophes can actually affect animal agriculture, right? We should have another way. It's to actually feed people. and even things like that just makes so much sense. There's no reason to really ban this stuff.”

Post-Event Media and Communications Analysis

Additional data from the media, attendees, and the company corroborated observations by researchers on-site, and expressed similar types and range of opinions to those in respondent interviews.

Post-Event Media Reporting

The media largely conveyed support for UPSIDE Foods and the concept of CM, portraying the Miami event as a showcase of innovation and food freedom that would be stifled by Florida's ban. Articles quoted company executives, attendees, and culinary experts praising the taste and potential benefits, emphasizing consumer choice, sustainability, and technological progress. The coverage was generally

critical of Governor DeSantis' decision to ban CM, with several outlets highlighting the contradiction between this and Florida's historic emphasis on personal liberty. The media also portrayed the ban as favoring "Big Ag", hindering progress, closely aligning with Upside Foods' perspective.[222]

The *Florida Phoenix* introduced DeSantis' position on the ban as protecting consumers from unproven technology, "take your fake, lab-grown meat elsewhere," and the CM industry position, including UPSIDE Foods and GOOD Meat, Inc., that the law violates business and consumer rights and that CM is seeking to reduce food industry environmental impacts in good faith. The event itself, was portrayed as a patriotic and defiant act, promoting the position that, "people should have the right to choose what they eat" and downplaying the Florida governor's assertion that CM is a threat to traditional agriculture, and Florida farmers in particular.[222]

Across various outlets, including *Food Processing*[223] and *Green Queen*,[224] the portrayal of the event emphasized the novelty and significance of the tasting event itself, and that respondents indicated surprise at how similar the cultivated chicken was to conventional. Chef Mika Leon's preparation of the CM tostadas was repeatedly praised, allowing the event to be depicted as both a culinary and political gathering. The coverage underscored the broader implications, such as the ability for the ban to harm Florida's burgeoning tech ecosystem, described as "short-sighted and damaging," in the *Tech Times*,[225] which also pointed out that CM indicates not only progress of scientific discovery but also offers solutions for pressing contemporary issues like the ethical, health, and environmental concerns of conventional animal agriculture. There was careful attention paid to other pending state-level bans, like the ban in Alabama that would take effect October 1, 2024, and earlier bans in countries like Italy. Overall, bans were portrayed by the media as a lost economic and scientific opportunity.

Public Reporting of Interviews

N	17
Age, years (mean, SD)	37.4 (13)
Sex (%F)	29%
Race/Ethnicity	
Black	2
White	9
Hispanic	6
Other/Mixed Race	1

Table 5. Attendee Characteristics and Reactions to Tasting in the Press and Social Media

Interviews in the press (Table 5) painted a picture of curiosity, surprise, and approval of CM offered by UPSIDE Foods. Many guests, like a male attendee quoted in *Your Basin* were impressed by the product's similarity to conventional chicken, remarking, "if you tell me it's cultivated chicken or real chicken, I wouldn't tell the difference." [226] The novelty of tasting CM in an environment where it was about to be banned was meaningful to respondents, with many expressing disappointment that it wouldn't be accessible to them after the event. Several interviewed also expressed frustration, questioning why Florida, a state previously known to rail against government intervention, would restrict access to a federally approved commercial product. One attendee's statement, "I think we should be allowed to eat what we choose to eat," captured the opinion of many that the law was at odds with values. These interviews underscored the disconnect between the state's legislative actions and the desires of many residents who were eager to explore and embrace new food technologies. However, much like the researcher interviews, those interviewed in the press reported mixed sensory appraisal. For example, a female guest interview published in *Your Basin* [226] said that "the texture was a bit different," but that the flavor exceeded her expectations. Additional quotes reported in media interviews and in attendee's social media posts can be seen in Table 6.

Table 6. Quotes and Codes from Publicly Published Interviews

CODES	SUB-CODES	QUOTES
Sensory Evaluations	Overall Smell	"That's f***ing fantastic! That's good meat. I like it."
		"It was really good! And I was so surprised!"
		"Smells like regular chicken" -CI1, "I know, right?!"
	Texture Appearance	"It gets stuck in your teeth in just the right way"
		"I would say the texture itself is, like, a little bit different, but the taste was really, really good. Like, way better than I was expecting."
		"It's like eating chicken breast, of course it is cooked nicely with spices."

	Verisimilitude	"It you tell me its cultivated chicken or real chicken I would not tell the difference." "There's no difference, I mean, there's no way you would ever know." "It tastes just like chicken." "It's really good."
Willingness To Try		"Never tried it before, I'm like super curious" "I've been waiting to try it for like two and half years now."
Political Views		"I think we should be allowed to eat what we want to eat. Florida is all about free market and liberties personal choice, so why can't we eat what we want to eat? I mean if it's bad for us, not that I believe it is because I think the science is proven, but even if it is why can't we eat it?"
Prior Beliefs	Nomenclature	"Fake meat. It's not fake though. It's real meat, it's just cultivated"
	Ethics	"I imagine cultivated meat could be a more ethical alternative."
	Taste	"I already believe it tastes like chicken but I just want to see for myself."
	Health	"I mean if it's bad for us, not that I believe it is because I think the science is proven, but even if it is why can't we eat it?"
Non-verbal		Licking Lips/Fingers Moves food around mouth, inspecting Happy Dance The Chicken Nod Head and Hand Gestures Emphasizing Acceptance Posing for the camera, smiling, enjoyment

Attendee Social Media Posts After the Event

After the event, some attendees shared their experiences on social media. One attendee posted videos of Chef Mika cooking, with the chef describing the chicken's 'realness', noting it "tastes like chicken because it is chicken." Another video captured an attendee's reaction while tasting the chicken for the first time, showcasing a positive response with the individual calling it "f***ing fantastic" (Table 6), remarking on the realistic taste and texture. Images demonstrated that the event drew a diverse crowd, including people eagerly lining up in front, and later waiting to receive their samples. Comments accompanying these posts often criticized the political opposition to CM as 'restrictive' and 'uninformed'. Some content also portrayed tension about the protest van parked in front of the event with the LED billboard bearing statements questioning the safety and transparency of "lab-grown meat". Another attendee posted a photo of Governor DeSantis meeting with representatives of the cattle ranchers in a meat packing plant implying that those pictured were the private interests being supporting by the ban, further criticizing the action as misplaced support due to concerns about the health and environmental harms of animal agriculture. These posts demonstrate that the event not only showcased the product but

also became a focal point for discussions on food innovation, consumer choice, and greater social and political implications of food production.

Semantic Thematic Analysis of Interview Responses

Across multiple sources, attendees used different language to describe their CM tasting experience (Table 7). Interestingly, physical sensory words related to texture such as “rubbery”, “greasy”, “tender”, “dry”, “juicy” or that described CM as “minced” were the most common and had the greatest range. By contrast, words about cooking (“charred”), or aroma and flavor (“meaty” or “umami”) were much less common, suggesting that texture was more salient for consumers trying CM at this event. Participants also had a tendency to consider CM in contrast to “real” or “regular” meat, indicating that even among consumers largely favorably disposed to CM, it may not yet be internally accepted as real meat. This is further demonstrated by the large number of respondents who referred to CM directly as “lab-grown” or “fake” versus the USDA approved terminology of “cultured” or “cultivated”, or with common terms like “alternative” or the researcher introduced hypothetical identifier of “cegan” (a portmanteau of cultivated/cultured and vegan, vegetarian, and/or flexitarian). However, not a single respondent indicated any positive support for bans against these foods. Terms describing the ban ranged from “nonsense” to “crazy”, and occasionally “authoritarian”.

Table 7. Terminology used by attendees interviewed by researchers and the media.

		Interviewed	Secondary Data
-	<u>Term</u>	<u>n(%)</u>	<u>n(%)</u>
Nomenclature for CM	Cultivated or Cultured	4(21)	2(18%)
	Lab-Grown	6(32)	0
	Alternative	1(5)	0
	Not vegan but “cegan”	3(16)	n/a
	Fake meat		1(9%)
Nomenclature for Conventional Meat	Real	6(32)	2(18%)
	Normal	1(5)	1(9%)
	Conventional	1(5)	0

Describing the Ban	Simply	3(16)	3(27%)
	Regular	4(21)	1(9%)
	Natural	1(5)	0
	Nonsense/Stupid/ Silly/Ridiculous	6(32)	
	Culture Wars	2(11)	
	Authoritarian	2(11)	
Sensory Words	Terrible/Crazy/Sad	5(26)	
	Charred	1(5)	
	Juicy	2(11)	
	Rough	1(5)	
	Rubbery	4(21)	
	Greasy	1(5)	
	Meaty	1(5)	
	Tender	1(5)	
	Aromatic	4(21)	
	Dry	2(11)	
	Umami	1(5)	
	Grain/Fiber	2(11)	
	Minced/Little Pieces	3(16)	
	Gets stuck in the teeth		1(9%)
Self-Describes Adventurous Eater	as	9(47%)	2(18%)

Company Posts After the Event

The company also used social media to document the event, emphasizing the novelty and significance of CM and the first ever, free-to-the public tasting. Videos and images showcased moments like the bustling crowd eagerly awaiting samples, and attendees expressing anticipation and satisfaction. For example, a young woman interviewed said, "I've been waiting to try it for like two and a half years now" and another enthusiastically declared "it tastes just like chicken!" Videos and images of attendees, Chef Mika Leon preparing dishes, close-ups of the sizzling CM, and the tostadas portrayed a lively scene and sensory appeal.

The event continued to be framed within the context of food freedom and the impending Florida ban. The company portrayed the event as a tasting and a stand against government infringement on rights. Dr. Valeti also posted a selfie in front of the protest van, including replies to the statements on the LED billboard clarifying that the CM chicken was 99% chicken cells – not laden with unknown chemicals as the

sign implied – and highlighting some benefits of CM (Appendix 1 - Supplemental Figure 7). Altogether, the UPSIDE Foods portrayal of the event extended the narrative that CM, and UPSIDE Foods in particular, are agents of societal benefit caught in the crossfire of the ongoing American culture wars.

Emerging Theory

Towards a Theory of Cultivated Meat Acceptance

From this analysis, a theory emerged that consumer acceptance of CM is heavily influenced by the interplay between realness, sensory attributes, and the sociopolitical context in which the product is made and experienced. Positive experiences are driven by alignment with conventional meat in taste and especially texture, while negative experiences often stem from unmet expectations for texture or quality, and cognitive dissonance experienced by those with ambivalent or conflicting views on ASFs and how CM is produced. Moreover, the preparation and presentation of the samples were often reported to obscure what tasters believe to be the food's true qualities, affecting consumer confidence in a willingness to endorse future trial or adoption. As CM continues to develop, addressing these will be critical to move CM from novel curiosity to mainstream acceptance.

Three theoretical pathways were observed that may help inform a theory of CM acceptance.

1. **Consumer Freedom Theory:** Support for CM during this period of political conflict was heavily influenced by the degree to which consumers believe that access to CM represents personal freedom and choice infringed upon by needless government intervention. While this may not promote consumer choice directly, without this, consumers may not be able to have further trialability – a loss of freedom all respondents seemed to reject.
2. **Ethical Consumption Theory:** Consumer willingness to try and to endorse willingness to later adopt, was heavily influenced by the alignment of CM with ethical values, particularly

environmental sustainability and animal welfare, which were of high importance to would-be early adopters of CM. While these components are classically not enough to drive large volumes of consumer behavior alone, the promise of CM centers around delivering superiority in these domains. As the industry works towards price and sensory parity, a failure to align with these values and to objectively demonstrate superiority could result in rejection.

3. **Innovation and Feedback Theory:** Enlisting early adopters and allowing them to socially congregate, such as in this public tasting event, was important for strengthening support for CM among attendees. These social opportunities can help identify product development targets that address unmet consumer demands and sensory improvement, and can also serve as a means of tapping into social networks, providing critical insights into social sources of acceptance inhibition and possible avenues for the dissemination of acceptance that is necessary to drive broader cultural acceptance and adoption.

Discussion

We gathered information from multiple sources to inform a multicomponent ethnographic and sensory evaluation of the first ever, free, public tasting of cultivated meat (CM) in the United States. The UPSIDE Foods “Freedom of Food Pop-Up” held in Miami, Florida on June 27, 2024, created a positive experience for many in an attempt to foster goodwill and excitement about the future of CM. However, we found that despite the supportive environment, the event was less effective at addressing concerns of more skeptical attendees, and that even committed attendees expressed that sensory qualities and premium attributes of the food fell below expectations and preferences. While tasting encounters are beneficial, attendees were clear in expressing a need for greater transparency and proof of the ethical, nutritional, and environmental impacts of the product. Our findings also highlight how event messaging and media coverage influenced attendees’ perceptions of CM’s environmental and ethical claims,

regardless of accuracy. While this research did not provide attendees with information or recruit attendees into a designed experiment, participants were exposed to information from multiple real-world sources and frequently and spontaneously echoed both company and media narratives on topics like sustainability, demonstrating how this messaging shapes consumer understanding even in the absence of independently verified data.[161, 227] They also seemed cognizant that elaborate food presentations composed by celebrity chefs may not be enough of a direct trial experience to be convincing. While many recognized the potential benefits of CM, respondents indicated that hope and potential only go so far and they are looking for greater and specific proof of benefit to corroborate claims made by companies. Importantly, even respondents with a high degree of prior exposure to CM used inaccurate information to describe it, including beliefs that CM doesn't involve the addition of hormones or animal inputs. While some attendees arrived with little or no prior knowledge of CM, others had previous exposure to cultivated meat through public discourse or distant professional engagement, and those with prior knowledge of CM tended to display less skepticism and more enthusiasm. Nonetheless, one of the most remarkable findings in this study was support for CM and more generally, food innovation, among diverse attendees, and that Democrats, Libertarians, and Republicans all seemed united against government interference in small business innovations working towards societal betterment. More direct encounter experiences with greater emphasis on education are clearly needed to bridge gaps in understanding and acceptance of CM, and to address misconceptions. Our approach aligns with Social Representation Theory (SRT), which posits that new concepts are anchored within existing cultural, political, and ideological frames.[228, 229] Rather than viewing CM as a neutral technological innovation, attendees framed it through consumer freedom, food authenticity, and ethical consumption, reflecting how novel food technologies are shaped by broader societal narratives rather than assessed in isolation. In the public event setting, our findings capture real-world consumer reflexivity, offering an independent perspective distinct from industry-led, incentivized studies. Our findings aligned with prior research and systematic

reviews that showed that perceived naturalness, safety concerns, and political identity shape consumer responses to CM food technology and that consumer attitudes are shaped by media narratives, cultural traditions, social contextualizing and experiential.[151-153, 230, 231] Results from this study contributes to ongoing conversations about cultivated meat perceptions across sociopolitical, sensory, and cultural domains and many of the lingering questions and priorities among motivated early adopters.

Since the introduction of canning in the early 19th century through to the advent of GMO foods in the late 20th century, food technology and processing has been met with a mix of skepticism, avoidance, and fear.[144, 145, 166, 232, 233] Joining consumer resistance, farmers also resist replacing traditional farming with technological advancements, such as electric equipment in the industrial revolution, and more recently computerized systems and the scientific green revolution that modernize the way we produce food.[166, 234, 235] Often, traditionalist agricultural stakeholders oppose and perhaps fear new technology due to concerns that they may result in a loss of tradition and/or require costly new tools to stay competitive at the risk of losing their income, identity, and way of life.[236-240] The constant evolution of technology is a storied setting for political tension between farmers, innovators, and consumers, but these advances support necessary and significant increases in food security and sovereignty.[241-244] Thus, finding ways to support stakeholders through technological transitions is of urgent importance.

Like CM, GMOs were also referred to as “Frankenfoods”, and feared for imagined health impacts despite a lack of evidence or even evidence to the contrary.[171, 173, 174] Origins of the cultural rejection of GMOs was driven by pervasive misconceptions about health risks, corporate distrust, and perceptions of unnaturalness, despite extensive scientific evidence supporting their safety and utility. Prior ethnographies of new food innovations, such as those in the wine industry, also faced initial resistance

due to concerns of "authenticity" and "naturalness" and a loss of traditional winemaking[239]. As with the current clash of ideologies around CM, these demonstrate that public skepticism of food technology often faces initial resistance followed by increased acceptance with additional familiarity, which diffuses through social connects to achieve broader acceptance. This operates similarly to other observations of food technology informed by the Diffusion of Innovations Theory [245]. Our findings are congruent with this diffusion theory which posits that early adopters play a crucial role in influencing broader societal adoption of novel technologies. At this event, the more familiar brought their friends, family, and loved ones to become more familiar, and while not uniformly associated with positive reception, it was highly associated with a willingness to try the food. By participating in this tasting event and socially processing their experience, these attendees serve as opinion leaders who may facilitate further acceptance within their networks;" highlighting the importance firsthand tasting experiences to foster acceptance. Despite these experience opportunities, there remains a pervasive belief that familiar and/or natural foods are self-evidently healthful – a phenomenon often termed the naturalist fallacy.[81, 171, 173, 246] The fear of the unnatural is a very important consideration for both the consumer acceptance and political opposition to CM, as it was for GMOs and modern innovations for traditional products like wine. Frequently, commonly available foods bear a resemblance to a historic version of familiar foods, despite having considerable alterations and genetic manipulation beneath the surface—where they are less likely to be salient to a lay audience or reinforced with images in the media.[168, 174] However, as identified in attendee interviews, greater knowledge and disambiguation for mistaken beliefs of naturalness or an absence of technological and scientific intervention in other familiar foods, like animal-sourced meat, are often not discussed.[174]

We saw the influence of message priming on participants as they extended concepts similar to media messaging and the CEO's speech. Use of the term "lab-grown" among attendees is an important indicator

of this, as none of the company messages used this term, but it is frequently used in media messages, and is thought to aggravate the ontological tension between food naturalness and synthetic science. Studies indicate that food technology or processing has a tendency to invoke medical and scientific perceptual domains, and that when applied to foods may have the effect of provoking disgust, such as from a fear of contamination of the self or the planet.[153, 171, 173, 174, 246, 247] While most medical innovation from penicillin to medical devices are met with acceptance, foods that veer into this terrain defy categorization and may find themselves in what could be an “uncanny valley” for food.[248, 249] As with other manifestations of the uncanny valley, humans tend to reject things that are close to, but slightly off from expectations, but this can be manipulated by certain kinds of knowing and priming. For food, we may be particularly sensitive to any such alterations because food is such a common element in daily life, with sensory experiences and central beliefs formed at a young age with frequent encounter opportunities for farms, gardens, food selection, and preparation. By contrast, medicine requires deference to the authority of medical professionals, both to develop and administer. As modern food technology blurs ontological boundaries between food and medicine, we may need to develop new systems of communication that alleviate misunderstandings and avoid perpetuating aversions through incendiary media imagery of heuristic falsehoods, like petri-dishes full of beef.[168, 174, 250]

CM may occupy a liminal state between food and medicine in the cultural understanding; however, proximity to the lab in the cultural consciousness need not be problematic. Some respondents indicated positive sentiments around the degree of safety and assurance that a lab origin would offer, especially pharmaceutical-level safety standards – a concept that could prove beneficial if leaned into by industry. Based on our findings, the CM industry, researchers, and other advocates for alternative proteins should prioritize providing clear information about the benefits, drawbacks, and production methods. Optimistic or idyllic portrayals that seek to spare negative public reactions carry real risks of negative consumer responses when the truth is revealed—a dramatic reaction that we saw firsthand. Further, consumers

have become wary of language that presents the promises of new foods without proof, and practices like “greenwashing” and “health halos” are increasingly salient for consumers and negatively influence the adoption of genuinely beneficial products.[251-257]

Another pervasive finding was that tasters do not consider the product mature and are unlikely to adopt it in the current form. Future tastings may benefit from a different approach to expectation management. For example, priming attendees to believe that what they will be tasting is “real meat” may have solicited high levels of scrutiny, leading people to evaluate the product with a maximizing mindset. By contrast, framing the tasting as an improvement compared to extant options may solicit more positive evaluations consistent with the satisficing mindset, leading to greater optimism about the success of future developments.[258, 259] While the general public largely reports a desire to reduce ASF consumption, data demonstrate that consumers are largely unwilling to fully commit to eliminating conventional meat, largely owing to a lack of hedonic satisfaction.[260, 261] In agreement, ongoing innovation in texture and alignment with ethical priorities were dually integral to attendees at the event. In other words, consumers are not willing to sacrifice their food pleasure to address their ethical priorities. In order to adopt something new, consumers need more than to be told that “tasting is believing” they need to be *experientially* convinced of the product’s superiority in both domains. As with many new technologies, release before maturity alongside inflated expectations often leads to a damaging period stuck in what is termed “the trough of disillusionment” all while research and development continues. These releases may help meet investor milestones, but often make later adoption, or even repeated trial an uphill battle.[262, 263]

Overall, the event was seen as effective in increasing consumer support and acceptance of CM, with various components helping to shape and confirm consumer attitudes. To date, the vast majority of CM tasting events have been for insiders, stakeholders, or policymakers.[264] In the highly publicized and politically fraught climate surrounding CM, this approach misses an opportunity to get candid feedback

about product maturity, and approaches that could foster engagement, and build trust and acceptance among diverse consumer groups. This event allowed consumers to directly engage with the product, alleviating some skepticism through firsthand experience while allowing like-minded individuals to form relationships between each other and the company. Attendees had mixed sensory evaluations, strong preferences, different priorities (e.g. culinary vs. animal welfare), and most emphasized the need for more and varied tasting opportunities. However, unlike passive exposure from media messages, the event offered alternative possibilities for social processing and accountability, creating a situation where individuals are more likely to consider multiple viewpoints, synthesize and introject complex understandings,[199, 265] and socially process the significance of this disruptive, novel technology – an especially important opportunity as the scientific is increasingly embroiled in the political.[266] However, consumer-company relationships were in flux throughout the event, which suggests that greater reciprocal engagement between the company and attendees in future events may be important, and that more community engagement may be beneficial. Companies nimble enough to regard feedback as an indicator of consumer needs and incorporate it can foster more opportunities for the normalization of CM in order to co-create cultural value for CM. Meeting consumer needs and fostering collaborative stakeholder engagement may help safeguard advancement of the industry.

Engaging Interested Demographics

CM appeals to individuals for different reasons, and thus market segmentation with tailored messaging may be the best approach to communicate information about complex novel foods. Attendees at the event are a cross-section of would-be early-adopters, and thus their characteristics could help inform about consumer segments for outreach. Many attendees at the event had prior awareness of CM or a pre-established favorable disposition towards food innovation. We observed distinct groups, including those who expected high-value from premium products, like structured cuts of meat, compared to

existing alternative protein foods which tend to be minced. The large contingent of ethical consumers was the most insistent on objective evidence to prove that CM was aligned with their values, which clearly overlapped with a desire for this industry to be reviewed with more rigorous oversight—not just for safety, but also for downstream effects on human and planetary health. The next most enthusiastic group did display some price-sensitivity but could still be early adopters; however, as of this trial, they are not willing to pay more for this product. We did also witness a dramatic negative transformation among some staunchly positive supporters. Some respondents who were first in line to get into the event had a radical shift when learning information about how the product is made through word-of-mouth rather than directly from the company. Transparency regarding production methods and basing claims on validated evidence is thus an important reputational risk consideration for CM.

Individual identity, including dietary habits and ethical stances are known to shape consumer behavior, especially for food choice.[180, 267] Early adopters are an important component of innovation adoption especially given their role in the diffusion of innovations that allow slower potential-adopters to observe modeled positive exposure through trusted social networks before themselves adopting the new technology.[245, 262, 268] Greater awareness is thus a key priority because those with prior knowledge were the ones willing to exert the effort to seek out the trial experience, and they are most likely to widen the sphere of interest. Thus, providing more resources to potential early adopters can help them to enlist future supporters from amongst their networks.[268] Current and former veg*ns showed notable interest, likely due to the role that ethics already plays in their food choices and identity,[267, 269] but some indicated that CM may not be compatible with veg*n lifestyles. This resulted in a mixture of acceptance and endorsement for oneself or referral to others. Respondents also indicated that acceptance of CM is polarizing within veg*n circles; however, most endorsed the idea that avoiding calling CM “vegan” and instead using a term like the researcher-introduced “cegan” to describe CM or a diet that

limits conventional ASFs and instead includes CM might be preferred. These consumers also specifically wanted to see evidence of health benefits that compared CM to ASFs, and proved that they were free from antibiotics and other forms of bioaccumulation.[126, 270, 271] In addition to attendees with ethical diet identities, those with a background in politics, law, or food marketing were also highly represented, and often viewed CM as a symbol of progress, individuality, and a belief in personal freedom.

Identity and Politics

Freedom and consumer choice are key aspects of the American self-concept.[272] Government intervention that prevents such freedom comes to become characterized as potentially corrupt and motivated by commercial interests. Currently, American food regulations do not prevent “unhealthy” foods from being sold, and the prevalence and intake of notably unhealthy products is well documented.[273, 274] Until recently, Florida, and Governor DeSantis in particular, has had a long history of opposing government intervention in business[275] and specifically arguing against government intervention to promote dietary health.[276] Many participants were cognizant of this sudden policy shift in Florida, and specifically sensitive to a loss in the right to choose what they eat, whether healthy or not, “I mean if it’s bad for us, not that I believe it is because I think the science is proven, but even if it is why can’t we eat it?”[226] Nonetheless, there is a rising trend to moralize healthy eating and to utilize paternalistic, state-level intervention to police consumer choices,[277-280] but these policies are rarely accompanied by evidence or substantive support for research that would be able to determine such hazards. As such, hopeful claims from industry and protectionist claims from political detractors volley across a court of public opinion. Meanwhile, attendees expressed a strong desire for a pluralistic approach that allowed for benevolent paternalism, but only if there was indeed evidence of harm with a strong scientific basis.

Attendees expressed a clear desire for greater regulatory standards and oversight for these foods, above and beyond other marketed food products. This opinion was in service of both their own preferences, and was framed as a way that they might be able to enlist others into accepting CM. Based on the recently modernized FDA Human Foods Program,[281] this opinion seems to be consistent between attendees and the federal government. One might imagine that these novel foods could serve as a testing ground and a food industry role model for new high standard in health and nutrition—especially as many hope to see the creation of a more healthful food system.[281, 282, 283]

Interestingly, many respondents simultaneously self-identified as Democrat, Liberal, and Libertarian. Self-identified Democrats, Liberals, Libertarians, and Republicans aligned on the belief that these technologies and foods should be allowed to progress and that government interference was overreach. This non-partisan opposition to CM bans is an unusual convergence. Libertarians typically prioritize freedom from government control, and it is usually Republicans that agree with this stance, advocating for small government and free markets.[213, 284, 285] By contrast, Democrats and Liberals often support government intervention to protect the common good, traditionally focusing on civil rights and social justice. CM thus brings these perspectives together – the ban violates engrained values of freedom for Libertarians, free markets for Republicans, and signifies moving away from progress for societal benefit for Democrats and Liberals. In 2024 American politics, alignment between these political factions is rare, and may be symptomatic of the growing skepticism in government benevolence, and the tendency to see selective intervention as an abuse of power rather than consumer protection.[213, 286] These unforeseen political alliances are just one example of how support for this novel food technology may cut across party lines in unexpected ways.[286, 287] CM could thus operate as a tangible symbol to foster a fluid political identity on the common ground of core values like a commitment to individual freedom in an increasingly issue-driven modern political landscape.

Balanced Approaches Support the Promotion of Cultivated Meat

CM is situated within a broader historical context of food technology. The political conflict and resistance to CM parallels the skepticism that greeted GMOs. Like GMOs, CM faces opposition grounded in perceptions of "unnaturalness," fears often magnified by media messaging and cultural anxieties about food safety. This aversion may be particularly potent for CM because food, unlike medicine, is an everyday sensory experience, tied to personal and cultural identity. To overcome these barriers, CM companies must prioritize transparent communication that dispels misconceptions and educates consumers about the production process, while avoiding marketing strategies that could provoke a backlash when setting unrealistic expectations. A balanced approach that integrates clear, evidence-based information with engaging, positive experiences will be crucial for fostering trust and long-term consumer acceptance. However, because one's taste for food develops not as a purely physical or private process but rather as a complex social one "actively constructed through [a] synchronization of approaches" engaged in by agriculturalists, food manufacturers, cooks, individuals, households, cultures and more,[288] events have the ability to bring not only taste buds but many interpersonal dynamics to the table interactively. Creating and proposing solutions for pressing issues such as feeding the world sustainably is noble, however accomplishing acceptance means understanding how taste operates socially and conceptually, as much as hedonically.[166]

Limitations and Future Research

One of the great strengths of this paper is that it is the first analysis of a public food tasting of CM and the only study to examine consumer willingness to seek out CM within a state banning CM. While we interviewed a large portion of the attendees and triangulated to cover a sample nearly as large, our study is the first of what we hope will be many more public ethnographies and taster interview studies of cultivated meat. No general public tastings have been previously described in the literature, and while it

describes a small volunteer sample, the number of respondents included is typical of such qualitative field work and was triangulated and highly in accord with publicly available press interviews. Unlike some other Grounded Theory work, which samples on multiple occasions to achieve saturation, event ethnographies only analyze information relevant to a single event.[192] Another strength of our study was our ability to mobilize in a very short time to attend and conduct research at an event with less than two weeks' notice. This short time, however, did not allow for more complex pre-post analysis components or further approvals for researcher-initiated follow-up contact with respondents which limits our understanding of respondent post-event processed impressions. Our approach was also greatly enhanced by a tandem approach not only to coding but also to the field ethnography itself allowing for more in-depth interviewing and greater perspective of a dynamic event. Event ethnography is a promising way to gain deep insights into consumer perceptions, however this represents one time and place and voluntary participants and is not intended to indicate a comprehensive or generalizable perspective of consumer beliefs of CM. While attendees were all ages and appeared to be ethnically and racially diverse, there were more men present than women, and proportionately more veg*ns relative to the general U.S. or Miami populations. Additionally, while event ethnography offers genuine insights, self-selection shaped the participant pool. Most attended to try the product, and although some protest was observed, the sample primarily represents motivated early adopters rather than a more diverse cross-section of all current general public opinion on cultivated meat. Future studies of similar events or that include deliberate random sampling may be able to build from our findings to explore public opinion, including among those who may hold conflicting opinions about CM. We did not gather names or images of interviewed persons in order to preserve privacy, and as such we are unable to determine to what extent persons and/or their specific opinions expressed in media interviews overlap with researcher interviews.

Conclusion: Acceptance of Cultivated Meat

The public tasting of cultivated meat (CM) hosted by UPSIDE Foods on June 27, 2024, in Miami, Florida provided a valuable opportunity to evaluate consumer reactions, highlighting both positive reception and areas of concern. While many attendees were excited about the potential benefits of CM, the sensory experience and quality of the product did not always satisfy expectations. The event demonstrated that while such tastings can foster goodwill and excitement, they are insufficient to address deeper concerns, particularly among skeptical or ethically focused consumers. Transparency, particularly around the product's processes and ethical, nutritional, and environmental impacts, were a recurring theme among attendees, many of whom expressed the need for more direct proof of these claims. The event revealed that sensory evaluations alone are not enough to drive acceptance – consumers need both intellectual and physical alignment with their needs for CM for it to be perceived as a comparable or superior alternative to conventional animal-sourced meat.

This study highlights the importance of aligning CM with diverse ethical priorities, such as animal welfare, environmental sustainability, and health. Our analysis examines how consumer perspectives were constructed, reinforced, or challenged in a dynamic social setting, extending beyond sensory evaluation to encompass cultural, ethical, and political frames of reference that shape consumer willingness to engage with new food technologies. Consumer willingness to accept CM is influenced not only by its sensory appeal but also by how well it aligns with these ethical considerations. Attendees were clear that CM must prove itself as more than just an alternative protein; it must emerge as a superior product that addresses the complex values of its target market. Political ideologies also play a role, as respondents from across the political spectrum were united against government interference in food innovation. This non-partisan alignment suggests that CM could transcend traditional political divides, particularly in relation to personal freedom and market innovation. However, for CM to do this, it must prove itself a

benevolent social agent and a responsible steward by meeting high standards of transparency and ethical rigor demanded by consumers.

The ethnographic insights gathered in this study underscore the importance of public tasting events, but also reveal that single events are not enough to ensure widespread adoption. Ongoing innovation, transparency, and consumer engagement are necessary to build trust and demonstrate the tangible benefits of CM. Including consumers in the process of communication and product development may be the most effective way to foster acceptance and align CM with societal values. As the industry continues to evolve, its ability to balance optimism with realistic, evidence-based messaging will be key to overcoming skepticism and achieving broader market success. Success for CM, or any ASF alternative food will require ongoing education, transparency, and product improvement to achieve broader acceptance and adoption leading to market success and hopefully, a reduction in the human, animal, and environmental costs of producing our food.

Methods

We conducted a multicomponent field ethnographic study to understand the impact of a public CM tasting event and gauge perceptions and sensory evaluations among voluntary attendees. This work was approved by the Tufts Social Behavioral Educational Review Board (Tufts SBER IRB) in June 2024. Immersive fieldwork was conducted at the “Freedom of Food” pop-up event in Miami, Florida on June 27, 2024, an event organized by UPSIDE Foods which advertised a free CM tasting. Approximately 100 people attended. Members of our team also attended to observe interactions, behaviors, and reactions of consumers in a natural setting.

Media and public information shared by the company, attendees, and commenters about the event was gathered before and after. During the event, two researchers took structured ethnographic field notes

(Appendix 1 - Supplemental Table 1) on the overall scene,[289] in addition to conducting in-depth, semi-structured interviews with attendees. Information used to promote the event available to the public before the event was used to inform the semi-structured interview script (Appendix 1 - Supplemental Table 2) and information published before and after the event was also analyzed to triangulate facts about the event (e.g. location and time) and the political context in which the event occurred (e.g. opinions of local lawmakers versus the company).

Data Collection

Participants were recruited on a voluntary basis, without pre-enrollment or incentives. Data collection included semi-structured interviews with 19 attendees, supplemented by field observations and secondary data analysis (e.g., media narratives and social media discourse). Interview questions explored perceptions of CM's sensory qualities, ethical considerations, and political framing, allowing themes to emerge inductively.

Media and Company Communications Analysis

Publicly available material about the event, from before and through three weeks after the event, from mainstream media (e.g. Associated Press) and social media accounts of the food company (UPSIDE Foods) and the general public (including attendees), respectively, were gathered. Appendix 1 - Supplemental Figure 1 details the number and type of each source of information used in these analyses.

Pre-event media and company messaging promoting the event[150, 208, 209] and prior literature on tasting events and political tasting event ethnographies[166, 192, 200, 201] informed the semi-structured interview script (Appendix 1 - Supplemental Table 2) and corresponding deductive codes.[290] These sources also provided additional context on who and why attendees might have attended, how their opinions and beliefs may have been primed by the company, and what their reactions were when not responding to researchers.

Communication with the company before, during, and after the event included emails describing the organization of the event such as the planned number of food samples, as well as on-site conversations with key staff about attendance and stakeholders in attendance, or statements from the on-site speeches made by CEO Dr. Uma Valeti and the event's Chef Mika Leon. (Appendix 1 - Supplemental Figure 1)

Our presence as researchers and the framing of the event itself could influence participant responses. To mitigate this, we used a reflexive approach, systematically noting potential biases in interpretation and triangulating findings across multiple data sources. Direct quotes from attendees in publicly published sources were treated as secondary interview data, which were coded and reviewed by two researchers using the same verification and agreement approach as for primary interviews (described below). This approach allowed for a more comprehensive understanding of attendees, scene, and sensory evaluation of CM by cross-verifying data from multiple sources and allowed for both a Grounded Theory approach to inductive analysis and a process-based abductive analysis using all available data to affirm and enhance the emerging theories about the event and acceptance of the CM food.[291] Screenshots of publicly published materials were gathered and converted into text, so they could be coded and reviewed by two researchers to achieve consensus, similarly to interview transcripts. Results from each phase were summarized separately, and then compared to inform the overall emerging theory.

Ethnographic Field Notes

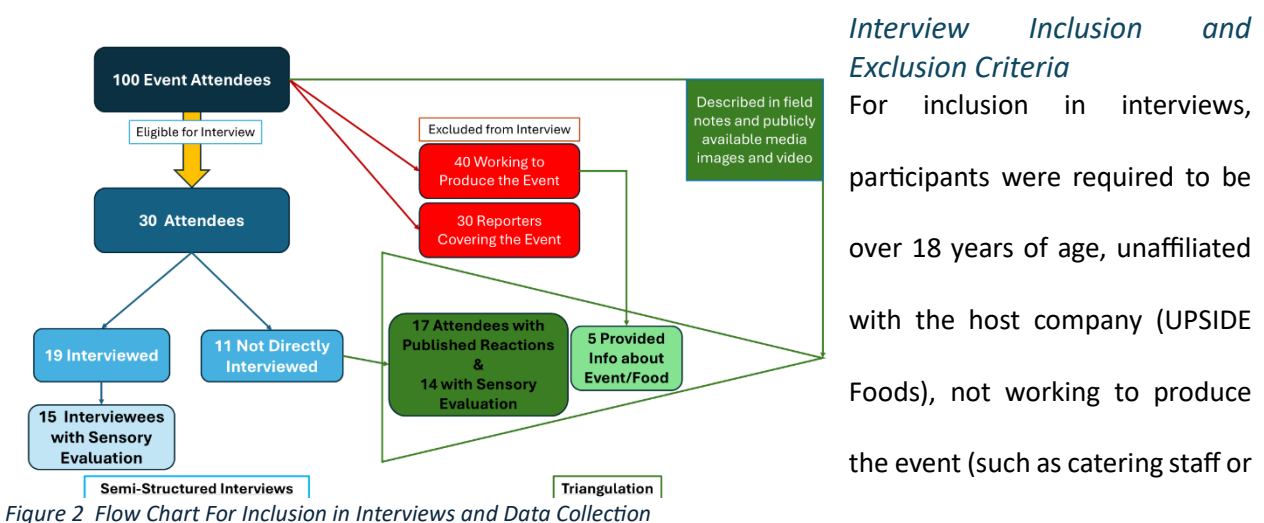
Structured ethnographic field notes and images of the food and scene were taken to document observations about event participant demographics based on appearance or conversational disclosure; visual observation of the food served; the crowd, and their level of enjoyment and participation in activities; sensory evaluations; conversations among attendees, and between attendees and staff; and the overall atmosphere.[289, 292, 293] To ensure a high degree of accuracy for field observations, notes were taken by two researchers who each reviewed the other's notes for agreement, and this was then

compared by a third researcher to assess agreement. No discrepancies between field notes were reported.

Semi-Structured Interviews

Nineteen participants were interviewed by researchers to gather in-depth insights into acceptance and sensorial evaluation of CM. Given the number of people in attendance, and the estimated number of attendees from the general public (n=30) our recruited interview sample represents an estimated 66% of public attendees. Participants affirmed consent verbally and were screened to ensure criteria for inclusion (Figure 2). Each interview lasted approximately 10-15 minutes and followed a flexible guide (Appendix 1 - Supplemental Table 2) that allowed for the exploration of key themes while permitting participants to discuss topics they found relevant.

When consent to record was obtained (n=17) interviews were audio recorded and transcribed using a phone-based recording application (Otter AI, California). Transcripts and audio were reviewed by two researchers to ensure accuracy and thoroughness. All other participants (n=2) were interviewed with notes gathered by hand by the interviewer, including direct quotes. 18 interviews were conducted in English; one interview was conducted and recorded in Spanish and was hand transcribed by the interviewing researcher, with transcript and recording reviewed by a second Spanish-speaking researcher.



facilities management), or otherwise working as a member of the media on-assignment covering the event. Of the approximately 100 persons in attendance, approximately 40% were identified as employees of the host company or otherwise working to produce the event, 30% were identified as members of the media, and a remaining 30% were identified as public attendees with varying backgrounds based on interviews, visual presentation, disclosure, and communication with the company (Figure 2).

Interviews were coded by two researchers, using both pre-established deductive codes informed by tasting and event ethnographical literature and media and company messaging published prior to the event[150, 166, 192, 208-210] (Table 8), and then using inductive codes emerging from themes in interviews and secondary data. Using Grounded Theory,[290] emerging themes were first identified within individual interviews as priority topics and then as themes when spanning across participants to describe overarching constructs which formed the basis for inductive codes and mutually agreed upon by two researchers. Emerging themes tended to be freely offered rather than prompted topics, including internal value structures or subjective evaluations and were often axially related themes linking categories and subcategories of deductive codes (axial) to form a more coherent framework.[290] For example, the emerging code “Need for Information” or “Need for Product Innovation” includes “Prior Beliefs about CM” and often “Sensory Evaluation.” As another example, the emerging theme “Social Awareness” often includes “Prior Beliefs” as well as “Event Evaluations”. Two researchers identified and conferred on deductive codes, emerging themes, and inductive codes and coded in a tandem practice. Conferencing was used to achieve consensus between the raters to ensure agreement. Initial disagreement in interpretation and coding of deductive codes was less than 5% and resolved in one conference. No disagreement for inductive codes was found.

	Flavor/texture/smell/appearance etc. Functional qualities or descriptive comparators Discriminating tastes
<u>Political Positions</u>	Florida/ state bans Political affiliation Petition/activism
<u>Relevant Prior Opinions</u>	Diet Beliefs & Diet Types (e.g. Health, self-ID, motivations) Beliefs about Cell Ag (e.g. environment, health, animal welfare, nomenclature) Beliefs about Animal Foods and Agriculture Beliefs about Plant-Based Food and Agriculture
<u>Ethical Stances</u>	Environmental prioritization Animal welfare prioritization Healthfulness of Food Prioritization
<u>Consumer Willingness</u>	Try (today and in future, or other products) Eat/Purchase, including routinely Recommend to others or for specific purposes Substitution (food currently eaten or specific foods (e.g. Animal, plant-based))
<u>Network</u>	How they heard about the event (person, web platform, etc.) Prior relationship to the cell-cultivated meat industry Having professional insights that may inform opinion (e.g. cell biologist) Effort/Time Expended to attend (e.g. Traveled to Miami specifically for the event)
<u>Company and Event Evaluation</u>	Sentiment or Trust in company Sentiment and trust for other Cell Ag companies or the industry as a whole Sentiment and experience of the event, especially those influence perception

Table 8. Deductive codes and sub-codes

Triangulation

To ensure the robustness and validity of observations, publicly available sources from both before, during, and after the event[225, 294, 295]:[296] including company-provided information and communications during (e.g. the CEO's speech), and after the event (e.g. social media posts) were used to triangulate findings and compare information with the results of the semi-structured interviews to thoroughly describe the scene, crowd, and context [290, 291, 296] (Figure 2, Appendix 1 - Supplemental Figure 1).

Semantic Thematic Analysis

Semantic thematic analysis was used to examine the language and meaning conveyed in interviews and the public discourse.[297, 298] This involved analyzing the use and frequency of specific words, phrases, and narratives to understand how CM is discussed and perceived. In particular, we looked for ways that

CM and animal-sourced meat were described including sensorial words and nomenclature, as well as how the ban was characterized. Additionally, while conducting the thematic analysis, we noted the strength and complexity of responses to enable a richer understanding of opinions and evaluations by looking for words and phrases that communicated variations in emphasis or that used emotional messaging that may indicate more complex positive, neutral, or negative positions. For example, foods may have been described as, “It was good” or, “That is F***ng delicious” or, “it wasn’t bad” which each convey a different level of enthusiasm and strength of evaluation.

Emerging Theories

Deductive, inductive, and abductive analyses were integrated to inform central theories to help explain consumer acceptance and sensorial evaluation of CM and the role of the tasting event in shaping those perceptions. Using Grounded Theory,[290, 296] theories emerge by iteratively reviewing interviews and secondary source materials. Theoretical pathways were identified to help describe topics of importance or common explanations and experiences based on the accounts of multiple sources. Reflexive memos were used to document emergent insights, refining categories until theoretical saturation was reached. Emerging theories were discussed and reviewed among the research team for face validity. Theories were agreed upon, citing representative statements as evidence.

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CHAPTER 2: Development and Feasibility of an eHealth Diabetes Prevention Program Adapted for Older Adults—Results from a Randomized Control Pilot Study

Suzannah Gerber ^{1,*}, Rachel E. Silver ², Sai Krupa Das ^{1,2}, Savana S. Greene ¹, Sadie R. Dix ¹, Isabella Ramirez ¹, Christina L. Morcos ¹, Maria Carlota Dao ³, Lisa Ceglia ^{2,4} and Susan B. Roberts ⁵

Abstract: Lifestyle programs that reduce health risks and support weight loss (WL) in older adults face adherence and attendance challenges due to reduced energy requirements, impaired mobility, lack of transportation, and low social support. Tailored lifestyle and weight management programs are needed to better support healthy aging for older adults. Here, we developed and piloted an age-adapted, remotely delivered modification of the Diabetes Prevention Program (DPP). The modification includes age-appropriate goals, visuals, and examples; flexible dietary composition; remote classroom and fitness-monitoring technology; and standardized online classroom materials employing pedagogical and behavior change theory. The modifications were designed to safeguard fidelity and to boost adherence, engagement, and knowledge integration, with the convenience of a fully remote WL program for diverse older adults. Six-month pilot data are presented from older adults (55–85 years, body mass index (BMI) 27–39.9 kg/m², N = 20) randomly allocated to an online DPP intervention with weight, diet, and activity monitored remotely, or into a waitlisted control. The intervention achieved 100% attendance and adherence to self-monitoring. The intervention group mean ($\pm$ SD) body weight change was –9.5% ($\pm$ 4.1); 90% lost $\geq$ 5%. By contrast, the control group gained 2.4% ($\pm$ 1.8). Once thought incompatible with older adults, remote interventions are feasible for older adults and can support fidelity, adherence, engagement, and clinically significant WL. Standardized materials are provided for future implementation.

Keywords: eHealth; lifestyle medicine; weight loss; older adults; remote monitoring; fitness; diet; intervention

1. Introduction

Forty percent of older adults in the United States have obesity, 49% have pre-diabetes, and 29% have type 2 diabetes [1–3]. The Diabetes Prevention Program (DPP) is a nationally recognized lifestyle intervention program designed to prevent diabetes and reduce risks for other cardiometabolic health outcomes with healthy lifestyle components including weight loss (WL), healthy diet, and exercise [4]. Higher attendance and regular participation in program sessions are associated with clinically impactful outcomes [5], but population compatibility, penetration, and program fidelity are known obstacles [6]. As a result, many interventions fail to attain clinically impactful weight loss ($\geq 5\%$) or to support weight loss maintenance for six months or longer [7–9]. Thus, an adaptation with standardized presentation materials optimized for online delivery and targeted to the specific needs of older adults could potentially increase compatibility, convenience, and fidelity, resulting in greater reach, efficacy, and accessibility.

One strategy to increase the accessibility of programs is to deliver them remotely, or in hybrid formats. Remote DPP programs have been explored for over ten years with mixed results [10–13]. Systematic reviews of online DPP programs predominantly study college-educated, white adults, aged 50–60, and report a mean WL of only 3–5% of starting weight [9,14]. However, there is considerable heterogeneity in the delivery of online DPP programs; hybrid programs that offer variable in-person and/or partially remote delivery report an overall lower WL [9]. Nonetheless, in randomized controlled trials that compare online to in-person interventions, the online groups had higher participant retention and engagement rates [9,10,14]. Similarly, app-based adaptations and/or those utilizing smart fitness devices for remote monitoring reported the greatest WL and the highest improvements in anthropometrics and other metabolic biomarkers [14,15]. Irrespective of delivery, programs with higher levels of interventionist support reported the greatest success with WL outcomes [9]. Thus, well-crafted, remotely delivered programs with strong interventionist support may be able to join accessibility and convenience with the education and social support that these programs offer.

Advances in remote fitness technology including wearable fitness trackers, mobile apps, e-dashboards, network-enabled scales, and social fitness platforms have helped to maximize the success of remotely delivered programs [16–18]. These tools allow for robust and real-time self-monitoring, interventionist surveillance, group social interaction, interventionist support, increased goal salience, program adherence, and dynamic opportunities for self-improvement [19–21]. Remote classrooms have also experienced a growth in supportive technology including things like live whiteboards, interactive polls, and other virtual activities, as well as methods such as flipped classrooms, in-class social time, and collaborative instruction [22–24]. These advances track alongside contemporary remote classroom pedagogy which recognizes and emphasizes the need to foster increased cognitive presence and engagement, which can be mutually reinforced by these tools and techniques [22–24].

Pedagogical and behavior change theories are known to positively influence outcomes in educational intervention programs like the DPP [5,9,25]. The Community of Inquiry (COI) framework focuses on supporting cognitive, social, and teaching presence to drive engagement in online and remote education [22–24,26,27]. COI incorporates the four-part pedagogical structure of the Practical Inquiry Model (PIM): first, an evocative topic or problem is presented (triggering event); next, students iteratively explore the topic through reflection, collaboration, and discussion; this is followed by integration exercises like student-led instruction; and finally, it is finished with resolution tasks where the new knowledge is applied outside of the classroom [27–29]. In and outside of classroom settings, change-readiness models like the Transtheoretical Model (TTM) and collaborative motivation- and commitment-driving techniques like Motivational Interviewing (MI) are well-received by intervention participants and provide tools for interventionists to support progress [30–38]. Previously, these methods have been observed to increase the application of program skills outside of sessions [31], to increase healthy diet and physical activity in patients with pre-diabetes and type 2 diabetes [32], and to be particularly effective in remote classroom interventions [35,36]. Together, theory-informed methods and modern fitness and remote classroom

technology join robust self-monitoring, interventionist surveillance, increased accessibility, convenience, and socialization opportunities with established behavior science to foster goal salience, program adherence, fidelity, and engagement [18–21].

The need to tailor interventions for at-risk populations to improve program reach and effectiveness is well established [39,40]. In prior studies, older adults requested modifications relevant to compatibility and functionality such as different approaches to physical exercise due to limited mobility, flexible scheduling due to transportation, and flexible dietary approaches due to a lack of social support [31,41]. Despite the known incompatibilities, no known published adaptations address these issues. While tailoring an online program to older adults could address known barriers to in-person attendance (e.g., mobility and transportation, as well as infection-avoidance), other modifications would be needed to address barriers to program adherence including nutrition literacy, self-efficacy, age-related exercise limitations, reduced social support and normativity of healthy diets, and to provide technology support for older adults [42,43]. Programs that rely on advanced technology have historically reported low compatibility with older adults, which largely limited their use [11]. However, internet use is now nearly ubiquitous—reported by over 95% of American adults, with nearly 90% reporting internet use ≥ 1 day [44]. Overall, technology fluency and adoption have increased among older adults with telehealth use becoming pervasive during the COVID-19 pandemic [11,16,17]. Nonetheless, remote DPP interventions for older adults are rare, but a recent pilot showed some success [41]. To our knowledge, previously published remote interventions for older adults pre-date the notable shift in eHealth and technology fluency among older adults that occurred during the COVID-19 pandemic [11,16,17]. Furthermore, there are no known adaptations that specifically seek to optimize the success of exclusively online programs for older adults while addressing the previously identified compatibility issues.

Remote programs could increase program accessibility for older adults, and paired with further modifications could help optimize acceptability, adherence, and engagement [18–21] and standardized

presentation materials can help to safeguard program fidelity to support the scalability of implementation. Additionally, remote programs also offer greater ease of administration, data collection, and scheduling flexibility, along with a reduced need for physical meeting spaces which can reduce program costs and interventionist burden [21]. Overall, we identified fidelity, accessibility, convenience, engagement, support, and technology compatibility as elements that reduced adherence and overall efficacy in previous programs. To address these, we developed a theory-informed novel modification to the DPP to support a replicable eHealth program with standardized materials, tailored for WL success in diverse older adults. This report includes justifications for the modifications made, results of the pilot, and includes all presentation materials.

2. Materials and Methods

The Brain and Body Health Study (BB-Health) aims to look at how food and lifestyle influence multiple cardiometabolic outcomes. This report focuses on the implementation process of a novel modification to the Diabetes Prevention Program Group Lifestyle Balance (DPP-GLB) [4,45] and the corresponding weight loss outcomes. The modification described below was designed to facilitate standardized delivery, engagement, and high adherence to a remote lifestyle intervention for older adults. Here, we report the results from the six-month pilot randomized control feasibility trial (Clinical Trial Registration #NCT05542199). The Tufts Health Sciences Institutional Review Board approved this study. Participants were recruited between September 2022 and March 2023 and given a stipend for participation. Baseline population characteristics are shown in Table 1.

Table 1. Study baseline characteristics.

Baseline Characteristics	<i>Intervention n = 10</i>	<i>Control n = 10</i>
Age, years mean(SD)	65.5(4.6)	65.3(6.3)
BMI, kg/m ² mean(SD)	31.3(2.63)	31.3(2.98)
Female, n(%)	7(70)	2(20)
<u>Race n(%)</u>		

Black/African American [†]	4(40)	1(10)
Hispanic/Latine	1(10)	1(10)
White [*]	5(50)	8(80)
<u>Educational Attainment</u>		
<u>n(%)</u>		
High School Diploma/Equivalent	2(20)	3(30)
Associate's Degree	2(20)	0(0)
Bachelor's Degree	6(60)	7(70)
<u>Weight Category n(%)</u>		
>25 BMI <30	4(40)	4(40)
BMI ≥30	6(60)	6(60)

[†] Non-Hispanic Black/African American; ^{*} Non-Hispanic White.

2.1. Adaptations to the DPP-GLB

The original DPP-GLB is designed to be delivered in person and centers around a written curriculum led by an interventionist during group sessions. Participants receive educational handouts in each session and the interventionist instructs based on a session-specific lesson plan which is intended to be secondary to group discussions [4,45]. In this modification, the core curriculum of the DPP-GLB was maintained including the use of participant handouts, goal targets such as 7% body weight reduction (accomplished through reduced energy intake and increased physical activity), group-meeting structure, and the temporal sequence of sessions (weekly: sessions 1–12; bi-weekly: sessions 13–16; and monthly through 22). Consistent with the DPP-GLB, participants were given a calorie counter, worksheets, and measuring cups. However, in this adaptation, lesson plans were restructured to include theory-informed prompts, individualized feedback, and formatting revisions to create dynamic standardized, online classroom presentations alongside flipped classroom lessons that adhere to the structured curriculum. Additionally, food and activity logs were primarily accomplished using the fitness device and corresponding application and dashboard, without relying on paper logs.

Seven key areas (Table 2) of the program were adapted in this modification to facilitate remote delivery and to increase acceptability and adherence to an entirely remote intervention among older

adults. Changes comparing this modification to the DPP-GLB are summarized in Table 2. All program presentation materials, including classroom polls and activities, were embedded into standardized presentation slides used in a videoconference-based, synchronous, remote classroom environment, to support fidelity across groups and for future implementations (Appendix 2.5).

Table 2. Adaptation versus Diabetes Prevention Program Group Lifestyle Balance.

<u>BB-Health Adaptation</u>	<u>DPP-GLB</u>
Technology:	
• Wearable fitness tracker for remote data capture. ○ Automatic step counting; ○ Automatic exercise duration and intensity; ○ Automatic sedentary time; ○ Automatic sleep quality; ○ Optional Mindfulness. • Wi-Fi Scale for remote data capture. • Mobile Application and Web Dashboard. ○ Self-monitoring trends and reports. ○ Logging food and water. ○ Goal setting. ○ Reminders. ○ Social fitness platform. ▪ Messaging group and interventionist; ▪ Comparing progress; ▪ Recipes and exercise ideas; ▪ Achievement affirmations.	• <i>Optional-pedometer.</i> • Reference material and instruction for oral delivery without slide presentation; self-monitored logging by hand.
Online classroom materials:	
• Session presentation slides. ○ Motivational Interviewing prompts; ○ Transtheoretical Model assessments, including Stage of Change; ○ Salience tasks with visual prompts; ○ Group goal setting and problem solving; ○ Polling, multi-media. • Flipped classroom. ○ Peer-led segments; ○ Resonant examples carried forward. • Age- and diversity-relevant images and examples. ○ Includes discussion of both cognitive and cardiometabolic health; ○ Stage of life and healthy aging focus; ○ Cultural and family focus;	• In person, sometimes remote. • Discussion-based, with handouts (presenter and participant guide). • General audience examples. • Fewer images and simplistic graphics.

-
- High-definition photography and modern graphics for visual aids.
 - Presenter guide embedded in slide notes to support quality control in delivery.
-

Affirmations and reports:

- Affirmations (cheers and progress) sent >3x weekly.
 - Trend alert messages.
 - Uptrend in body weight >3 days;
 - No log/weight >2 days.
 - Detailed progress report.
 - Diet composition;
 - Goal attainment;
 - Diet and exercise recommendations;
 - Preparation for contribution to the group discussion.
 - *Optional:* In-person private weighing and review of logs prior to sessions.
-

Flexible diet composition:

- Supports range of fat and carbohydrate intakes and popular diet patterns.
 - Emphasized age-appropriate protein targets and includes plant-based sources of protein.
 - Emphasize high-fiber targets.
 - Legumes, fruit, and vegetables;
 - Reduced total grains, and recommends only whole grains.
 - Emphasize reduced saturated fats.
 - Recommend healthy fats (unsaturated fats);
 - Total fat reduction only recommended when calorie budget exceeded.
 - Supported healthy dietary patterns such as plant-based, MIND, Mediterranean, and DASH diet in session one with encouraged meal planning.
 - Includes calorie counter guide and electronic food database to facilitate faster food logging, and food measuring tools.
 - Low-calorie, fixed.
 - Low-fat and/or high-volume.
 - My Plate.
 - DASH diet was introduced during the second half of the program.
 - Includes calorie counter guide, food-measuring tools.
-

Meetings:

- Same schedule, meeting time, and group format as DPP.
 - Videoconferencing using any computer or smartphone.
 - Discussion aloud or using the text-based chat.
 - Make-up sessions.
 - Joining another group or one-on-one with the interventionist.
 - In-person, infrequently by videoconference (primarily in COVID-19 adaptations).
-

-
- Review progress data simultaneously with sessions and curriculum examples.
 - Adult partner exposure to session discussions is allowed if requested.
-

Goal setting successively rather than fixed:

- Calorie range:
 - Supported exercise-adjusted targets adapted for older adults;
 - Weight progress-adjusted calorie targets.
 - Activity level:
 - Focus on walking, or usual exercise with doctor approval;
 - Increase over time based on improved fitness.
 - Weight loss:
 - Pace and attainment self-guided;
 - Shorter-term and longer-term individualized, initially 7% long-term;
 - Choice to focus on additional weight loss or weight loss maintenance after 7%; secondary goals based on new weight, not starting weight.
 - Calorie ranges are set based on starting weight with the corresponding fat (g) target.
 - Activity levels are the same for all participants and include aerobic and resistance exercise including sports suitable for general audience.
 - Weight loss goal is set to 7% for all participants, based on starting weight. Continued weight loss is only minimally discussed.
 - Other health goals are secondary to weight loss and behavioral targets.
-

Theory-informed changes

- Session concepts implemented as didactic polling to the following:
 - Drive participation and evocative vocalizing;
 - Encourage personal insights, self-reflection, and peer-based reflection.
 - Theory checkpoints such as Stage and Process of Change checkpoints:
 - Group and individual awareness raising;
 - Normativity of change;
 - Stage assessment;
 - Stage-matched recommendations.
 - Open discussion for experience validation, the opportunity for reframing and summarizing challenges and successes with input from group members and interventionist.
 - Presenter guide encourages group discussion, which may eclipse key session concepts.
 - Workbook-oriented examples and education.
-

2.1.1. Supplemental Pedagogical and Behavior Theories for the Modification

We aimed to increase motivational salience and engagement using theory-informed approaches known to foster improved results. Session presentations included polling questions informed by Transtheoretical Model (TTM) constructs of Stage of Change (SOC) and Process of Change (POC) [46,47] modified from Gonzalez-Ramirez et al. [48] that recurred as intervention checkpoints to increase

participant self-awareness and to enable stage-matched support and Motivational Interviewing (MI)-informed feedback, similar to the approaches described by Miller et al. [33], Van Der Veen et al. [49], Johnson et al. [50], and Prochaska et al. [51,52]

To foster group discussion and the internalization of key concepts, program topics, and the related behavior change goals were delivered as open-ended questions, polls, and discussion prompts, as well as communicated through participant-led and/or flipped classroom activities which have been previously observed to increase cognitive and social presence in remote classrooms. Methods for structuring questions and curricula for the remote classroom environment followed the Community of Inquiry (COI) framework [24]. Following the COI, a topic triggers a set of exploratory probing exercises, followed by group integration activities, and opportunities for applied and confirmatory resolution where participants vocalize subjective, first-person goals and intentions, consistent with MI concepts of “change talk” and “sustain talk”. The MI-informed evocation of motivational salience and goal planning guided the phrasing and frequency of discussion prompts and polls [33]. These prompts and polls offered participants various and recurring ways to examine and discuss progress, focus on obstacles that present challenges, and plan out intentions while engaging with peer and interventionist feedback employing the four processes of MI—experience validation, reframing, summarizing, and deployment of personal insights [30,33]—similar to methods described by Dineen et al. [31], in alignment with the logical framework presented in Hawkes et al. [25]

The flipped classroom structure was supported by emails with individualized feedback which were sent to each participant and included stage-matched and MI-informed affirmations of progress, identifications of recent behavioral choices that did/did not support success, and summaries of previously stated goals. These reports also included cues to review upcoming session materials and identified areas of specific success or challenges for them to present to the group in the upcoming session. Thus, sessions were able to foster large amounts of participant-led discussion time while addressing all major curriculum

elements; sessions were a mixture of components delivered by the interventionist and components told through reflection and insights from the personal experiences of peer-participants. To ensure even participation and progression through curriculum goals within each session, every participant was called on directly to respond to each prompt and poll, and to share such reflections.

2.1.2. Adapted Program Goals—Exercise, Diet, and Weight for Older Adults

Daily activity and calorie targets, and successive weight loss goals, were re-evaluated throughout the program [53,54]. In contrast to the original DPP-GLB which sets uniform minimum activity targets and weight-category calorie limits irrespective of activity level or weight loss attainment, this adaptation set physical activity targets first at 5000 steps/day, which would then increase to 6000–10,000 steps per day depending on individual goals and ability. Moderate–Vigorous Physical Activity (MVPA) targets begin at 100 min/week and would then rise to 150–210+ min/week, similarly, depending on goals. Exercise recommendations focused on walking/jogging at various intensity levels as the main form of exercise, and although safe exercising practices from the original DPP-GLB were included (e.g., warm-ups/cool-downs and stretching), instruction to perform more strenuous physical activity was removed. As a result, session 13, which is centered around vigorous resistance exercise in the DPP-GLB, was reconfigured as a mid-program review, allowing concepts presented early in the program to be foregrounded, and providing practice and conceptual mastery opportunities for group members (Appendix 2.3, and 2.5). These changes addressed feedback from older adult participants discussed in Beasley et al. and Lee et al. [35,36,41] and also aimed to reduce the risk of injury in this vulnerable population during remote-only delivery. Although walking/jogging was the form of exercise directly recommended, participants were encouraged to continue or to undertake other exercise if deemed suitable by their doctor.

Concerning diet, calorie targets were initially determined by using the participant's starting weight, as it is in the DPP-GLB. However, this modification employed energy intake ranges with the DPP-GLB target set as the minimum and the next higher level set as the maximum. Ranges were adjusted monthly based

on weight change (e.g., reduced to support continued weight loss) and in response to activity levels (e.g., lower if less active, higher if very active). Dietary composition recommendations were modified from the low-fat and low-energy density focus of the DPP-GLB to emphasize flexibility in dietary patterns recognizing the well-known reduced willingness, physical, and financial ability to change dietary patterns among many older adults [43]. Participants were introduced to the healthy Mediterranean [55], DASH [56], MIND [57], and healthy plant-based [58] diet plans in the first session and were encouraged to follow preferred plans while strongly emphasizing three main targets: (1) dietary fiber >25–35 g/day, by adding a daily serving of legumes, increasing whole fruits and vegetables, and eating most/all grains as whole grains [59]; (2) reducing saturated fat by emphasizing plant-based protein foods and smaller portions of lean animal-sourced foods, and limiting dairy to low-fat and/or fortified dairy-alternatives [60]; and (3) maintaining protein intake >50 g/day [61]. Reducing total dietary fat is a cornerstone of the diet recommendations in the original DPP-GLB, but in this modification, this was presented as one of several strategies for reducing total energy intake and as a strategy to prevent underestimating calories in food logs.

As in the DPP-GLB, the weight loss (WL) goal was 7% from baseline; however, in this modification, when this initial WL goal was achieved, participants were encouraged to self-determine either continued WL or to shift towards weight maintenance. Subsequent WL goals were set as an additional 5–7% of the new body weight, or less if a WL $\leq$ 5% would result in a BMI between 18.5 and 24.9 kg/m².

The practice of self-monitoring was a cornerstone of the intervention and factored heavily into the adaptation, supported by robust smart fitness tracking devices. Participants were encouraged to remain aware of their weight, intentional and spontaneous activity, foods consumed, sleep quality, water intake, sedentary time, and positive and negative social and environmental cues with daily logging and/or by reviewing values captured by their fitness devices. The concept of self-awareness (referred to as “Aware”; Figure 1) was repeated throughout the intervention, as a way to combat scale weight avoidance and to

help develop self-monitoring behavioral routines. Awareness was also described as an essential component of self-control (“In Control”; Figure 1) which was a recurring empowerment cue to action contextualized as the components of personal health response to modifiable lifestyle choices. In other words, participants were encouraged to remain aware of their weight daily, even if the value was disappointing, in order to take immediate action and thus remain in control of their outcomes, and thereby remain in control of their overall health. Empowerment strategies have been identified as a critical component of success for health behavior change interventions that support healthy aging for older adults [62,63]. This adaptation presented the concepts of “Aware and In Control” for the above healthy lifestyle domains as equivalent in importance to eating healthy, moving more, and providing and receiving social support (Figure 1; see also Session 13 in Appendix 2.5, and explanation Appendix 2.3).

Tools for Weight Loss and Healthy Lifestyle Success



Figure 1. Main strategies of the adaptation, as presented to participants.

2.1.3. Changes to Implementation and Self-Monitoring for Program Fidelity and Remote Delivery

The online group sessions were videoconference-based (Zoom, San Jose, CA) including any make-up sessions. No sessions were offered in person, and the delivery was not hybrid, but exclusively remote. A key advantage to the remote format is the ability for participants to join from anywhere, the ability to

accommodate rescheduled and make-up sessions, and/or the ability to allow group members to join other groups to make up a session they missed [13].

To support the remote monitoring of physical activity, weight, and dietary intake, participants were given a wearable fitness tracker (Fitbit Inspire 2; Fitbit, San Francisco, CA) and a Wi-Fi-enabled scale (Fitbit Aria Air), which were networked with the corresponding web-based dashboard and smartphone application (Fitbit, 2022–2023). The dashboard enabled both self and interventionist monitoring, in addition to logging, automatic heart rate and activity intensity measurement, behavioral cues and reminders, messaging, and other supportive resources for adherence. Participants were asked to use these every day, to weigh daily upon waking after voiding in the morning, and to log all daily foods.

Standardized presentation materials were developed to present curriculum materials during group sessions and to ensure program fidelity (PowerPoint, Microsoft, Redmond, WA). Each session was led by an interventionist using these materials which feature interactive elements to support engagement, rather than a passive lecture format or an unstructured group discussion. The same materials are utilized across groups ensuring no material is omitted and that different groups receive the same information [6,18,64]. Presentations include the use of modern videoconference tools such as live whiteboards and interactive polls, and also provide structured discussion prompts, solicit flipped classrooms with participant-led lessons and personal testimonies, and also deploy theory-informed checkpoints to monitor progress [13,18,65] (Appendix 2.2). Each session was structured using the COI framework with a critical topic for health, followed by interactive exploration that centered around personal examples from each of the group members, integration opportunities where participants offered advice to each other based on feedback or their own experiences, and planning to apply the knowledge gained in the time in between sessions structured using Motivational Interviewing techniques to elicit change and sustain talk. This resolution-driving exercise was presented at the end of each session and again at the beginning of the subsequent session for reinforcement using callbacks and personalized examples of how the

knowledge was applied outside of the session. This callback and examination of resolution exercises provided both an opportunity for commitment and goal salience and an opportunity for peers to witness healthy social norms developing within the group. Group-specific examples were gathered during sessions and able to be used as personalized examples in future discussions to enable group cohesion and cognitive presence with the material [39]. Standardized presentation materials also included rich visuals, such as images depicting diverse older adults.

2.1.4. Participant and Interventionist Interactions and Communication in the Adaptation

Social support has been identified as an important lever of successful health behavior change [47,66,67]. Social isolation and social-norm-based change-aversion have been especially indicated as significant barriers to healthy lifestyle change among older adults [42,62,68]. To address this, every session began with socialization and reconnection time. These periods afforded participants time to get to know one another, to celebrate life events, and to strengthen social bonds between each other and with the interventionist. This socialization time segued into the resolution discussion of successes and challenges during the period between sessions and allowed for organic social support and problem-solving before the structured educational session began.

As described above, detailed progress reports were privately sent to each participant prior to each session. Reports included affirmations, recommendations about how to improve outcomes, and feedback based on remotely collected data. Reports typically included a reflection on recent progress towards goal attainment, device management assistance, reminders relevant to that participant's action plan, an honest assessment of observed adherence, and prompting in preparation for discussions relevant to the upcoming session for the flipped classroom time. Reports also offered an open line of communication for participants enabling them to request additional support and to respond and ask questions privately, if desired.

Participants were linked to each other and to the interventionist through the online fitness dashboard and the corresponding app, synchronized with the fitness devices. The dashboard and app visibly share goals and activity levels with other group members, allowing for social comparison among participants; it also provides the interventionist with a venue for role-modeling healthy behaviors. The dashboard and app also had an internal messaging system that supported affirmations, questions, and direct peer-to-peer support outside of scheduled sessions. Additionally, the dashboard itself sent automatic, programmatic nudges that increase the salience of these social comparison pieces (e.g., step-count rank compared to the group; awards for top placement), and within-person progress compared to the prior week (e.g., accolades for increasing steps, reducing weight, or reaching logging or performance targets) [21,66].

Consistent with MI and prior MI-based DPP modifications [30,31,33,69], we utilized routine affirmations of participant experiences and choices during discussions, in response to prompts and polls, based on dashboard-indicated progress, and in private reports. These exercises provided opportunities to engage by both giving and receiving support and to iteratively refine action plans based on peer and interventionist responses. Self-affirmations were also elicited during sessions and part of resolution exercises practiced independently.

2.2. Pilot Randomized Controlled Study Using the Adapted Intervention

The pilot randomized controlled trial was pre-registered (#NCT05542199) and the protocol for the full trial was previously submitted for publication [70]. In brief, the Brain and Body Health Study (BB-Health) is a food and lifestyle-based clinical trial designed to evaluate changes in cognitive function, weight status, brain blood flow, and accompanying biomarkers of obesity (e.g., blood lipids). The feasibility pilot trial was conducted at the Jean Mayer USDA Human Nutrition Research Center on Aging (HNRCA) at Tufts University. Participants were recruited by the visitor services team of the HNRCA and through local print

and electronic media (e.g., advertisements, featured in newspapers, and social media posts) as well as through the posting of flyers in public places, such as local YMCAs, senior centers, supermarkets, and libraries. Additionally, HNRCA Volunteer Services recruits from an existing roster of contacts who have previously indicated a willingness to participate in nutrition research. This report describes participants randomized either into a healthy lifestyle program (DPP) or into a control group with no instructions regarding diet and lifestyle. CONSORT guidelines for the reporting of pilot randomized clinical control trials were used and can be found in Appendix 2.1. The sample size was determined to detect $\geq 80\%$ power for WL among randomly allocated intervention and control groups of approximately equal size. Randomization occurred after baseline assessment, stratified by age (55–69; 70–85) and BMI (27–32.9; 33–39.9). Participants were randomized by a statistician using the Research Electronic Data Capture (REDCap) randomization module in a 1:1 allocation (intervention or waitlisted control), which remained the same throughout this study. All participants, regardless of allocation, received equal monetary compensation for their time spent in this study and during outcome assessments—no additional stipend was given for participation in the lifestyle intervention. Stipends were distributed at multiple points throughout this study; at 6 months, pilot participants would have received approximately USD 1000 each. The principal investigator, physician, interventionist, and participants were unblinded to the randomized group assignment. Staff conducting outcome measurements were blinded throughout the study. Free-living adults, aged 55–85 years old, with a BMI of 27–39.9 kg/m², who have access to a computer and/or smartphone, and who are medically cleared to participate were eligible (Table 1).

To allow for rolling admissions, initial sessions up to the fourth were conducted one-on-one or in small groups, after which participants regularly met in groups of 4–10. Make-up sessions were usually accomplished by joining another group. Intervention sessions were recorded and transcribed, and poll responses were extracted. This report includes data from the first 20 enrolled participants, $n = 10$ randomized into the intervention (representing two total intervention groups) and $n = 10$ randomized into

the control group, and followed during a six-month pilot of the novel modification. Participant characteristics at baseline can be seen in Table 1.

Session attendance and engagement were documented. Engagement was defined as the percentage of sessions where each individual actively contributed verbal comments during the meeting and responded to all session prompts and polls. Fidelity was defined as the complete presentation of all program curricula and materials to all participants [64].

Remote monitoring matched to the intervention sequence was utilized for intervention participant weight, physical activity, and food records. The following data summaries were downloaded from the commercial dashboard (Fitbit, 2022–2023): the ending weight for each week, average daily step count, Moderate–Vigorous Physical Activity (MVPA) minutes, and food logs. The percentage at/above predefined targets was used to categorize adherence: days with step count above 5000; days with MVPA above 22; weeks with ≥ 3 days of food log; and weeks with ≥ 3 days of scale weights. MVPAs were determined using heart rate measured as beats per minute (BPM), with moderate BPM 110–132 and vigorous BPM ≥ 133 BPM. On-site fasted weight was collected in duplicate at baseline, and at two subsequent on-site visits (at approximately three and six months) post-enrollment for both intervention and control groups (See Appendix 2.4).

2.3. Statistical Analysis

Paired two-sample *t*-tests were used to assess new weight status in the intervention group after six months of intervention exposure (17 sessions) compared to baseline weight, using the at-home scale. Unpaired two-sample *t*-tests compared between-group differences (intervention versus control) in mean weight change percent between baseline and the third on-site visit using the research center scale (approximately six months post-enrollment, agnostic to intervention exposure; Appendix 2.4). At-home and on-site scale measurements were validated with repeat measures at three different time points

(Appendix 2.4) using Pearson correlation coefficients (Rho) with means assessed for statistically significant differences using paired *t*-tests. Paired two-sample *t*-tests assuming unequal variances were used to compare low- and high-weight-loss groups. Analyses were conducted in Microsoft Excel with the Data Analytics extension (v.2103 Excel, Microsoft, Redmond, WA, USA). Data from the current study are available upon reasonable request.

3. Results

After six months of the program pilot, participants reported a high degree of enjoyment and acceptability of the program, indicating good program compatibility. Additionally, participants indicated that the remote format supported their success (a sampling of questions and responses can be found in Appendix 2 - Supplemental Table 1). No harm relevant to the intervention was reported. Meeting attendance was 100% for intervention participants, and session engagement was high (Table 3). A total of 4 out of 120 participant sessions were make-up sessions. Program fidelity was high—both intervention groups received the same presentation material, and no curriculum materials were omitted for either group. The standardized presentations and perfect attendance ensured that the dose was the same across groups and in make-up sessions. Self-monitoring adherence was also high: all intervention participants wore their fitness trackers daily, weighed themselves >3 x/week, and logged food >3 x/week. The reported calorie adherence to the set calorie range was 74% for all six months (Table 3). The starting step count target of 5000 steps/day had 92% adherence over six months. Adherence to the MVPA target of 150+ minutes/week was lower (Table 3).

Table 3. Adherence and outcomes for intervention participants.

	Intervention (n = 10)					
	1 Month	2 Months	3 Months	4 Months	5 Months	6 Months
Adherence						
Daily kcal, mean(SD)	1284(305)	1289(352)	1289(387)	1407(742)	1252(466)	1326(490)
Calorie target, %(SD)	75(25)	77(27)	75(32)	70(28)	74(25)	73(29)

Steps/day, mean(SD)	10,918(6020)	10,765(5871)	10,872(5738)	10,932(5790)	11,453(5709)	11,608(5946)
Step target, %(SD)	95(11)	93(17)	93(17)	90(24)	85(27)	88(21)
MVPA/week, mean(SD)	455(436)	474(459)	492(430)	498(418)	530(395)	533(395)
Exercise target, %(SD)	70(42)	68(44)	73(34)	63(41)	65(43)	70(44)
Attendance, %(SD)	100(0)	100(0)	100(0)	100(0)	100(0)	100(0)
Scale weight, %(SD)	100(0)	100(0)	100(0)	100(0)	100(0)	100(0)
Food logging, %(SD)	100(0)	100(0)	100(0)	100(0)	98(3)	100(0)
Engagement, %(SD)	100(0)	100(0)	100(0)	100(0)	100(0)	100(0)
Outcomes	1 month	2 months	3 months	4 months	5 months	6 months
Weight change, % (SD)	-3.8(1.8)	-5.5(3.4)	-7.0(3.0)	-7.5(3.6)	-9.0 (4.4)	-9.5(4.1)
BMI, kg/m ² mean(SD)	29.9(2.6)	29.4(2.6)	29.1(2.7)	28.73(2.8)	28.40(2.8)	28.3(2.8)

Weight (Wi-Fi home scale) and Food log (self-report) adherence are defined as the percentage of weeks with these self-monitoring tasks completed ≥ 3 days/week. Engagement is defined as the percentage of sessions where each individual actively contributed verbal comments to the meeting and responded to all session prompts and polls [64]. Calorie target is the mean percentage of weeks where the average daily caloric intake was at or below the individual calorie intake target. Step target is the mean percentage of weeks with a daily step count average ≥ 5000 . Moderate–Vigorous Physical Activity (MVPA) is exercise minutes with a heart rate above 110 beats per minute (BPM). Exercise target is the mean percentage of weeks with a weekly average of MVPA minutes ≥ 150 .

Weight outcomes are derived from home scales, with the group mean at each time point; changes are compared to baseline. The baseline BMI for the intervention group was 31.3 kg/m² (± 2.63) (see Appendix 2 - Supplemental Table 1).

After 12 intervention sessions (approximately three months post-enrollment; Appendix 2.4), the mean (SD) weight change for intervention participants compared to baseline was -7.0% (± 3.0), which was significantly different from baseline ($p < 0.0001$) (Table 3). After 17 sessions (approximately six months), the mean weight change from baseline for the intervention group was -9.5% (± 4.1) ($p < 0.0001$). By

contrast, at three months post-enrollment, the mean weight change in the control group was +1.2% (± 2.5), and was +2.4% (± 1.8) at six months. The change in BMI for both groups is shown in Figure 2. Agnostic to intervention session progression, research center scales showed a weight change of -5.3% (± 3.1) at three months post-enrollment in the intervention group, and -8.4% (± 4.1) at six months. The between-group difference in mean weight was significant at both time points (intervention vs. control at 3 months, $p < 0.004$; at 6 months, $p < 0.001$). There was a small but statistically significant difference in date-matched WL comparing the home scale to the research center scale (-0.5 ± 0.6 kg; $p < 0.004$) (more details about comparative scale validation can be found in Appendix 2.4).

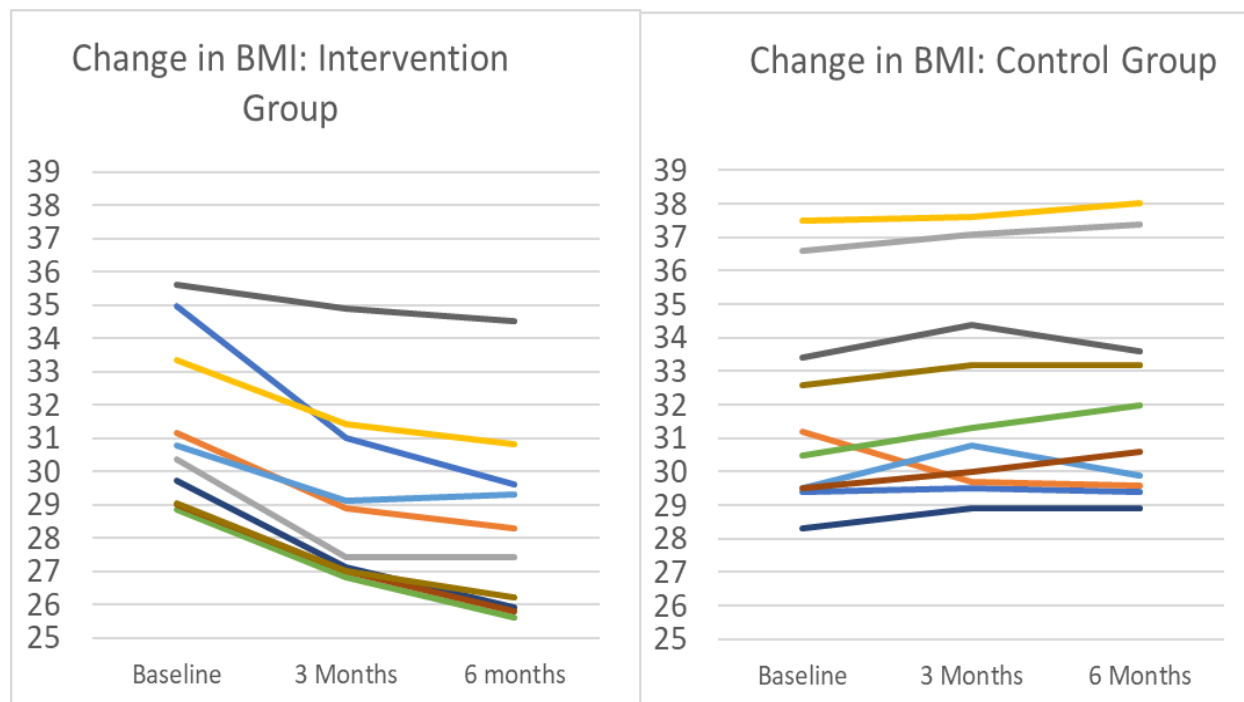


Figure 2. Change in BMI for intervention and control groups. Note: Each line represents an individual participant in the pilot. Intervention participants ($n = 10$) completed 3 months of remotely delivered intervention, including self-monitoring tasks, healthy lifestyle sessions, and interventionist support communication. Control participants ($n = 10$) were instructed to maintain current lifestyle behaviors. Mean (SD) change in body weight in the intervention group after 3 months was -7.1% (3.0%), from a baseline mean (SD) BMI of 31.3 (2.63) to BMI 29.06 (2.80). All intervention participants lost weight during the period. During the same time period, the BMI change in controls was a mean increase of 0.9 kg/m² from 31.3 to 32.2 , representing a 1.2% increase in mean body weight. Nine of the ten control group participants gained weight during the period.

Weight loss percentage and Stage of Change (SOC) progression were closely tied. No participants slid backwards in their SOC; all but two participants moved forward towards action and maintenance (Figure

3). These two participants also had the lowest overall weight loss percentage from one to six months—one participant remained in the preparation stage for both diet and exercise achieving 6% weight loss, and the other remained in the contemplation stage for diet achieving 3% weight loss. Interestingly, those in session one who indicated an exclusive focus on increasing exercise had a much lower mean (SD) weight loss at six months compared with participants who intended to change their eating behaviors ($-5.0 \pm 1.4\%$ versus $-12 \pm 1.8\%$, $p < 0.005$) (Appendix 2 - Supplemental Table 1).

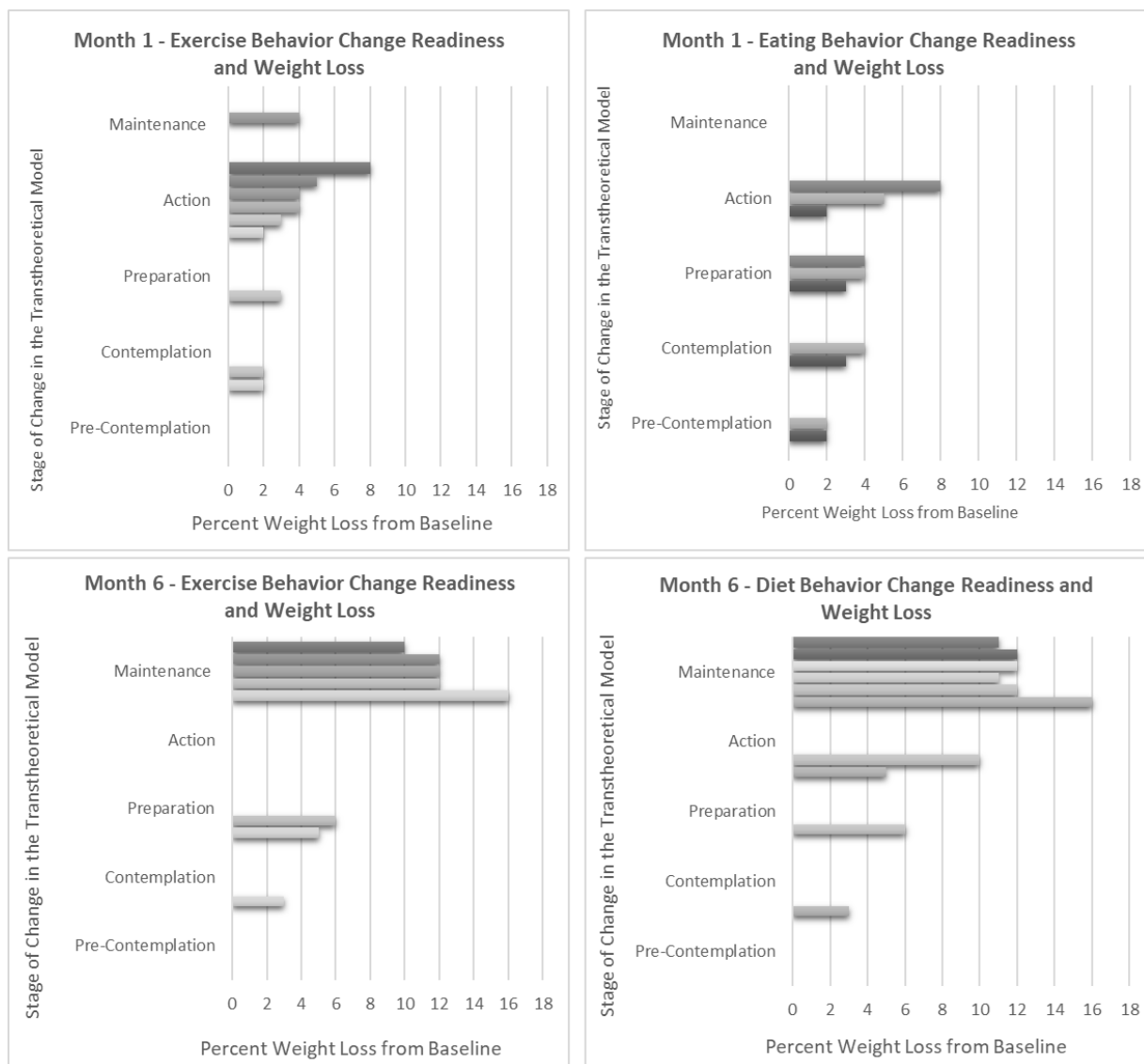


Figure 3. Weight change compared to Stage of Change readiness for exercise and diet at 1 and 6 months. Note: Each bar represents an individual in the pilot. Information on the Stage of Change (SOC) is gathered throughout the intervention during in-session polling. In the Transtheoretical Model, the SOC is an indication of the level of change readiness for a given health behavior and is known to change over time, sometimes progressing towards increasing levels of action and sometimes backsliding

towards non-adherence. As expected, greater percentages of weight loss correspond with progression towards action and maintenance for both diet and exercise behaviors.

4. Discussion

Previous eHealth weight loss (WL) programs for older adults have reported mixed success [16,17]. The original DPP achieved 7% WL with intensive intervention components including individual and group meetings, and provided food and other services; however, the results from scaled-up implementations of DPP and other similar programs have typically produced WL results of only 3–5% [16,17]. The DPP adaptation described here builds upon the strength of the original DPP, the DPP-GLB, as well as other remotely delivered programs and interventions tailored for older adults [6,10,41,71] to achieve a mean WL of 9.5% after approximately six months in a diverse group of older adults. The mean WL was significant in intervention participants; furthermore, 90% achieved and sustained WL $\geq 5\%$ —the level widely recognized to be clinically impactful [72]. During a similar period, the control group gained an average of 2.4% above their baseline body weight, with only one control group participant losing weight (–5.2%).

Main behavioral targets for WL, healthy eating, and daily exercise as well as strategies like logging were mostly unchanged from the original DPP. However, instruction of the curriculum, recommendations for achieving those targets, and the format in which they were delivered and logged were augmented by additional theory-informed components and reformatted into standardized presentations to maximize engagement and fidelity in the remote classroom setting. High fidelity, engagement, and interventionist and group support likely fostered increased acceptance and adherence to the program, which likely contributed to the greater weight loss outcomes achieved here. Stage-matched interventions informed by the Stage of Change (SOC) and Transtheoretical Model (TTM) are known to positively influence health outcomes in lifestyle programs, including the DPP-GLB [31,33,37,38], and for older adults [34]. Prior studies have also found MI to be effective in diet and exercise interventions, complementary to TTM [69], compatible with DPP, and effective for older adults [69,73]. These techniques are widely considered so

effective because they support self-efficacy and skill-building [31] and have been observed to increase the adoption of program skills outside of sessions in remote programs [31]. Furthermore, Motivational Interviewing (MI) is known to integrate well with flipped classrooms where open discussions can elicit “change talk” and “sustain talk”, and in activities designed to encourage change motivation, drive the salience of personal values and self-directed goals, and to reinforce commitment [33]. The addition of these theory-informed approaches gave our participants the chance to trial and practice change while routinely reflecting and revisiting these experiences with peers.

As remote classroom education becomes more common, pedagogical theory aimed at optimizing online education has rapidly expanded. However, prior online health behavior change programs mostly preceded advances in cultural acceptance and strategy advancement for online education. As such, current and future eHealth programs can benefit from employing strategies known to increase the success of online education. In our remotely delivered sessions, members were invited to openly examine goals, share subjective experiences, identify and work through obstacles collaboratively, and offer each other support and advice. The Community of Inquiry (COI) framework provided an efficient, theory-based outline for restructuring the curriculum for an online classroom approach. Additional SOC and MI components provided tested theoretical strategies to improve the efficacy of discussions and feedback. While the theoretical underpinnings of the DPP are often discussed as unknown [25,74], this adaptation explicitly and consistently applies theory-based methods throughout all sessions to drive engagement, self-awareness, and commitment. The original designers of the DPP indicated that support and feedback from interventionists during programs were a critical element, predictive of greater weight loss success [9,67,75]. We built upon that important finding and applied the COI framework, the TTM, and MI to guide and enhance interventionist–participant interactions. Supporting the utility of these adaptations, our pilot had very high meeting attendance rates, fitness tracker usage, regular weight monitoring, and food logging relative to previous reports [6,7,9]. Participants also reported their appreciation for the

convenience of the remote format and the ability to attend while at home, work, commuting, on vacation, and while caring for grandchildren.

Fidelity has previously been identified as a major issue for lifestyle program efficacy [6]. To address this, we developed standardized presentations to support program fidelity (Appendix 2.5) which, along with remote monitoring technology, allowed for an entirely online intervention. Sessions were structured around visual slides presented in a videoconference and outlined all session points. This allowed all participants to receive the same intervention information and to join other groups for make-up sessions without continuity issues. Session polling and structured conversation prompts resulted in high participation and engagement with learning objectives and offered the interventionist the ability to evaluate knowledge integration [76,77]. The use of the flipped classroom approach allowed concepts to be explored among peers and affirmed by both peers and the interventionist [76]. Additionally, operating the program remotely improved the ease of administration, required few research center resources, increased scheduling flexibility when, and enabled robust data collection, consistent with prior reports [21].

Technology utilization has historically been considered an obstacle for tech-based and/or remote programs for older adults [65,78]. The utilization of fitness tracking devices is associated with improved health outcomes for older adults, and some offer important added benefits including alerts for atrial fibrillation and for monitoring fall risks [16,17,20,78–82]. However, older adults are less likely than other adults to adopt these devices independently [79–83]. The perceived complexity and learning burden have been identified as key barriers to the adoption of fitness devices, but prior research suggests that when interventionist support is available, older adults indicate acceptance, enjoyment, and increased use of these self-monitoring tools [79–83]. Indeed, when adopted, these technologies seem to support greater WL success for older adults compared to younger adults [80–82]. Nevertheless, online, and tech-based interventions have historically largely been considered incompatible with older adults, and thus

infrequently attempted, and at times even discouraged [65,78]. However, the recent uptick in telehealth and smart technology utilization among adults >55 years of age presents a unique opportunity [16,17]. We found that the modifications made in this adaptation offered ample opportunity to support adoption, high utilization, and participant mastery of these modern tools. In previous studies, mixed doses of remoteness (i.e., hybrid formats) were suspected to negatively impact intervention programs, compared with exclusively in-person program formats [9]. Based on our pilot, we think that exclusively remote delivery may provide the opportunity for participants to try, practice, and adjust to technologies with exposure to more savvy peers. Unlike in a shifting format, or in one where participants can elect to go in-person, enrollment in a fully remote program provides opportunity for both vicarious and mastery experiences known to be key drivers for self-efficacy, alongside the persuasive and affective messaging of the program materials and interventionist communications [84].

Another minor, but interesting, observation was that participants who intended at baseline to focus primarily on exercise reached an average of 5% WL by six months, whereas those intending to change diet achieved an average of 12%. This supports findings by us and others that exercise may not play a central role in weight loss [85,86].

The proportion of adults in the United States over 55 years of age continues to increase, and along with it, the rise in prevalence of diet- and age-related chronic illness. Intervention programs that address lifestyle factors known to improve healthy aging and to reduce the prevalence, severity, and progression of these chronic illnesses are an urgent public health priority [1–3]. The DPP was developed to address major components of the disease progression from overweight/obesity and pre-diabetes to type 2 diabetes [4]; given that these components share considerable overlap with strategies to address other major diseases including cardiovascular disease, liver disease, kidney disease, and cognitive decline, strategies that optimize the efficacy of such interventions may have a substantial impact on the development and progression of several, co-occurring and discrete major non-communicable diseases

[72,87]. Our pilot was able to produce clinically impactful results among participants, whereas the otherwise similar participants randomized to the control group had a marked increase in their weight during the same period. Full-scale trials are needed to demonstrate the efficacy of this approach; however, if successful, further implementation in community and healthcare settings could help reduce the burden of cardiometabolic disease for this high-risk population.

Strengths and Limitations

A major strength of our study was the development of materials to support future remote delivery of the DPP (Appendix 2.5). In addition, we used a randomized trial design to pilot-test the new modification. Our study did find a small, one-time variation in weight between at-home and research center scales. However, this one-time observation only occurred among three participants (Appendix 2.4) and was most likely the result of participants neglecting to fast before their on-site visit, or because the amount of variation was very small, it may be due to fluid intake/retention. The small difference in values was reported but did not change the conclusion that the intervention achieved substantial weight loss for all participants and clinically impactful weight loss (>5%) in 90%.

This report includes results from a six-month pilot feasibility trial, and, as such, has a small sample size ($n = 20$). Future research will evaluate longer-term results and within larger samples, including investigations within sub-groups and identified strata to support greater generalizability and scalability. Additionally, a larger study will be able to compare results to other biomarkers and comprehensive dietary intake assessment data.

5. Conclusions

This adaptation of the DPP was tailored to older adults and delivered as an entirely online, remote-classroom, eHealth intervention. Tailoring approaches for compatibility and program fidelity are likely to

drive greater engagement and adherence to programs, with corresponding results in WL outcomes. Through a combination of personalized feedback, facilitated conversations, stage-matched prompts, dynamic classroom sessions, and remote-monitoring technology, we implemented a lifestyle program that fostered high adherence, attendance, and engagement (100%). Improved adherence and engagement were accompanied by clinically significant WL (9.5%), which is known to be a vital component of healthy aging among older adults with overweight and obesity.

Once thought incompatible with older adults, remote-education-based healthy lifestyle programs can be feasible and effective for this priority group. Remote technology and videoconferencing enable interventionist support, the development of health-promoting self-monitoring habits, and an environment of peer support that enables robust health behavior change. The use of standardized classroom materials developed for this pilot helped to safeguard fidelity to the program curriculum and can be utilized in future implementations with the potential to increase the efficacy of lifestyle interventions in older adult populations.

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Chapter 3: Scoring Adherence to Voluntary Restriction Diets (SAVoReD) in the ADAPT Study

Suzannah Gerber, Paul F. Jacques, Kara Livingston Staffier, Micaela C. Karlsen, Susan B. Roberts, Sara C. Foltz, Christina D. Economos, Nicola M. McKeown

Abstract: Voluntary adoption of popular food-group-restricting diets like Paleo and plant-based diets (PBDs) are often health-motivated. However, unlike the theoretical design of these diets, different levels of dietary adherence may result in different diet quality and bodyweight in real-world settings—a limitation to the efficacy of dietary interventions. Scoring Adherence to Voluntary Restriction Diets (SAVoReD) is a metric to quantify and compare adherence across food-group-restricting diets. We applied the score to four diets, whole food plant-based (WFPB), vegan, vegetarian, and Paleo to examine associations between adherence and diet quality (Healthy Eating Index; HEI), body mass index (BMI), and diet duration. We also explored the independent associations of adherence and duration with BMI. Higher adherence to WFPB and vegan diets was significantly associated with lower BMI, but no association was observed for vegetarian or Paleo diet followers. For vegan and WFPB, greater adherence was associated with lower BMI among those following their diet ≥ 2 years compared to < 2 years. Adherence was lowest in the diet with the most restrictions (WFPB); however, the stricter fully plant-based diets (WFPB and vegan) had the healthiest HEI scores and BMIs and many long-term followers. Our results suggest that identification with fully plant-based diets is associated with better diet quality and BMI. Vegan, vegetarian, and WFPB diets are often grouped as ‘plant-based diets’ despite the differing diet compositions, diet quality, adherence, and BMI of followers—thus, grouping them may distort findings. Individuals may benefit from encouragement following a fully plant-based diet, even without perfect adherence.

Keywords: Adherence, vegan, Paleo, vegetarian, plant-based, diet quality, adoption, maintenance

1.0 Introduction

Diet is the leading cause of chronic illness in the world [1], yet healthcare providers are reluctant to recommend dietary approaches for disease prevention or treatment, due to concerns about adherence [8, 9]. Greater adherence to diet has been associated with improved weight loss and maintenance [36], and better health outcomes including remission for type 2 diabetes (where diet is a first-line treatment) [299-301]. However, adherence remains a significant barrier to clinical application [9]. Real-world diet is influenced by many complex factors including motivation, food literacy, cooking skills, cost, access, social support, self-regulation, and commitment which influence diet behavior multiple times a day [15, 38]. While many studies explore diet adoption and motivation [11, 12], maintenance duration [16], and the diet quality of specific diets like plant-based diets (PBDs) [82] heterogeneous dietary assessment methods, definitions of adherence and diets, and nonspecific adherence metrics may conflate the above constructs.

Specific measures of adherence are needed to enable independent evaluation of distinct diet behaviors, facilitate the development of interventions targeting adherence, improve the accuracy of diet-disease models, and disentangle adherence from duration to allow for performance evaluations of popular diets over time. Given long latency of diet-related diseases [2, 95, 96] and the varying methods of reporting and categorizing dietary intake [97-100], current methods may obscure which diet sub-components drive outcomes. New methods to quantify dietary adherence may also help better define what is successful for adherence, which is needed to support diet adoption and increase the utilization of diet change implementation in policy and clinical practice.

Adherence typically refers to following clinical or research guidance [115], but free-living individuals hold varying beliefs about what health means regarding food and diet [81], and frequently adopt popular diets voluntarily outside of clinical or experimental settings. In that context, adherence to popular diets among free-living individuals would refer to how strictly an individual follows the rules of

their chosen diet [9]. Adherence is sometimes conflated with the construct of diet maintenance duration (i.e. how long a diet is sustained) [115]; however, diet adherence may vary unrelated to duration, including through intentional deviations like “cheat days,” fluctuations in dietary self-restraint, annual cultural practices [302, 303], or variations in food access [9, 80, 304, 305]. While diet duration and recidivism prevention are both important to health, duration is likely to be independent from level of adherence, further highlighting the need for accurate measures of adherence.

Diet-specific adherence scores exist for the Mediterranean [92] and Dietary Approaches to Stop Hypertension (DASH) diets [93], and indices like the Healthy Eating Index (HEI) calculate adherence to the Dietary Guidelines for Americans (DGAs) [94]. By contrast, very little research assesses adherence to popular food-group-restricting diets beyond a self-reported binary for perfect adherence/non-adherence [18, 90]. Further, no known method exists that quantifies and compares the level of adherence across multiple popular diets or that compares adherence to the average dietary intakes of proximal peers.

Popular diets differ in structure [306], with some including complete eating plans, like the Mediterranean Diet, and others recommending macronutrient proportions, like ketogenic diets [304]. In contrast, some restrict the intake of specific food types and groups, such as vegan (which restrict all animal-sourced foods) vegetarian (which restrict animal-sourced meat); whole-food plant-based (WFPB, which restrict animal-sourced foods, with additional restrictions for added oils, refined sugar, and refined grains); or Paleo diets (which restrict grains, legumes, animal-sourced dairy, and often processed sugars and oils) have food type restriction as the primary or sole guidance [307, 308]. Despite following the same diet type, diet followers often have vastly different dietary patterns, including relative amounts of foods theoretically restricted on their chosen diet [306]. Free-living followers may also adhere differently to their diet for subjective reasons, like fluctuations in restrictive eating [306, 309, 310], temptation [311], or “cheat days” [302, 303]. Diet composition thus varies, despite following the same diet [312].

Definitions of PBDs also vary [313-316], ranging from diets entirely free of all animal-sourced foods like vegan, to vegetarian diets that exclude meat but include eggs and dairy (e.g. lacto-ovo vegetarian diets) [313-316]. PBD may also refer to diets that exclude all animal-sourced foods and additional foods like WFPB diets. Grouping these diets together as “plant-based” has led to confusion as to whether PBDs eliminate all animal-sourced foods, or simply reduce them, like flexitarian diets, and also complicates comparison of adherence and effect of plant-based diets on health [313-317]. Paleo diets also restrict entire food groups, such as dairy, grains, and legumes with multiple versions suggesting additional restrictions to recreate a theorized pre-farming human diet [318]. While following a PBD, for example, is frequently associated with lower average BMI [313-317, 319], as well as improved outcomes relevant to cardio-metabolic diseases and some forms of cancer, studies often lack differentiation between types of PBD and rarely assess the level of diet adherence. These definitional variations necessitate the development and use of adherence metrics that can compare diets with more specificity which could better inform about the amounts and sources of diet variation among real-world followers of these popular diets, providing actionable information about the levels of adherence associated with improved health—a known priority for nutrition research [320]

Diet maintenance duration is also highly varied among diet followers. Over 50% of vegans or vegetarians reportedly abandon their diet within a year [31], and Paleo dieters report average maintenance durations of 5-6 weeks [101]. Studies on plant-based and Paleo diets have shown that adopting these diet identities have a positive influence on health over short durations, and is associated with an increase in the adoption of other healthy lifestyle choices, including diet and exercise [7, 101, 261, 321]. However, clinically meaningful changes in outcomes such as body weight may require longer diet adherence but there is a dearth of data describing long-term, free-living, voluntary diet followers [7]. As such, little is known about how adherence varies across different durations, how this relates to diet quality, and to clinically relevant health outcomes such as BMI [18].

No gold standard method exists to quantify adherence or to compare adherence across multiple, popular, food-group-restricting diets. The objective of this study is to describe the level of adherence to popular diets among self-identified diet followers, comparing adherence levels across diet types. To do this, we developed the Score for Adherence to Voluntary Restriction Diets (SAVoReD), an instrument that measures adherence to popular diets based on the theoretical rules of each diet. We used the score to assess the relationship between adherence and diet quality (HEI), BMI, and duration following one's diet for four popular diets in a U.S. survey sample. We also aimed to disentangle the construct of duration from adherence by examining whether duration is directly associated with adherence and to explore if these are jointly or independently associated with BMI outcomes.

2.0 Methods

2.1 Study Design

The Adhering to Dietary Approaches for Personal Taste Study (ADAPT) was an online prospective cohort study conducted using a survey hosted by Qualtrics at Tufts University. The study protocol was reviewed by the Tufts University Health Sciences Institutional Review Board (HS IRB) and was previously published [322]. The original aim of the ADAPT Study was to examine the diet composition of the followers of popular diets and to describe dietary differences among them. The entire study was conducted online without interviewer supervision.

This study represents a secondary data analysis of the survey data collected in the first examination of ADAPT (2015-2020). Total participants in Exam 1 were N=3001; however, this analysis is restricted to followers of the four popular diets (WFPB, vegan, vegetarian, and Paleo) that each had the greatest number of responses and together comprise approximately 73% (n=2187) of the total sample. We further excluded participants if they failed to complete a dietary intake assessment (n=894), if they reported implausible average energy intakes of <600 or >5,000 kcal per day (n=2); if their BMI (kg/m²)

was outside of the biologically plausible range (12-70 kg/m² (n=4 with BMI reported >70 kg/m²); and/or had missing body weight data (n=5). (See Fig 1–Flow Chart). No significant differences in demographic characteristics were found between the participants in this analysis and the total sample from ADAPT Examination 1.

2.1.1 Assessment of Dietary Intake

Dietary intake including intake of foods, food groups, and total energy was assessed using the Diet History Questionnaire II (DHQ-II) [323], a validated instrument that asks participants to report the frequency of the foods they consumed over the last month. Data captured included portion sizes and probing questions regarding types of foods, preparation methods, beverages, and supplements to reduce measurement error and recall bias. The plausible energy intake range (600-5,000 kcal/day) was determined using commonly applied criteria [324] and was verified within this population using 1st and 99th percentile intakes across all participants.

2.1.2 Diet Type Identification

Diet type was determined from self-report in response to the following question: “Would you use any of the following terms to describe what you typically eat? Please choose the one that best matches what you would say.” Participants were given 18 single-choice options that included vegan, vegetarian, whole-food plant-based (WFPB), and Paleo among the options. Ten respondents selected following a “raw vegan” diet and were included as “vegan”.

2.2 Measures

2.2.1 Adherence to Diet

Each of the four popular diets in this analysis restricts the consumption of different food groups (See Table 2). Using data from the DHQ-II, adherence scores were tabulated based on the amount that an individual consumed foods restricted by their self-identified diet. The total number of food groups restricted by each diet was five for vegans, eight for WFBP, three for vegetarians, and three for Paleo.

Data from the National Health and Nutrition Examination Survey (NHANES) [325] was used as a population-based reference for comparing the usual intakes of various restricted foods to diet followers within the ADAPT sample. We chose this approach to be able to describe adherence to a restriction-type diet, comparing intakes of restricted food groups to the intake levels in the greater population. Using a population reference allows for standardization of the adherence score, enabling it to be applicable for future studies, and allows the score to be tailored to different cultural and national contexts. NHANES intakes were derived from the What We Eat in America (WWEIA) sub-section of NHANES with food amounts categorized using the official USDA Food Patterns Equivalents Database (FPED) [326] from the 2013-2016 NHANES cycles [327-329] except for cured meats which were derived from 2007-2010 data [330] because no published data on the usual intakes of cured meats was available for 2013-2016. These cycles were chosen to match the period of ADAPT Exam 1. NHANES utilizes a 24-hour multi-pass method to collect dietary intake data, and data must be converted to estimate usual intakes at the population level. National Cancer Institute methods were used to estimate usual intakes from the NHANES 24-hour recall data, as published by the USDA [331]. Points in the SAVoReD adherence score correspond to quartiles of intake above zero within the reference population from NHANES, by sex, for each restricted food.

Adherence was calculated for each diet, according to the principles of each diet [313, 318]. Scoring was as follows: 0 points for perfect adherence (completely abstaining from a given restricted food

group), and one additional point for intakes in each successive quartile of intake based on NHANES intake data for a total of four possible points per food group, with lower numbers indicating higher adherence (Table 1-3). As an example, both vegan and WFPB diets exclude eggs, and the quartiles of usual intake of eggs for Americans from 2013-2016 was 0.20 eggs/day for both males and females (25th percentile), 0.5 and 0.4 eggs/day for males and females, respectively (median intake), and 0.90 and 0.70 eggs/day for males and females, respectively (75th percentile). Applying the score, vegan and WFPB diet followers would get 0 points for abstaining entirely from eggs, would get one point for consuming >0 and ≤ 0.20 eggs/day; two points for >0.20 and ≤ 0.5 for males, and ≤ 0.4 for females; three points for >0.5 (males) and 0.4 (females) and ≤ 0.9 or <0.7 , respectively; and four points for egg intakes above 0.9 and 0.7, respectively. (For more on this example, See Appendix 3 - Supplemental Table 1.)

Each diet has a different possible total number of points because the total point ranges correspond to the number of food groups restricted in each diet. Thus, the score range was 0-12 points for vegetarian and Paleo diets, 0-20 points for vegan, and 0-32 points for the WFPB diet. To account for this difference, the scores for each diet type were divided by the maximum possible score of that diet, subtracted from one, and multiplied by 100 to create a continuous adherence score allowing us to compare the degree of adherence (expressed as a %) within and across diets. Additionally, adherence was further examined by sorting participants into tertile categories of adherence within their diet group to assess whether low, medium, or high adherence was associated with HEI scores and BMI (kg/m²) outcomes.

2.2.2 Diet Duration

Participants reported their diet duration in response to the following question “What is the length of time you have been following your diet?” Seven possible responses ranged from “Less than 6 months to just under 1 year” to “Over 10 years/lifelong” (See Table 1). Durational periods were re-structured using the midpoint time of each response category to be used as a continuous variable. For example, the

category “5 years to just under 10 years” was re-structured to 7.5 years, the midpoint point between 5 and 10. Based on participant distribution, duration was also collapsed into two categories (<2 years following one’s diet (short-term duration), and ≥ 2 years following one’s diet (long-term duration)) to assess differences in stratified duration. (Table 4)

2.3 Outcomes

Diet quality was calculated using DHQ-II dietary intake data and scored using the HEI-2015 [94], a quality-based score from 0-100 assessing 13 components of diet adequacy in intake in concordance with the DGAs. BMI was derived from self-reported height and weight data and expressed as a continuous numeric value in kg/m^2 . We excluded BMI data that fell outside the biologically plausible range for BMI (12-70).[332] Adherence score was also used as an outcome variable when duration was the independent variable, as described above with both the continuous score and the tertile of adherence.

2.4 Covariates

Age (continuous) and sex (binary) were included as covariates in all models. For physical activity, the International Physical Activity Questionnaire (IPAQ) was used for estimating self-reported physical activity. IPAQ includes information about the number of minutes per week a participant spends walking or doing moderate and/or vigorous exercise. We used the protocol for the second version of IPAQ wherein exercise is weighted by vigor and calculated as a single continuous score estimating the metabolic expenditure of total exercise (MET-minutes). [333]. Continuous values were assessed for improbable numbers. No exclusions were necessary.

2.5 Statistical Methods

Differences in demographics of age, energy intake, exercise (IPAQ), and duration on diet across diet groups were tested using a general linear regression model, adjusting for sex and age (except age which was adjusted for sex). Differences in sex (binary) across diet groups were tested with logistic regression, with class-wide type three analysis Wald Chi-Square used to indicate significance.

Adherence scores were calculated as described above and reported as the mean percent of adherence by diet. The degree of adherence was also characterized as perfect adherence (100%), high adherence >75%, moderate adherence >50-75%, moderate non-adherence 25%-<50%, and non-adherence <25%. The percentage of diet followers within each NHANES intake quartile per category of restricted foods was also reported specific to each diet to depict and compare the sources of non-adherence.

Due to the complex relationship between diet, diet duration, and BMI [90, 116, 117] and our objective to disambiguate adherence and duration which are often conflated, we first tested duration (continuous) and BMI in our sample using general linear regression models adjusted for age, sex, physical activity (IPAQ Scored MET-minutes), and total energy intake before adding these into our primary research models. The model was first applied to the total sample and then disaggregated by diet group.

To evaluate the relationship between adherence to diet and diet quality, we categorized participants within their diets by tertiles of adherence. The association between tertiles of adherence and HEI Score as a continuous outcome variable was assessed using a least-square means from fixed effects linear model adjusted for age and sex (Model 1), with a second model adding adjustment for duration on diet (continuous) (Model 2). All models first assessed the total sample and then disaggregated by diet group.

Tertiles of adherence and BMI as a continuous outcome were also evaluated using a least-square means from fixed effects linear model. Models were adjusted for covariates additively, first adjusting for

age and sex (Model 1), and then adding diet duration (continuous), physical activity (IPAQ Scored MET-minutes), and total energy intake (Model 2), with a further model adding HEI score (Model 3). All models were first applied to the total sample and then disaggregated by diet group.

To establish that adherence and duration are independent constructs, the association between duration (continuous) as the independent variable and adherence score (continuous) as the outcome was examined using a general linear model adjusted for age and sex (Model 1). We then examined this relationship using short-term and long-term duration (Model 2).

As part of exploratory analyses to examine differences in the relationship between adherence and BMI among short- and long-term dieters, we conducted an additional analysis with the adherence score (continuous) as the independent variable and BMI as the outcomes variable, stratified by diet duration. Using a linear regression model adjusted for age, sex, IPAQ score, total energy intake we explored mean BMI among short-term and long-term diet followers in the full group, and then disaggregated by diet. We also explored the possibility of an interaction between adherence and duration for BMI outcomes by adding an interaction term of the adherence score and continuous duration (for maximum power) to the regression model adjusted for age, sex, duration (continuous), IPAQ score, and total energy intake, as described above.

Statistical significance was set at the $\alpha=0.05$ level or lower. Models used predetermined covariates and were developed additively, using the adjusted R-squared to assess model fit. All analyses were performed using SAS for Windows version 9.4. As a secondary data analysis, hypotheses were not specified before the data were collected; however, the analytic plan for this study was pre-specified before analysis commenced and no data-driven analyses were employed.

3.0 Results

Participant Characteristics can be seen in Table 4. Sixty-one percent of participants reported that they have been following their chosen diet for >2 years and 46% reported following for >5 years, 79% were female, and the average age of participants was 52. (Table 4) Additionally, 51% of participants reported annual income >\$100,000/year, a majority were married (71%), well-educated (82% college degree or higher), and were non-Hispanic white adults (95%). The final sample was n=1282 (vegan: n=352 (28%); WFPB: n=706 (55%); Paleo: n=135 (11%); vegetarian: n=89 (7%).

There were some significant differences between diet groups (Table 4), notably for sex (adjusted for age, $p<0.02$), with a higher percentage of females following a vegetarian diet and WFPB diet than males. Concerning age, after adjustment for sex, the mean age of those following the WFPB diet was higher (54.7 years compared to less than 49.8 years of age in other diets). Mean daily energy intake, after adjustment for age and sex, was lower in Paleo followers compared to other diet groups (mean 1,424 kcal, vs >1630 kcal in other diets). A greater proportion of Paleo dieters followed their diet <2 years (53%) compared to WFPB (41%), vegan (32%) and vegetarian (24%). No significant differences were observed in IPAQ scores across diets ($p<0.58$). Adjusting for age, sex, physical activity, total energy intake, and duration following one's diet, a 10-point higher HEI score was significantly associated with a BMI 2 kg/m² lower in WFPB diet followers ($p<0.001$), a BMI 1.3 kg/m² lower in BMI for vegans ($p<0.001$), and 1.5 kg/m² lower for vegetarians ($p<0.048$). There was no statistically significant relationship between HEI and BMI for followers of the Paleo diet ($p=0.88$). (Data not shown.)

3.1 Adherence

The mean adherence score for all diets was 71.3% and scores ranged from 25% to 100%. Vegans had the highest mean adherence score (75.2%), followed by vegetarians (74.6%), WFPB (70.2%), with

Paleo diet followers found to have the lowest adherence score (64.9 5%) (Table 5). For high adherence, a greater frequency of vegans were classified in this group (27%), followed by vegetarians (15.6%), WFPB (14.6%), and Paleo diet followers last (13.2%) (Table 5). Perfect adherence to any diet was observed in less than 1% of the sample. A greater proportion of Paleo diet followers (19%) showed moderate-non-adherence (<50%-25%), compared to <5% of persons following all other diets, and less than 1% of vegans (Table 5).

Based on DHQ-II dietary assessment, the vast majority of the sample had intakes of foods restricted in their diet that were considerably lower than the U.S. reference. However, the degree of adherence within diets varied by restricted food group. For individual food groups, 10% of vegetarians and >5% of WFPB diet followers (compared to 1% in vegans) reported non-adherence (consumption greater than the U.S. mean intake) related to seafood, while more than 20% of Paleo diet followers were non-adherent to legume intake (Figure 2). No WFPB or vegan followers reported perfect adherence regarding dairy restriction, while no Paleo followers had perfect adherence regarding grain restriction. Finally, no WFPB followers reported perfect adherence to oil, sugar, or refined grains. (Figure 2). For vegans, dairy was the only food group where non-adherence was reported by greater than 5% of followers (6.5%). Both vegetarians and WFPB had considerable non-adherence related to seafood intake (8.9% and 5.4%, respectively). With Paleo diet followers, 10.3% reported non-adherence to dairy intake and 19.1% had non-adherence to restriction of legumes. The restricted food group with the greatest degree of non-adherence was refined grains among WFPB (17.2%).

3.2 Duration and BMI

Compared to those with long-term durations following their diet (≥ 2 years), those with short-term diet durations had a BMI >1.4 kg/m² higher, on average adjusted for age, sex, exercise, and total energy intake ($p < 0.001$). This association was stronger for WFPB: compared to long-term diet followers,

short-term duration was associated with $>1.8 \text{ kg/m}^2$ higher mean BMI ($p<0.001$). Short-term duration was significantly associated with $>1 \text{ kg/m}^2$ higher average BMI among vegans ($p<0.05$). In paleo and vegetarians, a non-significant higher mean BMI was observed (0.85 kg/m^2 ($p=0.37$) and 0.18 kg/m^2 ($p=0.81$), respectively).

3.3 Adherence and Diet Quality (HEI Score)

HEI scores were above the US mean of 59 for all diets [334]. The lowest and closest to the US mean HEI score was observed for Paleo diet followers, with an unadjusted mean HEI score of $62.6 (\pm 8.5)$, followed by vegetarian at $72.6 (\pm 9.7)$, vegan at $75.7 (\pm 6.7)$, and WFPB with the highest mean HEI score of $76.7 (\pm 5.8)$. The percentage of participants with HEI scores below the US mean of 59 was 30.1% of Paleo followers, 7.8% of vegetarians, 1.7% of vegans, and 0.9% of WFPB dieters.

Figure 3 shows the relationship between the degree of adherence and HEI score, for each diet, adjusted for age and sex. Significant associations were observed between increased tertile of adherence and HEI score for WFPB (p for trend <0.001), vegan (p for trend <0.04), and vegetarian diets (p for trend <0.03). The relationship between adherence to the Paleo diet and diet quality was not statistically significant ($p<0.11$). In the second model, adjusting for duration, the association between adherence and HEI score remained statistically significant for WFPB (p for trend <0.001) and vegetarian (p for trend <0.02), but was attenuated and no longer statistically significant among vegans (p for trend <0.07) (figure 3). After adjustment for all covariates, the adjusted mean HEI scores in the highest tertiles of adherence for WFPB and vegetarian were 78.2 and 73.8 compared to the 76.2 and 72.3, respectively in the lowest tertiles for WFPB and vegetarian.

3.4 Adherence and BMI

The highest mean (SD) unadjusted BMI was observed in Paleo diet followers at 25.5 (± 5.3) kg/m², followed by vegetarian 24.9 (± 5.5) kg/m² and WFPB 23.9 (± 5.1) kg/m²; it was lowest among vegans 23.6 (± 4.1) kg/m². (Table 4) The association between the degree of adherence (expressed as tertile) and BMI across each diet is shown in Figure 4. After adjustment for sex, age, exercise, total energy intake, and duration following one's diet, a significant inverse association was observed between increasing tertiles of adherence and mean BMI for WFPB (p for trend <0.001) and vegan diet (p for trend <0.001) followers (Model 2). Although further adjustment for HEI score (Model 3) slightly attenuated the association between adherence and BMI, the significant inverse associations remained. Compared to the least adherent tertile, the highest tertile of adherence had a mean BMI 2.2 kg/m² lower for WFPB (p<0.001), and 1.8 lower for vegans (p<0.001). No statistically significant associations were observed for vegetarian or Paleo dieters.

3.5 Relationship of Diet Duration to Adherence

Greater duration following one's diet was associated with modestly higher adherence in the total sample, adjusted for age and sex (each additional 1.6 years associated with a 0.20 percent increase in adherence score on average, p<0.009). However, when disaggregated by diet, duration was not significantly associated with adherence for any of the four diets. Similarly, when duration was stratified into short and long-term (above and below 2 years), no statistically significant associations were observed between duration and adherence directly.

3.6 Exploratory Analysis of Adherence and BMI By Diet Duration

To explore whether the relationship between adherence and BMI varies by duration, we looked for strata-specific differences in mean BMI (Table 6, Appendix 3 - Supplemental Figure 1). In the fully

adjusted model with the entire sample, higher adherence (continuous) was significantly inversely related to BMI (10% higher adherence score was associated with 1.33 kg/m² lower BMI, $p < 0.0001$) for those following their diet for < 2 years. Among long-term followers (≥ 2 years), this was slightly reduced, but still significant (10% higher adherence score was associated with 0.76 kg/m² lower BMI, $p = 0.0018$). In the fully adjusted model classified by adherence tertile and disaggregated by diet, BMI was significantly lower among those with long-term diet durations compared to short-term dieters following a WFPB diet (BMI -1.78 kg/m², on average; $p < 0.0001$) and vegan diet (BMI -1.04 kg/m², on average; $p < 0.042$). The Paleo diet group was similar, but not statistically significant (BMI -0.85 kg/m², on average; $p < 0.37$), and unlike the other groups, long-term vegetarians had a slightly higher average BMI, although this was not statistically significant (BMI 0.29 kg/m², $p < 0.86$).

The model evaluating interaction between adherence and duration was not statistically significant for BMI in the pooled sample ($p = 0.07$), or for any single diet (Paleo $p = 0.30$; vegan $p = 0.24$; vegetarian $p = 0.28$; WFPB $p = 0.96$).

4.0 Discussion

We developed the Score for Adherence to Voluntary Restriction Diets (SAVoReD), a metric to calculate the level of adherence to popular food-group-restricting diets and used it to analyze the relationship between adherence to these popular diets and BMI, diet quality (HEI), and duration on diet, respectively. SAVoReD is designed to compare adherence across popular diets and can be adapted to reflect the usual intakes of restricted foods in different populations. In our sample of voluntary popular diet followers in the United States, we found that higher adherence to WFPB and vegan diets was inversely associated with BMI. In contrast, we did not observe this association in followers of the Paleo diet, or those following the partially plant-based vegetarian diet. Although our study did not evaluate

many clinical outcomes, our findings corroborate other studies that found that vegan and WFPB diets positively impact diet quality and BMI [319, 321]. Our findings add valuable insights and confirm our hypothesis that the level of adherence, not simply self-identification, to these diets correlates with better diet quality and healthier BMIs.

Dietary adherence is commonly assessed with self-reported single survey questions like, ‘How closely do you follow your diet?’ (Lemstra, Bird, Nwankwo, Rogers, & Moraros, 2016) or ‘How important is following your diet?’ (Cruwys, Norwood, Chachay, Ntontis, & Sheffield, 2020). By considering the degree of adherence to each diet based on self-reported diet intake data, together with the rules of adherence to each diet, we were able to classify adherence more accurately than subjective self-reports of adherence or dichotomous indicators of perfect adherence—however a gradient of benefit at multiple levels of adherence was observed suggesting opportunities for future applications of the SAVoReD score in research on diet-disease relationships. Additionally, by differentiating between types of PBDs we were able to improve the specificity of results by diet type, including identification of specific sources of non-adherence. The structure of theoretical PBD and Paleo diets are believed to improve diet healthfulness [307, 318]; however, our findings suggest that greater adherence to fully PBDs is associated with healthier diet quality and BMI. Especially following additional testing, the SAVoReD metric can be used to provide greater insights into these diets as they are freely followed, including direct evaluation of which adherence variations relate to indicators of health.

Prior methods for scoring adherence exist for diets such as the HEI, DASH, and Mediterranean Diets [93]. Those scores are tailored to each diet, based on the theoretical list of foods both to include and to exclude on that diet. In contrast, adherence to restriction-type diets is defined by food group exclusion, and thus for many of these diets, adherence may be high even when optimal healthfulness is not prioritized. Diet healthfulness is well characterized by indices such as the HEI, and for PBDs with the Plant-Based Dietary Index [82]. However, no method for describing adherence to restriction-type diets

has been developed that disentangles adherence from empirical estimates of healthfulness to allow adherence and healthfulness to be compared, compared across diets, or compared to usual intakes within the greater population.

Comparing intakes of popular diet followers to intake levels in the general population is an important consideration [320] not often included in adherence metrics. Voluntarily adopted popular restriction diets promote reduced intakes of specific foods; however, different populations likely have different usual intakes of these food groups [98, 335-337]. Thus, comparing intakes of food groups based on a population reference allows for a measurement that is more sensitive to cultural, regional, and contemporary dietary practices among proximal peers and thus may more accurately reflect the level of restriction performed in pursuit of following a popular diet. We developed our novel adherence score to be complementary to existing healthfulness indices and can be used to compare dietary adherence behavior between restriction-type diet followers in order to identify differences in operation, dietary composition, and how the level of adherence may influence health beyond diet identity. Isolating adherence with this objective method, and by using established dietary assessment instruments, the associations between the level of adherence and clinically relevant outcomes can be directly assessed. Furthermore, this approach provides more accurate information on adherence than self-identification or the report of subjective importance, intention to adhere, or other often conflated constructs, such as diet duration.

A higher HEI score has been positively related to cardiometabolic outcomes and to a healthier BMI in particular [338]. Indeed, a higher HEI score was observed in those with healthier BMI in the participants enrolled in the ADAPT sample. Of note, all four diets in the study had mean HEI scores higher than the US average of 59 [334, 339]; however, approximately 30% of Paleo diet followers had HEI scores below the national average suggesting that diet quality may be a concern for a significant number of individuals following this diet. This is similar to observations in other studies that found that

the more plant-based the target diet, the better the diet quality, even with only partial adherence [13]. PBDs consistently produced the highest diet quality scores, and although vegetarians had higher HEI scores than Paleo, vegetarians had considerably lower HEI scores than the fully PBD groups (vegan and WFPB). Compared to WFPB and vegan, vegetarians had median intakes of dairy that were nearly three times higher, egg intake that was >3.6 times higher, tended to have far lower median intakes of legumes, and also had an additional teaspoon of added sugar and oil per day. (Appendix 3 - Supplemental Table 2). Compared to the fully PBDs, the lower HEI scores for vegetarians can be largely explained by higher intakes of saturated fat and worse fatty acid ratio (total unsaturated fats/unsaturated fats ≥ 2.5), as well as from lower intakes of whole grains, total fruits, and slightly lower intakes of total vegetables. (Appendix 3 - Supplemental Figures 2 and 3.) However, vegetarians had higher HEI component scores for lower intakes of sodium and higher intakes of dairy per recommendations from the DGAs, compared to vegans and WFPB. HEI scores for Paleo diet followers were the lowest of all four diet groups; lower Paleo HEI scores were largely explained by high saturated fat intakes (although fatty acid ratio scores were similar to vegetarians) low whole fruit, low plant- and sea-protein, and low whole-grain intakes. However, the Paleo group had higher HEI component scores for lower intakes of refined grains and higher intake of total protein, they also had greater HEI scores due to higher intakes of dairy compared to vegans and WFPB despite dairy restrictions on the Paleo diet. While vegan and WFPB HEI scores were similar including for many of the sub-components, vegan scores were lower than WFPB scores largely due to eating slightly less total protein, whole grains, fruit, and more added sugars, although they had slightly better component scores for saturated fat, fatty acid ratio, and sodium. Further research comparing these diet groups is needed to examine their impact on BMI and the specific health impacts attributable to these dietary sub-components, a nutrition research priority [320].

Emerging research focuses on evaluating the role of identity in the eating behavior of vegans and vegetarians and how these volitional diet identities form and influence food choice, diet quality, duration on diet, and adherence [17, 21, 22, 27-29]. Veganism and vegetarianism are frequently referred to as “lifestyles,” with a wider ethical system of belief wherein diet represents just one part of a larger identity and way of life. Thus, for those who identify closely, these diets may be intended to be lifelong when initiated, rather than an experiment for health, the exploration of a popular trend, or a short-term goal-oriented diet such as weight loss [21]. The lack of significant association between adherence and duration adds evidence to suggest that adherence and duration are separate constructs and further supports that dietary adherence is influenced by factors other than having more practice or exposure to one’s diet, as discussed in the literature on the behavioral drivers of diet. [8] Appendix 3 - Supplemental Figure 4 depicts a four-quadrant chart illustrating adherence and duration as separate constructs, using a plant-based diet as an example. While we did not find a significant direct relationship between adherence and duration, when stratifying by duration we observed that for those following their diet for a shorter duration tended to have higher BMI than long-term followers. Interestingly, we also observed that higher adherence was associated with lower BMI for both short- and long-term followers of WFPB and vegan diets, whereas greater adherence was only associated with lower BMI among short-term followers of vegetarian and Paleo diets. While small sample sizes in the Paleo and vegetarian groups limit comparisons between these groups, there appears to be long-term BMI benefit for maintaining WFPB and vegan diets at higher levels of adherence. This exploratory finding merits further investigation into divergent patterns in temporal effects of popular diets—given that all four of the diets in this study have higher average diet quality than the standard American diet, we would expect to see greater adherence associated with healthier BMI. Our findings agree with prior studies that indicate that weight status improves as target diets are increasingly adherent to plant-based diets [13]. Diet behavior theories often emphasize factors such as self-regulation, social and environmental

support, and identity congruence [305] as drivers of diet maintenance— but difficulty, or level of restriction of the diet is often thought to be a major barrier [35, 311]. Future research may benefit from evaluations of subjective commitment and other psychosocial factors related to diet-type identity to further examine drivers in diet duration.

Prior research and clinical perspectives include skepticism about the feasibility of adherence to restrictive diets. However, prior research may be lacking important nuance regarding the benefit of flexible or imperfect adherence, with clinical implications. While the WFPB diet excludes the most individual foods (all ASFs, and refined grains, sugar, and added oils) diet quality was highest among free-living followers of this diet (30% better than the American mean)—despite imperfect adherence. The next most restrictive diet, the vegan diet, which restricts all ASFs, had an HEI score close to WFPB and also had the highest adherence score. The most adherent tertile of vegans also had the healthiest mean BMI in the entire sample. This may suggest that not only can high diet quality be achieved on restrictive fully PBDs, but that adherence may not be inherently tied to the level of restriction. These results may also suggest that identifying with and attempting to adhere to these stricter diets long-term may support greater routine healthfulness even when perfect concordance with dietary rules is not achieved in a given dietary assessment period. While clinicians often resist treatment and prevention plans that center around food-group-restricting diets, our study found that the most restrictive diets (WFPB and vegan) had the highest adherence levels, best diet quality, and more followers of longer duration. Thus, support and encouragement along with further insights into the drivers of adherence such as diet motivation [11, 35], diet identity [17, 21, 22, 27-30, 91], and food and diet health beliefs [81, 171, 340] may help facilitate the adoption, adherence, and maintenance of these health-promoting diets. Future research comparing constructs of internal factors to adherence using the SAVoReD score may be able to reveal such insights in support of successful clinical and individual implementation.

The diets discussed in this study show promise to support health compared to the standard American diet; however, restrictive diets have at times been associated with some forms of disordered eating [341-344]. Plant-based and Paleo diets, as well as other popular restriction-type diets have been explored for possible relationships with disordered eating and are associated with the cognitive restraint and fixation on ‘healthy eating’ that accompany some disordered eating patterns [344-346]. However, plant-based diets and other “healthy orthorexic” eating patterns have also been observed to play a potentially therapeutic role in the behavioral management of disordered eating, including orthorexia nervosa, binge eating disorder, bulimia and anorexia nervosa [91, 347-350]. Just as there are low and high adherence patterns among individuals following these popular diets, there are more and less healthful ways for individuals to engage with these diets. Clinicians should monitor diet changes similarly to any other treatment or lifestyle change. The adherence score presented is not designed to assess disordered eating and cannot take the place of metrics of diet quality, overall diet pattern, total energy intake or eating behavior pathologies but may be an effective tool to use alongside these other specific measurements.

This novel method for calculating adherence to restriction-type diets can be adapted to any such diet to evaluate adherence, compare across diets, and compare intakes to an identified reference population. This approach could aid researchers seeking to understand how closely an individual follows their diet and can be included in other studies of diet-health relationships, alongside the clinical implementation of diet, and to help inform voluntary diet adoption among individuals.

4.1 Limitations and Future Research

The SAVoReD score offers great potential for future research to examine the association between dietary adherence and health outcomes. Future planned research will use SAVoReD compared to

subjective self-reports of adherence and commitment to diet, and to apply the score in studies that can gauge more robust health outcomes.

This report represents a cross-sectional analysis and as such it is limited by the possibility of reverse causality, especially for outcomes such as BMI. While a major strength of this study is the inclusion of a large number of diet followers with long-term diet durations, it is impossible to determine if recent diet adoption was related to a need for weight management. The ADAPT sample includes volunteer respondents to an online survey who overall tended to be affluent, white, highly educated, middle-aged, females and a high number of respondents following a vegan and WFPB diet, with fewer respondents following vegetarian and Paleo diets. Smaller sample sizes for Paleo and vegetarian diets prevented more granular investigation of duration, presenting an opportunity for future research to fully investigate the exploratory results of duration on BMI outcomes. Future research is also needed to understand the use of this algorithm among more diverse groups, compared to other reference populations, for other diet types, and to better understand how adherence relates to clinical outcomes other than BMI.

ADAPT utilized the well-established DHQ-II to assess dietary intake [351]. While the DHQ-II is a commonly used dietary assessment method, the food list was not developed or validated for these popular diets. DHQ-II includes some dairy and meat alternative foods; however, we found a higher-than-expected amount of dairy consumption among participants following diets that restrict dairy, and although this varied by diet and intakes were highest in the group that does consume dairy (vegetarian) some alternative dairy products might be misclassified as cow's milk—revealing an opportunity to develop methods tailored to these populations and as these products become more popular. The DHQ-II identifies foods classified as having added sugars but does not make distinctions between the types of added sugars or fat sources. Paleo diets commonly exclude some refined sugars and fats, but allow added sugars and fats such as honey, molasses, tallow and lard; similarly vegans typically do not

consume honey or any animal fats but otherwise don't restrict added sugars or plant fats, and WFPB restrict all added sugars and fats but may allow fruit pastes and juices which are at times classified as added sugars in the United States. Additionally, WFPB diets recommend reducing, but not eliminating, added salt; while DHQ-II captures sodium it does not differentiate between added salt and total sodium. We did not include salt or sodium in our criteria for WFPB adherence, especially given that this diet merely recommends limiting, but not restricting added salt. Future research may wish to adapt SAVoReD when applying it to other diets, when using other diet definitions, and assessment instruments with food lists created and validated for specific populations. As more novel foods are developed to cater to these diets, accurate intake assessment will become increasingly important to better understand the nutritional implications of these diets and their association with health outcomes [352-357].

The HEI score was used for these analyses because it is considered the gold standard for describing diet quality in the United States. While the total possible HEI score is impacted by the diets that exclude food groups positively scored by the HEI (such as dairy and grains) participants are non-differentially subject to those limitations.

5.0 Conclusions

While many popular diets offer a healthier alternative to the standard American diet, they do not equally or inherently increase diet quality. Clinicians often resist recommending restrictive diets due to adherence concerns, yet our study found that the more restrictive diets (WFPB and vegan) had higher adherence levels, better diet quality, and more followers of longer durations. Higher adherence was significantly associated with healthier diet quality and BMI for vegan and WFPB diet groups including for those following their diet long-term; however, we could not adequately compare these to relationships among the vegetarian or Paleo groups due to the relatively small number of study participants following these

diets. Our study results join prior studies in concluding that greater adherence to more plant-based diets may support nutritional health; our study further observed that sustaining identification as a follower of these diets long-term is further independently associated with healthier BMI and with diet quality. While, our results suggest that individuals may benefit from being encouraged to follow these diets with greater adherence, our results also indicate even imperfect or flexible adherence to these diets may be associated with improved levels of health indicators like HEI and BMI.

Despite being commonly grouped together as ‘plant-based diets,’ vegan, vegetarian, and WFPB diets are distinct diet types with different diet compositions, diet quality, adherence, and mean BMI among followers. Grouping these diets may thus distort findings in studies evaluating diet-disease relationships, especially when combining fully and partially plant-based diets. Assessing different levels of adherence can inform areas needed to improve diet quality, or to identify target levels of adherence, above simple diet identification and a subjective self-report of adherence, thus improving the clinical use of diet. SAVoReD may be used in the future to help develop targeted dietary interventions; to more accurately examine relationships between food groups, dietary patterns, diet types, and outcomes; and, importantly, to disentangle the construct of adherence from duration allowing us to examine how different diets perform over time, and whether outcomes are mediated by specific intake patterns or other factors that accompany diet identity.

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Tables and Figures

Table 1. Scoring Scheme

POINT VALUE (per restricted Food)	4	3	2	1	0
Usual Intakes (Sex-Specific)	>75 th percentile	>50 th -75 th percentile	>25 th -50 th percentile	>0-25 th percentile	0

NOTE: Usual intakes are specific to males and females and were derived from NHANES. Intakes for each food group was grouped into quartiles of intake which correspond to the points in the adherence score (1 point for each additional quartile, representing higher intakes of restricted foods), as listed above.

Table 2. Restricted Foods By Diet

	Legumes	Grains	Refined Grains	Dairy	Eggs	Red/Cured Meat	Poultry	Seafood	Added Fats	Added Sugar
Vegan				X	X	X	X	X		
WFPB			X	X	X	X	X	X	X	X
Vegetarian						X	X	X		
Paleo	X	X		X						

NOTE: Vegan (5 restricted foods): 0-20 possible points; WFPB (8 restricted foods): 0-32 possible points; Vegetarian (3 restricted foods): 0-12 possible points; Paleo (3 restricted foods): 0-12 possible points

Table 3. Cut-points Used for the Adherence Score: Usual Intakes from NHANES 2013-2016

		Males			Females		
		Percentile			Percentile		
		25th	50th	75th	25th	50th	75th
Legumes [§]	ounces	0.20	1.02	2.13	0.10	0.92	1.22
Grains	ounces	5.60	7.20	9.10	4.20	5.40	6.80
Refined Grains	ounces	4.60	6.20	8.00	3.40	4.50	5.90
Dairy	cups	1.10	1.60	2.30	0.90	1.30	1.80
Added Sugar	teaspoons	10.60	16.90	25.40	8.40	13.00	19.10
Discretionary Fats [§]	grams	52.60	68.90	88.00	39.70	52.80	68.30
Red/Cured Meats [§]	ounces	2.00	3.00	4.30	1.20	1.70	2.50
Eggs	ounces	0.20	0.50	0.90	0.20	0.40	0.70
Poultry	ounces	1.00	1.60	2.40	0.80	1.20	1.70
Seafood	ounces	0.20	0.50	0.90	0.20	0.40	0.80

NOTE: All data and units are derived from National Health and Nutrition Survey (NHANES)—What We Eat in America (WWEIA) and the related Food Patterns Equivalents Database (FPED), with usual intakes describing observed intakes from 2013-2016, with cured meats derived from 2007-2010, calculated using the National Cancer Institute methods for estimating usual intakes.⁵ Combined categories Legumes (legume vegetable, legume protein, and soy protein foods), Red/Cured (beef, organ meats, lamb game, pork, and processed meats of similar origin), Discretionary fats (Solid fats of animal origin and from sources such as tropical oils and added oils or foods with naturally high oil contents).

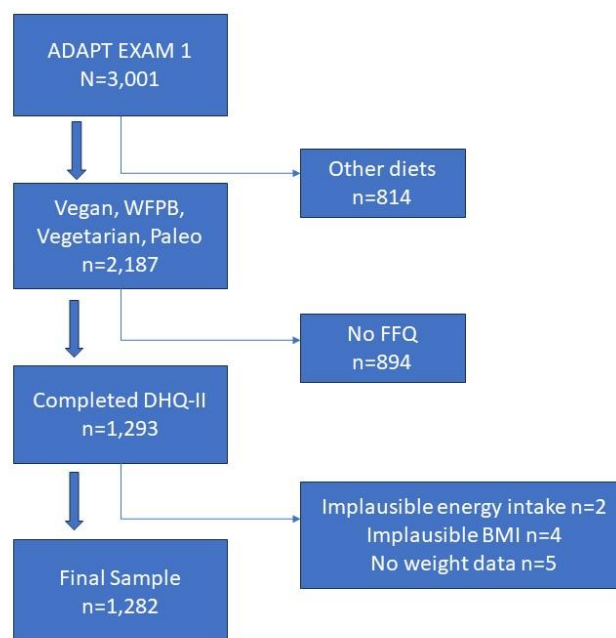
Table 4. Sample Characteristics of ADAPT Participants

	Total	Vegetarian	Vegan	WFPB	Paleo
N	1282	89	352	706	135
Age mean (SD)	52.1(14.0)	49.8(15.5)	48.6(14.9)	54.7(13.1)	49.2(12.4)
Sex, % female	79.3%	90%	76.4%	80.0%	77.0%
BMI, mean (SD)	24.1 (4.9)	24.6 (5.7)	23.6 (4.7)	23.8 (5.4)	25.5(5.3)
Daily Energy Intake (kcal) mean (SD)	1631.5 (625.3)	1637.6 (765.4)	1611.6(617.9)	1676.1(620.7)	1424.6 (505.4)
IPAQ/MET, mean (SD)	2736.7(1008.7)	2733.9(1064.6)	2747.6(1004.6)	2700.2(1016. 9)	2891.6(943.2)
HEI Score mean (SD)	74.6 (7.9)	72.6 (9.7)	75.7 (6.7)	76.7 (5.8)	62.5 (8.5)
<u>Diet Duration (n)</u>					
<6mos	40	3	4	25	8
6mos<1yr	61	3	11	41	6

1-2 yrs.	398	15	99	227	57
2-5 yrs.	199	2	58	122	17
5-10 yrs.	372	18	100	212	41
10+ yrs.	213	48	80	79	6
<u>Diet Duration n(%)</u> <u>re-categorized</u>					
<2 years	499 (39%)	21 (24%)	114 (32%)	293 (41%)	71 (53%)
≥2 years	784 (61%)	68 (76%)	238 (68%)	414 (59%)	65 (47%)

NOTE: Population Characteristics for participants in the Adhering to Dietary Approaches to Personal Taste (ADAPT) study (2015-2020). Participants included in these analyses represent those following a vegetarian, vegan, whole food plant-based (WFPB), or Paleo diet who completed a one-month Diet History Questionnaire II (DHQ-II) developed by the National Cancer Institute. No substantive differences were found comparing the above-described sub-sample of participants (n=1283) to the full sample (n=2187) following the same diets who did not complete the DHQ-II.

Figure 1. Inclusion Flow Chart



NOTE: The ADAPT study (2015-2020) recruited N=3001 participants. This analysis reports findings among followers of four diets (vegetarian, vegan, whole food plant-based (WFPB), and Paleo) together representing >73% (n=2187) of the total sample. We further excluded participants who failed to complete the Diet History Questionnaire II (DHQ-II (n=894)), or if they reported average energy intakes below 600 or above 5,000 kcal/day (n=2); had a BMI outside of the biologically plausible range (12-70 kg/m²); and/or had missing body weight data (n=5). No significant differences in characteristics were found between this sub-sample and the total sample.

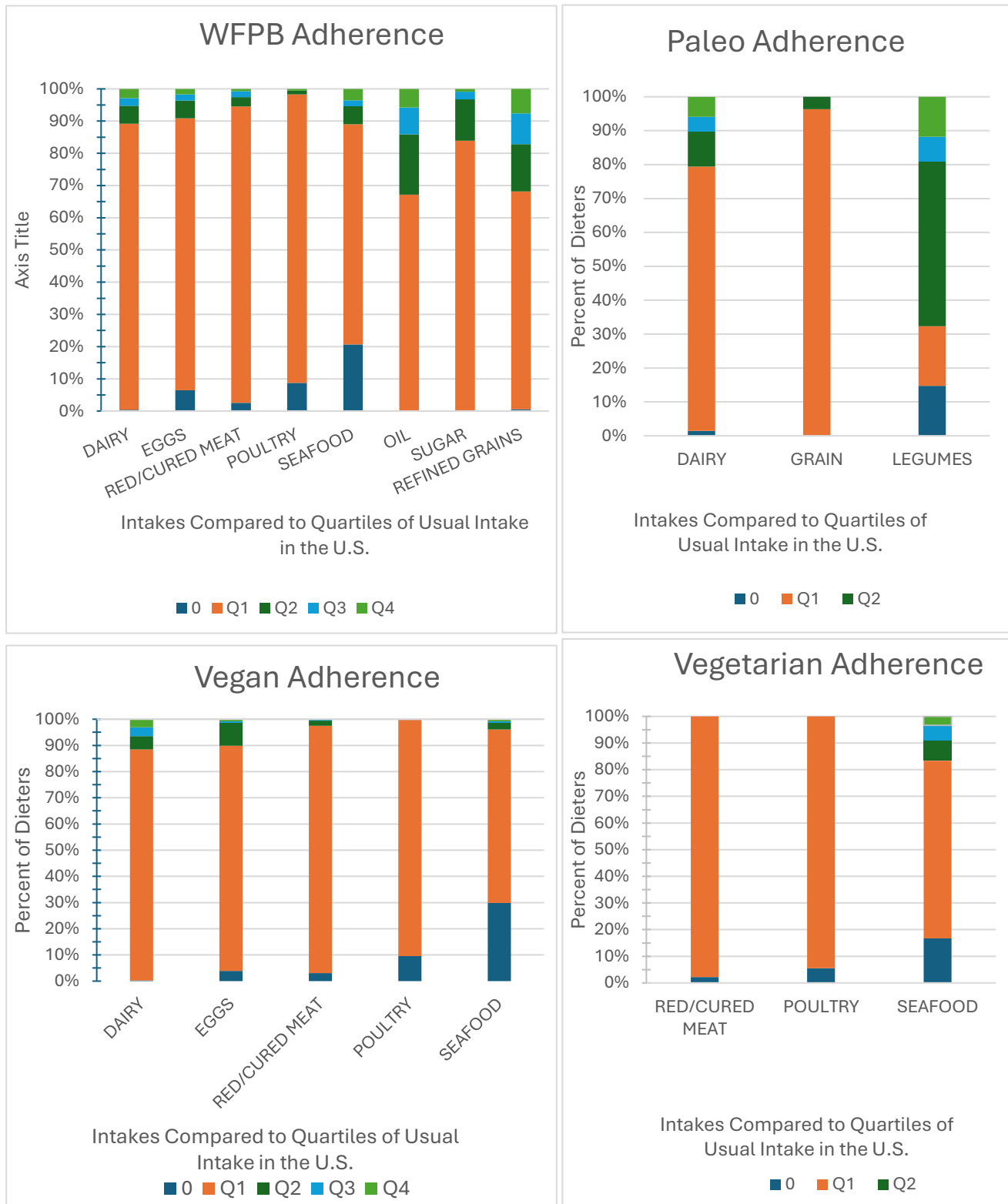
Table 5. Average Adherence Across Diets

	Mean (STD)	Median	Min	Max	Degree of Adherence				
					100%	>75%	>50-75%	<50% - 25%	<25%

TOTAL	71.33% (9.1)	75%	25 %	100 %	2 (0.1%)	232 (18.1%)	994 (77.5%)	61 (4.8%)	2 (0.1%)
Vegan	75.17% (6.6)	75%	45 %	100 %	1 (0.28%)	96 (27.0%)	256 (72.1%)	2 (0.6%)	0
WFPB	70.23% (8.4)	72%	34 %	94%	0	104 (14.6%)	576 (81.1%)	30 (4.2%)	0
Vegetarian	74.62% (8.2)	75%	50 %	100 %	1 (1.11%)	14 (15.6%)	72 (80%)	3 (3.3%)	0
Paleo	64.85% (13.0)	67%	25 %	92%	0	18 (13.2%)	90 (66.2%)	26 (19.1%)	2 (1.5%)

NOTE: Based on the rules of the self-identified diet, participant dietary adherence was scored and percent-standardized. Distributions within each diet can be seen on the left. On the right, the Degree of Adherence indicates the number of diet followers within each quartile of adherence.

Figure 2. Intake of Restricted Foods, within Diet Groups

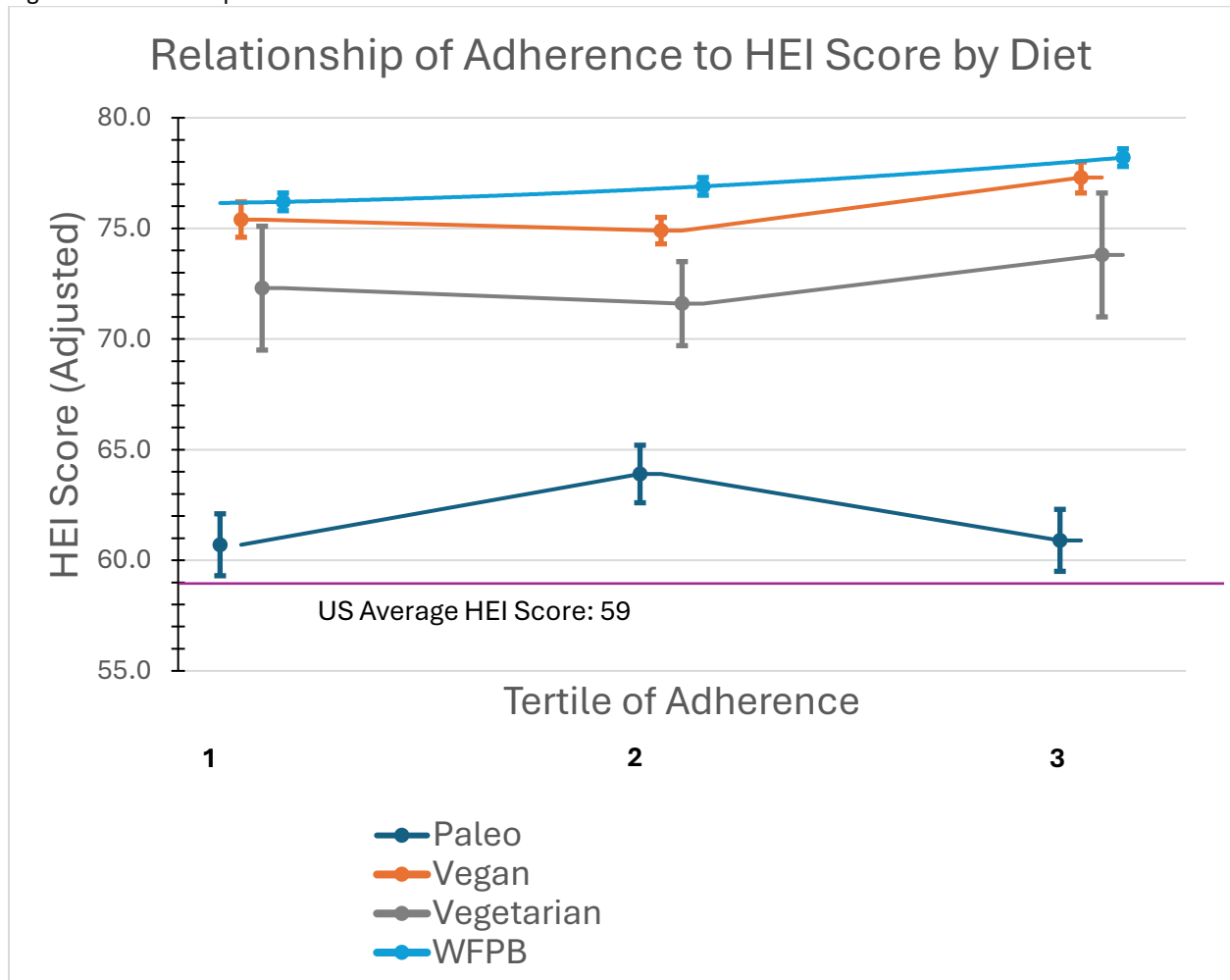


Note: Adherence to diet type by restricted food

group. Percentage of intakes of each restricted food group reported by ADAPT participants compared to the

quartile of usual intake of those food groups in the American population according to NHANES 2013-2016. The y-axis describes the percent of followers within each diet within the quartile of adherence (from 0 for perfect adherence, to quartile 1 (Q1) “highly adherent”, quartile 2 (Q2) “somewhat adherent”, quartile 3 (Q3) “non-adherent”, and quartile 4 (Q4) “highly non-adherent”).

Figure 3. Relationship of HEI Score to Tertile of Adherence



NOTE: Adjusted for age and sex. In the adjusted model, an increase in adherence tertile was significantly associated with reduced BMI for WFPB ($p < 0.001$), vegan ($p < 0.04$), and vegetarian ($p < 0.03$), but not for Paleo ($p < 0.113$). Lines depict fitted linear trend lines.

Table 6. Mean BMI Stratified by Duration Following One's Diet

<i>Duration and Mean BMI (unadjusted)</i>					
	TOTAL	<2y	≥2yrs	DIFF(%)	p-DIFF
Total Sample	24.1	25.0	23.5	-1.5(-6%)	<0.0001***
Paleo	25.5	25.9	25.1	-0.8(-3%)	<0.38
Vegetarian	24.6	24.5	25.0	0.5(2%)	<0.73
Vegan	23.6	24.4	23.3	-1.1(-5%)	<0.025*
WFPB	23.8	25.0	23.2	-1.8(-8%)	<0.0001***
<i>Duration and Mean BMI (adjusted)</i>					
	TOTAL	<2y	≥2yrs	DIFF(%)	p-DIFF
Total Sample	24.1	24.9	23.9	-1.4(6%)	<0.0001***
Paleo	25.5	26.1	25.0	-1.0(-4%)	<0.37
Vegetarian	25.1	24.5	25.3	0.8(3%)	<0.86
Vegan	23.7	24.4	23.4	-1.0(-4%)	<0.04*
WFPB	23.8	24.9	23.1	-1.8(-8%)	<0.0001***

Note: The top includes unadjusted mean BMI within diet for two durations: short duration (<2 years on diet) and long duration (≥2 years on diet). DIFF(%) is the difference between the stratified means, and the p-value for the different durations. The bottom depicts the means adjusted for age, sex, exercise (IPAQ), and total energy intake. Comparing short and long duration was significant for WFPB and vegan diet groups. (Reference values: *= p<0.05, ** = p<0.01, and ***=p<0.001.)

Discussion and Summary

Integration of Acceptance, Adoption, and Adherence

Together, the three studies offer insights into the interrelated stages of diet change: from initial exposure and acceptance of a novel food innovation to a theory-driven, short-term intervention aimed at supporting adoption and tracking sustained behavior change alongside real-time health outcomes, and finally, to an analysis of long-term voluntary diet adherence and its associations with diet quality and BMI. Each studied a distinct approach to reducing animal-sourced food (ASF) consumption and investigated a different pathway in the process-based framework of the three A's- acceptance, adoption, and adherence. In these studies, we see not only how acceptance, adoption, and adherence are interrelated, but also how they are constantly at play in daily decisions about what we eat, and how they influence the impact of dietary choices.

Summary of Key Findings by Study

Aim 1

The first study was an ethnographic examination of the world's first free and open-to-the-public cultivated meat (CM) tasting event. Despite being largely unavailable to the public, CM is frequently discussed in the news media and faces widespread domestic and international legislative prohibitions. Unsurprisingly, attendees at the tasting event had a mix of enthusiasm and skepticism for this novel food. Many were eager for the potential benefits of CM – citing interest in animal welfare, environmental sustainability, and the advancement of scientific innovation – and nearly all expressed a willingness to taste it. Importantly, while the sensory feedback was generally positive (e.g. referring to it as “juicy” and comparable to conventional meat), positive taste evaluation alone did not guarantee acceptance. Rather, attendees indicated that acceptance was contingent on trust and value alignment. While attendees endorsed that the event gave them newfound confidence in CM as a viable part of the future of food,

they also indicated that elaborate events in and of themselves do not allay their deeper value-based concerns and almost uniformly stated an expectation and preference for more information to be provided. A recurring theme in interviews was the demand for transparency about how CM is produced and regarding its true ethical, nutritional, and environmental impacts. Attendees expressed a need for credible evidence to substantiate claims that CM is safe, healthy, more humane, and/or more sustainable than traditionally farmed meat – mere assertions from the producing company were not sufficient. This represents a fairly distinct break from traditional food marketing—claims about these dimensions for most foods are seen as secondary or tertiary and when this information is absent it rarely perceived as an omission. However, for CM, these qualities seem to be intrinsically tied to the value proposition of CM for would-be early adopters at the event and are certainly dominant themes in both media and company talking points. Thus, consumer willingness to embrace CM seems to require both realistic taste and enhanced societal benefit—perhaps setting an insurmountably high bar for these developing foods. Indeed, respondents routinely indicated that they felt CM must prove itself as more than an “alternative”, and rather, a superior choice for moral, health, and ecology in order to move their choices away from existing alternatives or indeed away from conventional meat.

The event unfolded against a unique political backdrop: Florida’s impending ban on “lab-grown meat” would go in to effect just a few days later—the nation’s first state-level prohibition. Notably, attendees across the political spectrum were united in opposition to what they perceived as government interference in freedom, with some framing their attendance as activism. This unusual non-partisan consensus suggests that CM can be both a food and a symbol when framed around American identity which is highly tied to free-markets and freedom of food choice, even though meat eating is also historically viewed as an American patriotic behavior [32, 358, 359].

Consumer acceptance of CM seems to be attainable but somewhat fragile and conditional. Results underscore the need for more public engagement and education to increase trial willingness and identify

informational gaps that can foster a more meaningful level of acceptance. Ongoing innovation, evidence-based messaging, and consumer involvement in dialogue and product development emerged as thematic strategies to bolster confidence in CM. Stakeholders in research and development should consider consumer acceptance as multi-dimensional where taste is the minimum expectation for positive evaluation following trial, but changing behavior to include these foods seems to require greater intellectual and moral appreciation—things that could be better platformed as access increases in the near future. In essence, sensory appeal may open the door (or when negative, immediately shut it), but consumer acceptance seems currently situated within value alignment long before purchase decisions present to consumers.

Aim 2

The second study reports results from six months of a pilot randomized controlled study testing an adapted Diabetes Prevention Program (DPP) lifestyle intervention, tailored for older adults, and delivered entirely in an online classroom. Consistent with current scientific evidence [82, 360-362], the program emphasized a plant-forward diet, encouraging increased consumption of foods like green vegetables, whole grains and legumes, plant-based alternatives to ASFs (especially plant protein sources) alongside recommendations to reduce portions of ASFs overall, and increased daily dietary fiber intake. The program also included coaching for improved lifestyle health such as physical activity, sleep hygiene, mindfulness, and hydration, with all content tailored to be age-appropriate and to optimize convenience in order to increase attendance and adherence to program targets and related health outcomes.

The pilot demonstrated remarkable success in the adoption of and adherence to program recommendations, as well as lively real-time engagement during recurring program sessions. Participants in the intervention group had clinically significant weight loss, considerably higher than other similar programs. Self-reported enjoyment and acceptability of the intervention were also very high, suggesting that participants appreciated the flexible, supportive, and convenient remote format. The intervention

achieved 100% attendance to live sessions among participants, with only minimal make-up sessions needed, and high program fidelity indicating that the virtual classroom environment supports organized and replicable delivery of program materials [363].

Participants consistently self-monitored their behaviors using Wi-Fi and dashboard enabled wearable fitness trackers which were also monitored remotely by the research team. Routine metrics monitored included scale weight and food logging at least three times per week. Notably, participants adhered to these requirements consistently above 90% of weeks over 6 months, and adhered to their individualized calorie goals 74% of the time, step-count goals 92%, and moderate-vigorous physical activity 63-73%, depending on the month. These high levels of adherence resulted in clinically significant outcomes: by 6 months, the intervention group lost an average $> 9.5\%$ of their initial body weight, far exceeding the typical 3–5% weight loss seen in many standard DPP programs [363, 364]. In contrast, the control group (who received no intervention) gained a significant amount of weight $+2.4\% \pm 1.8\%$, resulting in a significant between-group difference ($p < 0.0001$).

Nearly all intervention participants progressed forward in Stage of Change (SoC) for diet and exercise, indicating internalization of program concepts, with some moving into maintenance. Of note, change in stage was highly related to both adherence and health outcomes, in accord with prior research [51, 61, 63, 105, 365-367] on stage-matching support for health behavior change. However, our findings contradict prior beliefs that older adults are unable to change entrenched habits [368-371]; instead, our results suggest that when social support is offered, when materials are tailored to population needs, and when barriers such as transportation and mobility are removed through videoconferencing, older adults enthusiastically participate. Study 2 shows that a remotely delivered lifestyle intervention is not only feasible for older adults but can facilitate high program adoption (enrollment and participation), excellent adherence to recommendations including increased intake of plant foods and thus confer significant health benefits (e.g. quality of life and weight loss). By mitigating common barriers and maximizing

engagement through personalization, technology, and support behavioral tools in educational interventions can boost the adoption of sustainable lifestyle habits for vulnerable at-risk demographics.

Aim 3

The third study developed and tested a novel metric for adherence to popular diets that restrict food groups—Scoring Adherence to Voluntary Restriction Diets (SAVoReD). SAVoReD was applied as a secondary analysis of data from a large online survey that included participants voluntarily following one of four diets with a range of time following those diets, most for several years. Participants self-identified as following a whole-food plant-based (WFPB), vegan, vegetarian, or Paleo diet; each of these systematically eliminates ASFs to different extents—fully plant-based diets such as vegan (which excludes all animal products) and WFPB (which excludes all animal products as well as added sugar, refined oils, and most added salt), the partially plant-based vegetarian diet (which excludes animal-sourced meat, poultry and seafood but includes eggs/dairy), and Paleo (which eliminates legumes, grains, and dairy but typically includes meat, poultry, seafood and eggs). SAVoReD allows researchers to quantify the degree of adherence to these restriction-type diets, in other words, how consistently a vegetarian avoided meat in reported usual intakes, or how often a WFPB follower ate sugar-added foods. The core findings from this study begin to reveal how complex diet adherence is and provide a metric for more specific descriptions about the level of adherence and perhaps eventually to enable finding the thresholds of adherence associated with health outcomes.

There was substantial variation in adherence across the different diets. While WFPB and vegan diets are similar with regards to restriction ASFs, WFPB has added restrictions for sugar, oil, and salt making it the most restrictive diet type, and consequently also the diet with the lowest average adherence score. This suggests that the stricter the diet the harder it is to adhere completely, which is intuitive. However, individuals following the vegan diet (second most restrictive diet studied) had the highest adherence score, suggesting that restriction alone may not always predict adherence, and instead that

some dietary flexibility, diet identity, and underlying motivations [11, 14, 29, 30] may also support higher adherence. Despite imperfect adherence, WFPB dieters had the highest diet quality score closely followed by the vegan group, which suggests that striving for healthier diet along with diet identity may help support healthy diet quality even with flexibility otherwise considered non-adherence. Using the Healthy Eating Index (HEI-2015) to measure overall diet quality, WFPB and vegan followers had diet quality with every participant having an HEI score well above the U.S. average—indicating very nutritious eating patterns rich in fruits, vegetables, and whole foods. Vegetarians’ diet quality was lower than vegans’ but still somewhat higher than the U.S. average; Paleo dieters had the lowest diet quality, and although most, were above the national average, they were the only group to include participants with scores at or below the national average. SAVoReD presents an opportunity for further exploration into adherence and health wherein specific outcomes may have different associational levels with differing adherence cut points, and indeed some sources of non-adherence may be more strongly associated with negative outcomes than others. Importantly, stricture has been previously reported by some as a key driver of recidivism for PBDs and rejection of messaging for vegan diets and food alternatives [29, 372, 373], and thus public health communications with specific data, but flexible messaging about levels of adherence may make both dietary and food adoption more feasible and inviting.

There were notable differences in body mass index (BMI) comparing diets. On average, vegan and WFPB diet followers had lower BMIs than those following vegetarian or Paleo diets. Strikingly, greater adherence was only significantly associated with better outcomes in the fully plant-based groups. For vegan and WFPB followers, the highest adherence tertile (most strict) had significantly lower BMI (about 1.8–2.2 kg/m² lower) than those in the lowest adherence tertile, after adjusting for relevant factors. In contrast, vegetarians and Paleo diet adherence was not significantly associated with lower BMI – suggesting that simply “sticking to” these diet rules may not help maintain a healthy weight, possibly because those diets still include more calorie-dense foods. Similarly, adherence was only significantly

positively associated with diet quality for WFPB and vegan diets suggesting that there may be a dose-response relationship to be explored in future research.

The study found that long-term vegan and WFPB diet followers, and notably, those with both longer diet duration and higher adherence, had healthiest BMI and diet quality. For instance, among those following their diet for more than 2 years, the association between adherence and lower BMI was stronger than in short-term followers, again only for the vegan and WFPB groups. This suggests that sustained commitment, perhaps due to higher motivation or more stabilized habits, can yield cumulative benefits, provided the diet can support these health improvements.

Another important finding was that not all PBDs are equal. Thus, the tendency to combine vegan, vegetarian, and WFPB and others together as “plant-based diets” (as is often the case in research or policy) can obscure critical differences. Through the lens of adherence and dietary composition, vegans and WFPB dieters, who completely avoid animal foods, achieved the highest diet quality and tended to have lower body weights, whereas vegetarians had a very wide range of diet quality and adherence levels, heterogeneous within-diet and comparing so-called PBDs. Thus, the term *plant-based diet* needs a careful scientific re-evaluation, and given the stronger similarities between diet composition and outcomes the term PBD may be best reserved for *entirely* PBDs, rather than diets that include some amount of ASFs.

The cross-diet adherence metric developed can be used alongside other metrics to better examine the link between real-world dietary practices and a given diet’s impact on nutrition and health. While we found that higher adherence to a diet that restricts ASFs is associated with better diet quality and lower BMI, in agreement with many prior studies [82, 374, 375], we note that those diets are also the hardest to adhere to perfectly and that the proposition of all-or-nothing may be even off-putting. This underscores a central tension underlying nutrition behavior: the most health-promoting or sustainable diets pose the greatest adherence challenges, making real-world outcomes depend not only on a diet’s design but on individual ability to adopt and maintain it. Nevertheless, the presence of many long-term

vegan and WFPB followers in the sample indicates that sustained adoption of such diets is feasible for motivated individuals, and that even if adherence is not perfect, intending to maintain a PBD can confer significant health benefits.

Acceptance as a Precursor to Change

Acceptance, such as novel ASF alternatives (like CM), is a crucial first step. If people do not accept a product—whether due to distrust, misaligned values, sensory rejection, or multiple aspects of disgust—they will not incorporate it into their diet, no matter its potential benefits. In the context of behavior change theories, acceptance can be seen as coinciding with pre-contemplation and contemplation stages of change: consumers are becoming aware of and evaluating a new option. The ethnography conducted in Study 1 showed that acceptance for CM is shaped by its ability to meet both sensory expectations and psychosocial needs (e.g. the need for ethical consistency or cultural fit). However, it also highlights that acceptance is conditional and importantly is not fixed. For instance, participants were willing to *try* cultivated meat (an encouraging sign for future uptake) [152, 376-378], but whether they would endorse a willingness to regularly eat it depended on factors like further knowledge about production, believing in its safety and benefits, and alignment with values. In other words, a cursory acceptance (willingness to try) does not automatically translate to sustained acceptance, or indeed an intent for adoption. The sociopolitical context (e.g. a looming ban) further complicated acceptance: while it galvanized support for the concept (by triggering reactance to regulation), it also perhaps underscored that CM remains controversial, priming skepticism. Even support among would-be early adopters was hedged, framed in aspirational and contingent language, with relatively taking actual action to oppose the ban despite freely saying they were against such legislation in principle. Banning a food is certainly one way to prevent acceptance – by removing its availability – however, novel foods may also be further facilitated or hindered by policy signals (a point returned to below). In a food system with a range of healthful and unhealthful food items, and indeed a range of accepted food technologies (including those behaviorally

accepted when attitudinally rejected, like GMOs), the arm's length scrutiny for CM is somewhat unique. However, some of this skepticism may stem from previously observed consumer disappointment with earlier alternatives, like plant-based meat alternatives, which have received notable criticism for falling short in taste, health perception, and cost [42, 379-381]. These shortcomings have led some to question whether any alternative protein can displace conventional meat consumption at a significant scale.

Novel products won't be utilized if not viewed favorably, and similarly, a plant-based/meat-reducing diet would likely not be initiated if there was no belief in the value of doing so. In Study 2, there was an adjustment period over several weeks of coaching wherein participants considered changes and made incremental shifts. There was also a small subgroup of participants reluctant to change their diet at all (20%), opting instead for exercise-based approaches. This was reflected in change readiness comparing diet to exercise change and was also reflected in resultant weight loss at intermediate time points. Mastery experiences, such as witnessing peers have success and hearing them describe dietary enjoyment, and similar social normalizing seemed highly influential to support more dietary change. We also saw that those who did shift their diet lost more weight than those who remained most resolved to exercise-alone—indeed, the only participant to not lose more than 3% of their starting body weight was an exercise-only intender. However, the shift in acceptance as SoC for change readiness and ultimate weight-loss demonstrated that there are multiple avenues, and speeds, for supporting change even among those with initial hesitation. The program's perfect attendance and enthusiastic engagement indicate that when participants see value in the program and are given the opportunity to engage on their own terms, that they are able to interact with materials, integrate information over time, and are thus more likely to adopt at least some meaningful changes. It also suggests that group composition can be leveraged strategically, composing groups with a range of baseline change-readiness to allow for greater autonomy and role modeling, perhaps even a greater likelihood of internal rather than introjected knowledge integration and motivation [57, 382-384]. In study 3 we have Individuals who already

voluntarily chose to follow a popular diet, indicating a prior acceptance largely motivated by ethical and/or health beliefs for those diets, which drove them to adopt them in the first place according to Miki et al in the first analysis of motivations for the ADAPT cohort [11]. Therefore, across studies, acceptance emerges as a foundation for change—whether accepting a new food technology or accepting a healthier dietary pattern. Strategies to boost acceptance (e.g., education, exposure, value framing) thus represent the groundwork for adoption of sustainable diets, much like for other health behavior changes.

From Acceptance to Adoption

Adoption refers to the actual decision to implement a change – such as incorporating a new food in one’s diet or starting a new diet and altering one’s routine. Study 2 was predominantly about facilitating the adoption of a flexible, plant-forward diet in an at-risk population, and the success of the pilot demonstrated how acceptance can be cultivated into action and sustained adoption. Participants in the trial were older adults who both agreed to participate and were able to observe trial and error in peers while making attempts themselves. This aligns with behavior change theories that emphasize self-regulation and social support in the adoption phase [382, 385, 386]. Enrollees were encouraged to try new foods, cooking methods, approaches to portion control, and routine behavior and biometric self-monitoring. With these tools, education and support combined, participants greatly changed their eating patterns (adding legumes, green vegetables, choosing smaller portions of ASFs, staying beneath calorie limits, etc.), increased physical activity, and practiced maintaining this in their day-to-day lives. The program facilitated adoption by providing constant support, a structure to inspire progressive incremental growth, social feedback and peer modeling, as well as offering skill building opportunities to bolster self-efficacy (e.g. goal-setting, flipped classrooms and sharing, peer interaction in sessions).

Conventional lifestyle health programs, such as the original Diabetes Prevention Program (DPP), may be difficult for many to adopt due to strict energy intake and dietary restrictions. In contrast, tailoring dietary guidance to be flexible, with food-based rather than nutrient-based restrictions, may support

greater success for plant-forward diet adoption, as it allows individuals to align dietary changes with personal preferences while nudging them towards more plant foods [387-389]. Acceptance and adoption are not only influenced by personal values but also by how realistically a change fits into one's life. For example, in Study 1, event attendees noted that while they might accept CM in taste or principle, actual adoption would depend on external factors such as availability, price, and whether the product could meet their culinary needs. Study 3 further illustrates that diet adoption can be self-directed and maintained over long periods without formal intervention; however, sustained adherence is often inconsistent. This variability is echoed in Study 1 by participants who identified as former vegetarians or vegans—supporting prior research showing that many who attempt veg*n diets relapse within the first year [24, 31]. Together, these findings suggest that long-term maintenance may require different approaches than those used to communicate diet recommendations for adoption—for example, methods of reasonable, moderate indulgence versus austere self-deprivation.

Overall, the findings suggest that successful adoption requires more than a one-time decision—it benefits from being situated in a context with ongoing support. In Study 2, the support was in an intervention bolstered by both interventionist and peer social support. In Study 1, the context allowed for social modeling and reinforcement but was a one-time event that, while positive, did not seem sufficient to produce adoption, and in some cases unable to produce acceptance. Adoption of CM will likely require repeated encounters, access/availability, normative acceptance, and confidence in the product's benefits. Encouraging the adoption of alternatives requires that they be appealing and value-aligned (to gain acceptance) as well as a sociopolitical infrastructure to be developed to facilitate the transition from curiosity to intention, and from intention to action (adoption). Such infrastructure could be modeled on existing mechanisms used to increase the normativity and accessibility of alternative protein sources. For example, public-private partnerships that subsidize cultivated meat for inclusion in institutional foodservice, paired with promotional education campaigns, could help socialize its presence and build

consumer trust[390]. Once adoption is attempted, this infrastructure would be especially impactful for the next challenge—helping people maintain adopted behaviors over time.

Adherence and Maintenance

While adoption reflects change, long-term impacts for diet likely depend on adherence. Dietary risks and benefits have long latency periods [391], and diets may shift to be more or less healthful over time, requiring sustained durations for true benefit [82, 392]. Study 2's impressive results were largely due to exceptional adherence: participants not only adopted a new diet and lifestyle routine, but maintained high levels over six months. This led to continued weight loss, illustrating that not only can groups historically resistant to change be reached, but that when they adhere to a plant-forward diets, significant health benefits accrue. Study 3 showed that in less structured contexts, adherence can be highly variable, which has important implications for dietary recommendations and methods of change. For instance, many vegans adhered very strictly, while WFPB diet followers had less adherence but slightly higher diet quality and corresponding health benefits like healthier BMI. For a WFPB diet follower, non-adherence could mean many things, it could mean non-adherence to similar foods that would make any vegan diet non-adherent or simply to the elements that differentiate WFPB from vegan. For the very large group of WFPB dieters in this study, the former was more the case, indicating that while stricter diets produce less adherence, setting the bar higher—with room for flexibility—may result in better outcomes.

The vegetarian and Paleo dieters demonstrated lesser benefits and had no clear association between adherence and health outcomes. This may indicate that those diets have a greater tendency to lead to less healthy dietary choices even when “adhered” to, and also suggests that greater encouragement to follow PBDs, even imperfectly, confers greater benefit than unstructured flexible diet plans, or than some other popular diets. Through the lens of behavioral maintenance, it is generally challenging for individuals to maintain restrictive behaviors perfectly over a long period of time, especially without external support [16]. Study 3's data confirms this known challenge—fully eliminating food

groups requires strong resolve, which not everyone can sustain daily. The fact that WFPB dieters had the lowest mean adherence despite being highly motivated [11] speaks to the difficulty of maintaining very strict diet rules over years in a food environment where making whole food choices isn't always accessible and other food temptations are always present [393, 394]. Study 2, however, offers insight into how this can be improved; high adherence is achievable when support systems are in place, and while this study relied on creating a social group to support adherence over 6 months, other forms of support at the community and national level(s) could extend this approach for broader success.

Adherence links the theoretical to the physical outcome. Adherence runs alongside adoption and simultaneously follows from and informs ongoing acceptance. From a synthesis standpoint, the results in Study 2 and 3 suggest that adherence is pivotal for translating dietary change into tangible health or sustainability outcomes, echoing prior literature that greater adherence to interventions predicts better weight loss maintenance and disease outcomes [Gibson, 2017 #36; Kelly, 2020 #182]. Studies 2 and 3 highlight both the potential and possible pitfalls of adherence for those in the pursuit of healthier diets. However, when people do adhere—as seen among the committed vegans or WFPB followers—the benefits are substantial, including healthier weight, higher diet quality, and likely corresponding reductions in cardiometabolic risk factors. On the other hand, individuals struggle with adherence, and when this is compounded by variation in the healthfulness of dietary patterns, the long-term benefits may be diminished—albeit to varying degrees depending on the extent and source of the deviation. Importantly, if we promote less healthful diets solely because they are easier to follow, we risk not only limiting meaningful improvements but also reinforcing the belief that “diets don’t work” when perceived benefits fail to materialize. This can make individuals more reluctant to initiate future dietary changes. Perhaps the emphasis should be on effective communication around acceptance of demonstrably healthful diets, and the thresholds of adherence for benefit—in other words, communicate what is healthy and personalize the flexibility rather than downplay the need for healthy choices. Interventions

and innovations therefore could be designed not only to facilitate initial uptake, but also to establish systems and strategies that support sustained adherence in real-world, free-living contexts. This might involve ongoing community support, periodic re-engagement (e.g. follow-up plans), technological aids (apps, reminders), and more mature food alternatives that minimize adherence difficulty (e.g. affordability).

Connecting Acceptance, Adoption, and Adherence

Acceptance, Adoption, and Adherence are not independent, but rather are best understood as a series of reciprocally enforced pathways of sustained dietary behavior. If a person accepts the idea of reducing ASFs (believes it is worthwhile for one or combination of reasons), they may then adopt behavior change(s) in congruence with that acceptance including incorporating a meat alternative, reducing meat intake, starting a plant-based diet, or identifying as a vegan. However, behavior does not always follow attitude, nor is it always concordant [55, 80, 104, 395]. Once adopted, even sustained adoption has variable maintenance in both time and also level of adherence [13, 30, 396]. Gaps in support moving between these steps, or bad experiences along the way (e.g. taste or social rejection) can provide negative reinforcement, and ultimately may mean adopted behaviors, or even once held strong favorable beliefs can convert into rejection as is the case with so-called “ex-vegans” [23, 26, 31, 58, 111, 397]. In other words, without acceptance, behavior change may never begin; without access, intentions may not translate into adoption, and if access is lost, even established actions may not be sustained; and without continued adherence, initial improvements can stall, with behaviors potentially reverting toward baseline. However, the studies identify possible solutions for each of these stages: 1) educational and experiential events to foster acceptance, 2) structured programs and social support to aid adoption and strengthen action leading towards maintenance, and 3) metrics that can be applied to match thresholds of adherence with measurable outcomes. From there, greater social support needs to be broadened, given that it is a key component of health behavior change and also because it can help accomplish the diffusion of health

behaviors and novel food acceptance through networks and communities [68, 398-400]. Greater sociocultural support for the multiple methods of meat reduction remains an important policy approach that is currently underutilized [43, 118] [401].

Technology-based solutions (like food innovations) and behavioral interventions both have roles in improving both public and planetary health, and their success relies on influencing attitudes and habits. In essence, to meet public health and environmental goals, simply having sustainable foods as an option or being exposed to the knowledge of a healthy diet is not enough – people must also be supported along the way with acceptance driving experiences and tools for sustained adherence. These study underscore that people *can* change their diets in profound ways (even longstanding habits in later life, or deeply ingrained practices of like eating meat) when the conditions are favorable, and that such changes can be maintained with the right mix of motivation and support. Not only that, but also that strict diets may still confer benefit when flexibly adhered to, such that recommending strict diets may still promote benefit.

Implications for Public Health Nutrition and Sustainability Policy

Insights from these studies can help inform public health initiatives, nutrition policy, and environmental sustainability strategies. As nations and communities grapple with how to promote healthier and more sustainable eating patterns, this section explores some potential levers and pitfalls.

Integrating Sustainability into Dietary Guidance

Recently, the Dietary Guidelines for Americans (DGAs) more strongly encouraged PBDs and choosing more plant-based sources of protein foods [362, 402]. Over the last two decades, there has been growing recognition of the need to incorporate sustainability alongside direct dietary effects given the role of environmental exposure on food availability and chronic disease [360]. However, the US decided to intentionally omit sustainability from official nutrition policy, breaking step with many countries around the world that choose to include it [403-406]. Many large observational and experimental studies have

found that especially in the Global North, diets with fewer ASFs are associated not only with better health indicators (lower BMI, higher diet quality, lower CVD incidence, etc.) but that they also have smaller environmental footprints (contribute less greenhouse gas emissions, use less land and water, etc.) [407]. Thus, greater emphasis on PBDs could be a win-win for public health and sustainability, if the population is provided with the appropriate public infrastructure to support this shift. Public guidance could encourage greater salience for self-empowerment to effect positive self-change towards different degrees of plant-based eating. For example, policies and communications could be tailored to support specific at-risk sub-populations (e.g. emphasizing health span for older adults) to be most effective. Policies could set ambitious but flexible goals (such as “aim for most meals to be plant-based”) and provide resources to help people achieve high adherence (like subsidies, recipes, cooking classes, or meal services) – normalizing PBDs and increasing the feasibility of adoption across the population.

Supporting Behavior Change and Adherence in Public Health Programs

Knowledge alone is insufficient to produce large scale change; people often need structured support to change diets and sustain those changes. Health agencies and providers might replicate Study 2’s approach by implementing a plant-forward module into existing diabetes prevention or weight management programs or leveraging new technologies to provide support for individuals in convenient ways. Policy could incentivize healthcare systems to offer group, remote, or even AI-facilitated programs that emphasize reducing ASFs by focusing on important dietary components to bolster, like green vegetables and legumes, especially. The success of the remote DPP adaptation for older adults also highlights an opportunity for scaling up digital interventions—governments and NGOs could develop online platforms or apps that guide users through weekly lessons, self-monitoring, and goal setting making support widely accessible at low cost. Importantly, because high adherence was facilitated by regular monitoring and feedback, consistent with other studies [408, 409], incorporating behavior tracking technologies (like apps or wearable trackers) should be further supported to enhance both

adherence and beneficial outcomes. Policy can encourage innovation (e.g., public-private partnerships to develop user-friendly diet adherence tracking tools in smartphones) or expand public support for low or no-cost access to existing tools. Additionally, training healthcare providers to address adherence barriers would appear to be a critically underserved gap [9]. Providers report skepticism that patients will adhere to dietary recommendations, indicating this as why they prefer medical management options, such as GLP-1 receptor agonists, like Ozempic [410, 411]. However, a finding of our pilot and other similar approaches [412-414] is that when nutrition counseling augments implementing strategies to include adherence and maintenance strategies, individuals can indeed make changes and that non-adherence may not preclude the benefits of promoting adoption.

Another promising strategy for encouraging healthier and more sustainable dietary choices is the use of behavioral “nudges” that subtly shift defaults without restricting choice. One such approach—Greener by Default—reframes meal offerings so that plant-based options are the norm rather than the exception, effectively normalizing these choices in public and institutional settings [415]. This approach leverages established behavioral science principles to promote healthier and more climate-friendly behaviors while remaining cost-effective, scalable, and politically feasible [416]. Particularly in schools, universities, corporate cafeterias, and cultural institutions, such low-barrier strategies have demonstrated success in shifting population-level consumption patterns toward reduced ASF intake. Attwood et al. (2020) found that even just enhancing the appeal of plant-based dishes through descriptive naming in corporate cafeterias led to a notable rise in their selection [417]. These interventions are not only cost-effective and easy to implement but also help to mainstream healthy and sustainable food choices.

Cultivated Meat and Food Technology – Regulation and Communication

Governments worldwide are navigating the regulatory landscape for novel foods, like CM. The public tasting event demonstrated consumer interest and initial grassroots acceptance. However, it also revealed consumer concerns regarding transparency and the availability of health-related information from both producers and regulatory bodies. This situation unfolds amidst a broader decline in public

confidence in governmental health agencies, a sentiment that contributed to the rise of the "Make America Healthy Again" (MAHA) movement, spearheaded by current Health and Human Services Secretary Robert F. Kennedy, Jr. MAHA emphasizes a return to 'natural' foods and a need for increased scrutiny of processed foods and pharmaceuticals, reflecting a cultural shift towards skepticism of technological solutions for food and health [418, 419]. The MAHA prioritization of naturalness may be the product of the rapidly accelerating technology landscape that recently remade the global food system in what is sometimes referred to as the Green Revolution [420]. While the Green Revolution significantly increased agricultural yields and greatly helped address food security, it has also been widely criticized for unintended consequences, including environmental degradation, loss of biodiversity, and the consolidation of agricultural power among a few large multi-national corporations [420-424]. Research indicates that consumers' acceptance of innovative food technologies stemming from the Green Revolution (notably, GMOs) is heavily influenced by their perceptions of naturalness and the associated risks and benefits. For instance, Siegrist et al.[379] found that perceived naturalness and evoked disgust significantly affect the acceptance of CM, and Bryant and Barnett's [378] systematic review found that naturalness framing plays a crucial role in acceptance. It is possible that the increasingly sophisticated methods used to produce and cultivate novel foods—such as cellular agriculture, genetic engineering, and precision fermentation—shroud otherwise promising innovations in a veil of intimidating scientific complexity. These methods are often perceived by consumers as more salient and unnatural than earlier, less visible human interventions such as selective breeding, hybridization, and controlled feeding, which have dramatically shaped agriculture for millennia—but at paces and with methods that most humans can conceptualize [425-427]. These shifts have amplified a phenomenon commonly described as technophobia or techno-disgust, particularly in relation to GMOs, bioengineered foods, and now CM [379, 426]. Curiously, however, this same avoidance response is not typically extended to other cellular agriculture products like precision and biomass fermentation, despite their reliance on closely related

technologies and similarly novel food outputs [152, 428]—a disparity that presents a compelling opportunity for further investigation.

Regulators must serve as authoritative and trusted sources of information and acknowledge their unique role in shaping public acceptance. It isn't just companies and researchers who must improve communication around novel foods—nor should the responsibility fall solely on them, given their vested interests in driving advancement. While ensuring food safety and clear, comprehensible labeling remains a core mandate, regulators and policymakers must also consider the broader societal imperative to expand food options and promote sustainability across nutritional, economic, and national security domains. Policymakers meaningfully shape public acceptance or rejection of novel food technologies, influencing not only consumer trust but also the trajectory of innovation adoption [429, 430]. State-level bans on certain food products, such as Florida's prohibition against the sale, manufacture, and distribution of CM and California's restrictions on specific food additives, have sparked public backlash and diminished trust in federal regulatory bodies like the FDA—joining COVID-era criticisms stemming from an accelerated vaccine approval process [431, 432]. State-level bans, despite federal approvals, have prompted debates over the balance between state and federal authority in food regulation, reflecting a growing trend where local governments take proactive measures in food safety and public health, purportedly in response to perceived federal inaction [431, 433, 434].

Ironically, the regulatory pathway for CM is markedly more stringent than that for any other currently traded foods. Under the FDA's GRAS (Generally Recognized as Safe) framework, food additive companies can determine that a substance is safe for its intended use either by submitting a GRAS notice to the FDA or by self-affirming GRAS, wherein the company conducts its own safety assessment without FDA review. Self-affirmed GRAS has especially faced criticism as allowing substances to enter the food supply without adequate oversight [435, 436]. In a striking contrast and despite widespread misunderstanding about lax regulation, CM products undergo a rigorous, hands-on premarket review

process and then a comprehensive safety during and after production and harvest. In a joint regulatory framework formalized in 2019 [437, 438], the FDA and USDA share the review and oversight of CM: the FDA oversees cell collection, cell banks, cell growth, and differentiation, while the USDA's Food Safety and Inspection Service (FSIS) takes over during the harvesting stage, overseeing further production and labeling as it does for all other meat and poultry in the US. However, despite a high level of rigorous oversight, this stringency is not well communicated to the public. Even straightforward communication about labeling regulation for CM has been lacking, leading to calamitous confusion. Recent state-level Senate hearings show that multiple lawmakers remain unclear about what CM products are, maintain a belief that they are currently unregulated, and that no regulation exists for their labeling—highlighting the need for clearer communication from these federal agencies [439].

Federal regulators have both the capacity and responsibility to provide clearer, more accessible evidence of labeling oversight and novel food approval processes. This includes correcting misinformation—particularly when for state legislators—who are now advancing a patchwork of statutes that threaten to undermine federal authority and create confusion in regulatory enforcement and potentially insurmountable compliance barriers for companies (e.g. different labeling requirements by state). While often framed as protective of public health, such state-level legislation can inadvertently erode trust in food safety systems and exacerbate consumer confusion about emerging food technologies, including CM [434, 437, 438, 440]. Instead, coordinated public education campaigns can foster transparency and informed decision-making. For example, the UK government launched a £15 million initiative to establish the National Alternative Protein Innovation Centre, aiming to accelerate the commercialization of plant-based, cultivated, and fermentation-made foods. Similarly, Germany allocated €38 million to support plant-based, fermented, and cell-cultivated proteins, reflecting a commitment to sustainable agriculture and innovation [441, 442]. These efforts align with global recommendations; the United Nations emphasizes the urgency of dietary shifts for public and planetary health, advocating for transition to more

sustainable and less resource-intensive food systems [443, 444]. However, while US lawmakers and the Congressional National Security Commission on Emerging Biotechnology (NSCEB) have expressed concerns about the food and national security risks of deprioritizing innovations like CM [445, 446] few concrete efforts have been made to safeguard this advancement or preserve what could be a critical component of the nation's competitive edge.

The ethnography suggested that consumers require honesty and responsibility from producers. To support this, policies could be implemented that require companies across the food value chain to disclose environmental impacts and production methods (such as methods of food processing, etc.). However, it is long past due for nutrition policy to include real consideration of how alternatives to ASFs can functionally fit into recommendations. While plant-based alternatives to fluid milk are increasingly represented in both official dietary databases and nutrition science literature [447], the same cannot be said for other alternatives. Currently, only two to three meat substitutes—and no egg alternatives—are described in detail (beyond manufacturer-provided nutrition labels) within the USDA's Food and Nutrient Database for Dietary Studies (FNDDS; Food Data Central) [448, 449] which significantly limits the ability for dietary assessment tools to capture the impact of these foods despite widespread commercial availability for 10-25+ years. This is a substantial gap in understanding, which in turn has led to relatively few experimental studies that can more rigorously evaluate this because funding for these studies commonly builds on earlier results from lower cost population surveillance data to justify more intensive investigation. High-quality trials such as the SWAP-MEAT crossover study [450], its identical twin extension [451] and additional randomized trials with athletes remain the exception. As CM becomes commercially available, an important question arises: should it be treated as a direct substitute for conventional meat in dietary guidance, or should CM and other alternative proteins be considered a distinct category? This question also extends to seafood, which is generally recommended—particularly fatty fish like salmon—for cardiovascular, neurodevelopmental, and cognitive benefits. However, for

certain subpopulations, such as pregnant individuals, seafood consumption should be limited due to concerns about mercury and other contaminants. Cultivated fish may offer a unique solution: delivering essential nutrients that support maternal and fetal health during gestation, while eliminating the risks that underlie current recommendations to limit fish intake. Surely, to achieve the maximal benefits from these technologies would first require ample research and better communication for these foods. Also, perhaps more effectively than other alternatives, CM could serve as a behavior change shortcut for those unwilling to give up meat and who need to reduce it, or those unwilling to eat conventional meat but would nutritionally benefit from doing so; but to be impactful, would require policy-level support.

Tailoring Strategies for Different Populations

The variation observed in Study 3 between diet groups suggests that one-size-fits-all policy is not optimal. While promoting PBDs is good, our results suggest that the support needed may vary. For example, vegetarians might need guidance to improve diet quality (e.g. not simply substituting meat with cheese); WFPB followers might need resources to support maintenance (e.g., recipes, meal plans, increased options for eating away from home); and Paleo dieters might benefit from strategies to ensure adequate vegetable and fruit intake, and importantly increasing intakes of calcium, fiber, and B vitamins. Public health communications should specifically acknowledge different diet identities – for instance, a public campaign could have tailored messages like: “Eating plant-based? Here’s how to do it healthfully whether you’re meat-free or just meat-reduced” and provide tips for vegans that are different than for flexitarians—an appropriate extension of the recent ACEND position paper on the importance of appropriately planned vegetarian and vegan diets [452]. Those following PBDs are frequently encouraged to be mindful of nutrition; however, the same is not true for Paleo diets, which although restricting dairy, grains, and legumes, receive far less nutrition guidance largely owing to continued consumption of ASFs—a blind spot that is further exacerbated by the rise in adjacent diets like keto and carnivore.

Policies that encourage food industry change can help improve population health [453] and also assist healthy diet adherence. Institutional dining programs in the U.S. and U.K.—like those in recent NYC and UK NHS facilities—have successfully implemented plant-based defaults, demonstrating reduced greenhouse gas emissions, improved patient satisfaction, and cost savings (ex., \$318,000/year in NYC) [454, 455]. These initiatives also support social diffusion, as seen in U.S. colleges and NHS campaigns, where shifting defaults subtly changed norms and improved dietary health outcomes [456, 457]. As longer duration on healthier diets associates with better outcomes, better monitoring of how many people stick to changes once initiated could lead to data-driven refinements in national dietary recommendations and complementary intervention programs with more effective personalization approaches.

Aligning Health and Environmental Messaging

Health and sustainability can overlap, but can also diverge, making different messaging and approaches important. Studies generally discuss the convergence —diets or foods that are good for both personal health and the planet. Indeed, this is the premise of the Planetary Health Diet [360] developed by the first EAT-Lancet commission, and led to large amounts of environmental marketing of foods [257].

While the goals of promoting diets that are both healthy for individuals and sustainable for the planet are often aligned, recent discussions have highlighted potential conflicts between these objectives. Members of the Global Alliance for Improved Nutrition (GAIN) and academic leaders like Dr. Dariush Mozaffarian have expressed concerns that environmentally protective diets, such as the Planetary Health Diet, may lead to micronutrient deficiencies, particularly in vulnerable populations, due to limited intake of ASFs [458, 459]. Similarly, the heavily contested Dublin Declaration [460-462] emphasizes the essential role of livestock-derived foods for nutrition and cautions against dietary recommendations to reduce or limit these foods. Importantly, while many studies find that consumers report having high environmental and health motivations and intentions, few observe the behavior congruent with these values at decision points [463-465]. In agreement, many in Study 3 reported ethical and/or environmental reasons [11],

which they claimed strengthened their resolve to adopt and even follow strictly [29], but future investigation would be needed to determine if any one, or unique combinations, of motivations best supports adherence. In Study 2, participants were primarily motivated by health (preventing cognitive decline, losing weight, increasing life/health span), but the intervention indirectly achieved a diet shift with greater sustainability. Study 1 echoes this same concept; participants expected CM, as an alternative to conventional meat, to address multiple needs – support health by providing nutrient dense meat free from contaminants and have reduced environmental impacts as well. It is clear that modern consumers hold alternative foods and diets to a higher standard of social responsibility than entrenched traditional practices [21, 22, 28, 104, 112, 118, 380], and as inherent to the value proposition of these approaches [123]. Thus to support the multiple benefits of these different approaches, care should be taken to examine the messaging that is most impactful. Public health agencies may wish to explore framing dietary recommendations in the broader context of societal benefit or person-centered motivations, such as being able to play with your grandchildren and leave a better world for them to increase public buy-in. However, it is crucial that such messaging remains evidence-based and balanced, backed by scientific consensus, and evolves alongside the literature to build and safeguard trust.

Making sustainable choices easier and more appealing (through food innovation, economic incentives, and supportive programs) is just as important as educating about why these choices matter. Ultimately, achieving population-level shifts in diet consistent with climate and health goals will require coordination between sectors: agriculture producers, food industry manufacturers and service, healthcare, and government together and separately should each engage individuals and communities collaboratively to ensure progress meets food preferences and needs.

Unanswered Questions and Future Research Directions

Study 1 captured a snapshot of consumer reactions at a world-first event, but many questions remain about what happens beyond initial tasting, and especially in normal food choice environments.

For instance, research should seek to understand if the individuals like those who expressed enthusiasm at the tasting would actually purchase and eat CM regularly once it is commercially available, at what price(s), and what if any tradeoffs consumers report that influence their decisions. Longitudinal studies or pilot market trials could track whether curiosity leads to sustained adoption or, if like plant-based, initial novelty fails to translate to consistent adoption. Additionally, as the sociopolitical resistance (e.g. state-level bans and framing as “frankenmeat”) evolves— research could examine how different regulatory environments or media narratives affect consumer acceptance over time. Perceptions and impacts among various populations (e.g. rural communities, older individuals, or those with strong culinary traditions centered on livestock) would also be valuable. Alongside the need for more representative and longer-term consumer behavior studies, no human consumption data exists for cultivated meat, a notable absence in the scientific literature. Continued study of consumer psychology, health outcomes, and strategies for communication and policy will be crucial to complement research on technical development.

Study 2 showed what is possible in a controlled context with intensive support. Future research should explore how such interventions can be scaled up and extend over longer periods, and for larger populations. One immediate step is to conduct a full-scale randomized controlled trial with more diverse participants to confirm the efficacy observed in the pilot. Ideally, effective programs can be augmented for delivery through community centers, clinics, and national platforms to reach wider audiences. A larger trial could also incorporate longer follow-ups (e.g. 12 or 24 months) to assess whether participants maintain weight loss and healthy habits post-intervention. The role of technology in maintaining adherence also warrants further research. For example, can mobile apps or text messaging maintain high adherence after the program ends? Do group participants that interact in a dynamic fitness dashboard during a program keep the social support momentum going, unsupervised? Finally, examining how

enrollment and post-enrollment impacts psychosocial domains, such as self-concept, relationships, and overall well-being beyond weight loss needs further exploration.

Study 3 developed a metric to measure adherence, but future work needs to apply the metric to larger datasets to better understand when and how adherence should be supported to improve health outcomes. Studies with data on dietary intake and health outcomes can have the score applied post-hoc to evaluate interrelationships with different outcomes. Future research can also explore whether score salience might motivate improvement, analogous to how self-monitoring in Study 2 increased adherence, or whether raising awareness about health outcomes tied to specific food non-adherence can be effective for improving health versus promoting greater overall adherence. Interestingly, one of the largest proponents of WFPB diets, Forks Over Knives, very recently announced a relaxed approach to prohibiting refined oils [466] which may make the use of this score even more important and timely. More broadly, there is a need to study behavioral and psychological determinants of adherence in the context of voluntary diet change. Surveys or interviews with current and former dieters could identify the most common reasons for lapses or quitting (e.g. social pressure, convenience, cost, craving, nutritional concerns) [31] and identify what if anything would facilitate resuming. Addressing these in future interventions or educational resources could also help new adopters avoid common pitfalls. Additionally, research to investigate whether biological or metabolic drivers of adherence (e.g. taste sensitivity, gut microbiota, and other appetitive factors) mediate behavioral non-adherence.

Study 3 suggests that there are still health benefits for partial adherence, provided the diet identity aligns with a health promoting diet. This finding merits further investigation to determine the relevant cut points. Future studies might apply the score to help quantify the dose-response—for example, if someone eats 100% plant-based 5 days a week and 50% the other two, how does that compare to full adherence compared to 50% daily? This can inform about flexible dieting strategies for those who cannot maintain 100% adherence, illuminating not only where the flexibility should best be

applied, but perhaps also how often. Future research should apply score to other diets and cultural contexts, like the Carnivore diet, and using population references from other countries.

Another important remaining question is how food technology solutions (e.g. cultivated or plant-based) and behavior change interventions (e.g. fitness-technology and supportive programs), might complement each other. While studies suggest that the availability of plant-based meat alternatives can facilitate adherence to PBDs [450, 451], there is limited experimental data on whether reliance on these substitutes prevents recidivism or maintains cravings for meat, potentially leading to lapses. Few trials have examined operational meat substitution diets, and even fewer have focused specifically on commercially available alternatives. Experimental studies could assess diet adherence among groups with varying levels of alternative product availability. Evidence indicates that moderate dietary shifts by a large population can have a greater impact on system-level outcomes, such as greenhouse gas emissions, than more dramatic changes by a smaller group [467, 468]. However, the implications for population health remain unclear. Future nutrition research with public-level modeling is needed to guide optimal strategies for achieving climate targets through dietary changes that also improves personal and public health.

Finally, more research is needed on the social dynamics and cultural acceptability of these foods and diets. Study 1 touched on political and cultural factors that interact with acceptance, but further research across different communities can uncover how cultural identity and social norms influence this to inform about how best to construct messaging especially for cultures with strong meat-based culinary traditions versus those with existing plant-based traditions. Political science research could also further explore bipartisan or value-based framing that resonates across contemporary party lines.

These studies advanced our understanding of how people come to accept, adopt, and adhere to approaches designed to support better personal and planetary health, but they also raise many questions for further exploration. Future research can build on this foundation and help close the gaps between knowing *that* we should change our diets and understanding *how* to make those changes attainable and

lasting for diverse populations. Only with such continued inquiry and subsequent action can we fully realize the potential of dietary change to improve public health and achieve global sustainability goals.

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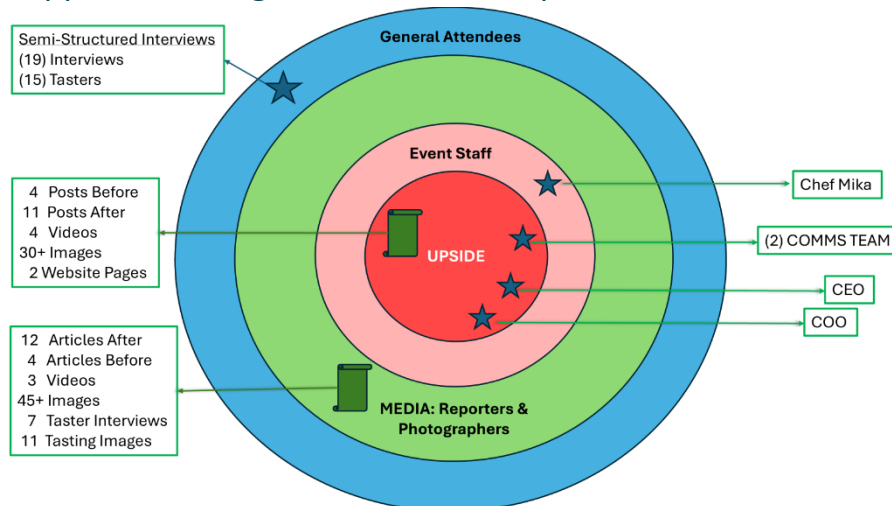
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APPENDIX

Appendix 1: Chapter 1

Supplemental Figure 1. Crowd Composition and Information Sources



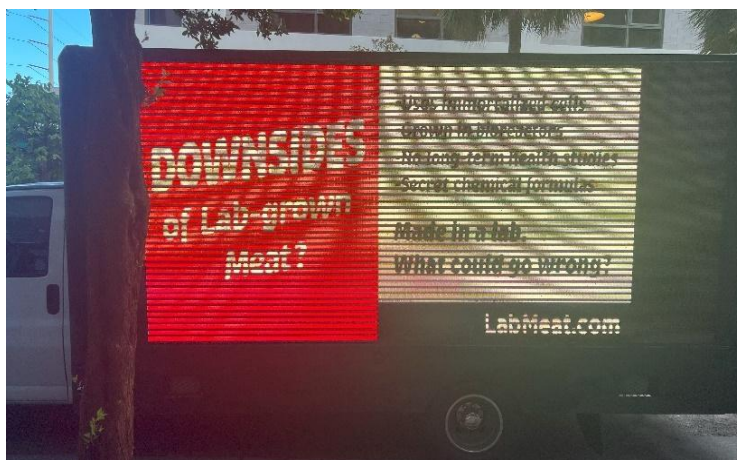
NOTE: Information about the event, the company and product were obtained from direct communication with the company, public statements made by representatives at the event, and were also triangulated from statements published by the company or media. Media, including mainstream media published by the Associated Press, and local newspapers such as *Your Basin* as well as company and attendee social media accounts were also used to gather information about the event.

Supplemental Figure 2. UPSIDE Foods Website Call to Action for Petition



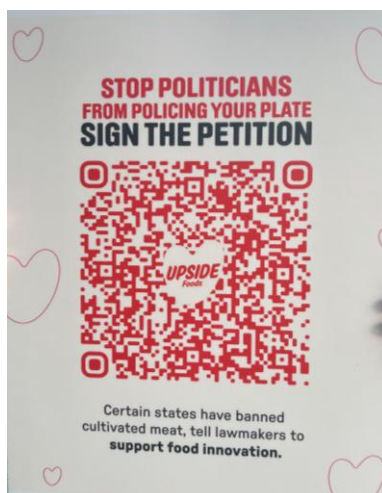
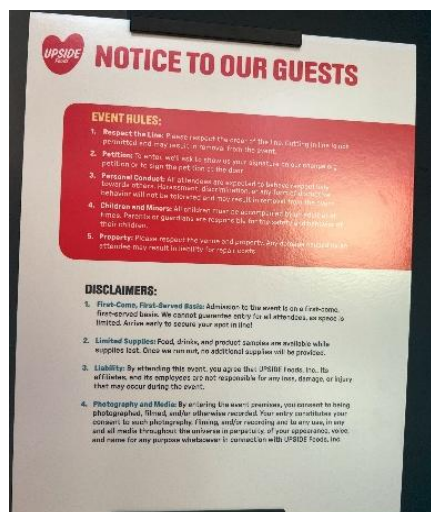
Used with permission from UPSIDE Foods.

Supplemental Figure 3a Protest Van with LED Billboard in Front of the Event Entrance; Supplemental Figure 3b Protest Van view from event doors.



Images by Suzannah Gerber

Supplemental Figure 4 Event Rules and Petition



Images by Suzannah Gerber

Supplemental Figure 5. Buffet at the UPSIDE Food “Freedom of Food” Pop-Up Event.



Images by Suzannah Gerber

Supplemental Figure 6 Menus of Food at Event



Images by Suzannah Gerber

Supplemental Figure 7 CEO, Dr. Uma Valeti Selfie and UPSIDE Response to Protest Van

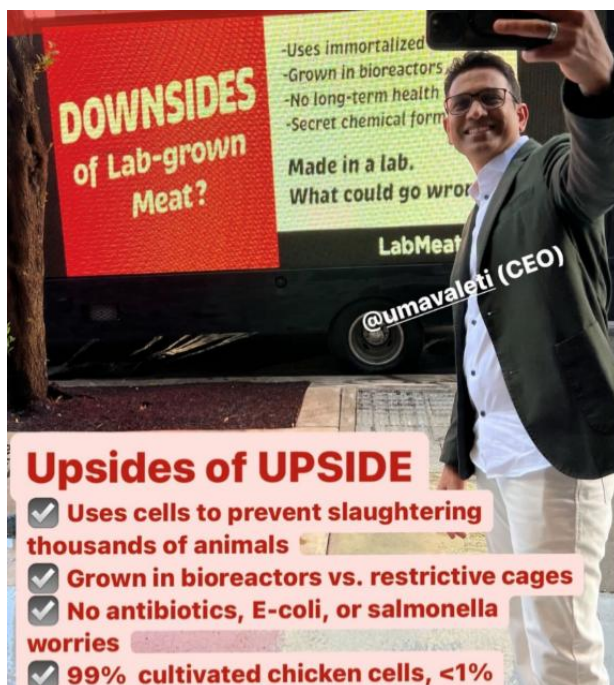


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Supplemental Table 1. Ethnographic Field Note Guide

EVENT	
Setting	Visibility, layout, flow through space, outdoor, tent, security
Info/guidance	Promotional materials, signage, schwag
Crowd comp	Media presence, Company presence, Speakers on stage, music playing
Encounter design	Line, free-moving, spatiality; welcoming; speed of movement within and how quickly samples expend (size and type of sample)
Prime	Freedom? Culinary? Science? Politics? Size and type of sample
CROWD	
Attendee	singles, families, men, women NB/O, age, race/ethnic
Clothing	Demonstrating vegan or political identity; tourism status; affluence; youth/fashion
Affect	Excitement (pre/post); anticipation; boredom; surprise, disappointment, event frustration
Eat	Slow/quick; savor; inspecting; social activity or analytical activity; sharing; finishing all
Time	Linger, meander, come early, ask for more info

Supplemental Table 2. Semi-Structured Interview Script

Question	Central Language	Probing Concepts
Affirm	Informed	
Consent	Confirm consent; Confirm recording consent	
Intro NOTES	Assign Participant ID: (FAKE NAME) Time: Location:	
Begin Prompt	You may choose to not answer any of my questions, or only answer as much as you like. Are you ready to begin?	
QUESTIONS		
Q1	Why did you come here today?	To try, to taste, curious, were you excited...
Q2	In your own words, what has your experience been coming here and trying this food?	What is your impression of cultivated food overall?
Q3	How did the food look?	Surprising, just like the real thing...
Q4	How did the food taste?	Probe: texture, flavor, presentation, surprising, met expectations etc.
Q5	Is there a way you might prepare this food that you would enjoy more (even more)?	Would you be willing to eat this again? Regularly?
Q6	What has your experience been at this event?	Energy of the room, impression of the company making the food
Q7	Compared to when you arrived, do you feel any differently about these foods?	Glad you tried, willing to try more now, still excited...
Q8	How do these foods compare to similar animal foods (if chicken, then chicken)	Environment, Health, Animal Welfare, for society overall, process/natural... Is it "real meat"?

Q9	How do these foods compare to similar plant-based foods (if chicken, then chicken)	Environment, Welfare, process/natural...	Health, for society	Animal overall,
Q10	If given the option, in a local or federal vote, would you vote for or against Cultivated foods like the one you tried today?			
Q11	What do you think about the upcoming ban on these foods in Florida?			
Q12	Is there anything else you'd like me to know about your opinions on what you tasted today, your overall experience, or your overall opinion on cultivated foods?			
Background Diet	Now I'm going to ask you some questions to get to know you a bit better. Do you follow any particular diet?	vegan/vegetarian/low-carb etc		
Background Politics	How would you describe your political affiliation?	party, or leaning. Please feel free to not answer if you wish		
Background Field	Do you work in food, healthcare, science or a related field?			
Background- Socio-Demographics	What is your age? What is your highest level of education? What is your sex/gender? At is your race/ethnicity? Do you live in Miami?	Did you travel here just for this event?		

Appendix 2: Chapter 2

2.1 Consort Checklist



CONSORT 2010 checklist of information to include when reporting a pilot or feasibility trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a pilot or feasibility randomised trial in the title	82
	1b	Structured summary of pilot trial design, methods, results, and conclusions (for specific guidance see CONSORT abstract extension for pilot trials)	82
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale for future definitive trial, and reasons for randomised pilot trial	83-86, Appendix 2
	2b	Specific objectives or research questions for pilot trial	86-87
Methods			
Trial design	3a	Description of pilot trial design (such as parallel, factorial) including allocation ratio	97
	3b	Important changes to methods after pilot trial commencement (such as eligibility criteria), with reasons	n/a
Participants	4a	Eligibility criteria for participants	97
	4b	Settings and locations where the data were collected	98
	4c	How participants were identified and consented	98
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	97-99
Outcomes	6a	Completely defined prespecified assessments or measurements to address each pilot trial objective specified in 2b, including how and when they were assessed	87-99
	6b	Any changes to pilot trial assessments or measurements after the pilot trial commenced, with reasons	n/a
	6c	If applicable, prespecified criteria used to judge whether, or how, to proceed with future definitive trial	n/a
Sample size	7a	Rationale for numbers in the pilot trial	99-100
	7b	When applicable, explanation of any interim analyses and stopping guidelines	n/a
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	99-100
	8b	Type of randomisation(s); details of any restriction (such as blocking and block size)	99-100
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	99-100

Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	99-100
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	99-100
	11b	If relevant, description of the similarity of interventions	n/a
Statistical methods	12	Methods used to address each pilot trial objective whether qualitative or quantitative	97-99
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were assessed for each objective	99-100, Table 1
	13b	For each group, losses and exclusions after randomisation, together with reasons	n/a
Recruitment	14a	Dates defining the periods of recruitment and follow-up	97
	14b	Why the pilot trial ended or was stopped	n/a
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Table 1
Numbers analysed	16	For each objective, number of participants (denominator) included in each analysis. If relevant, these numbers should be by randomised group	99
Outcomes and estimation	17	For each objective, results including expressions of uncertainty (such as 95% confidence interval) for any estimates. If relevant, these results should be by randomised group	100-104
Ancillary analyses	18	Results of any other analyses performed that could be used to inform the future definitive trial	100-104
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	100-104
	19a	If relevant, other important unintended consequences	n/a
Discussion			
Limitations	20	Pilot trial limitations, addressing sources of potential bias and remaining uncertainty about feasibility	108-109
Generalisability	21	Generalisability (applicability) of pilot trial methods and findings to future definitive trial and other studies	100-108
Interpretation	22	Interpretation consistent with pilot trial objectives and findings, balancing potential benefits and harms, and considering other relevant evidence	100-108
	22a	Implications for progression from pilot to future definitive trial, including any proposed amendments	106-109
Other information			
Registration	23	Registration number for pilot trial and name of trial registry	99
Protocol	24	Where the pilot trial protocol can be accessed, if available	99
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	Published
	26	Ethical approval or approval by research review committee, confirmed with reference number	99

2.2 Supplemental Table 1. Participant Responses to Three Salience Prompts

	Session 4 prompt: "How do you know it is working? What keeps you coming back?"	Session 2 prompt: "Where can you improve the most?"	Session 1 prompt: "How do you see your success?"
#5, Female	"I am able to fit it into my schedule because I can zoom in from anywhere. In the car, at home, or with my grandkids I can still participate—I never have to miss a session."	"I need to make more time for exercise"	"I'd like to lose more weight."
#1, Female	"I lost weight right away. I'm not going to say its been difficult, its been both difficult and not difficult. Its kind of exciting and the program definitely helps me with the motivation to keep going."	"I need to have a plan for each meal, and plan to increase my fiber and protein the most"	"The scale keeps going down, I have more energy, and I feel happy."
#6, Male	"This program is great because it is making me more aware of what I'm eating and why I'm eating it and what I should be eating. I am becoming more aware of what a healthier way of living is and how to get going on it."	"I need to try to eat my meals at the same time every day to keep from snacking and overeating"	"Having at least one healthy meal per day, trying new foods and skipping the junk food."
#3, Female	"You know I always thought 'I eat well', and, thanks to {the program}, I now realize changing is going to help me lose the weight quicker. I realized that because I'm older it takes longer to get into shape."	"I'm still looking for things to improve, you'll tell me what I need to change as we go."	"My head is still in the game, I'm proud of my progress and I feel motivated to keep going."
#2, Male	"I wouldn't miss a session for the world. I love coming to meet with you guys every week."	"I don't get enough water throughout the day."	"I see changes in my body."
#7, Female	"I've realized that I've got to take control of my life to be able to control my weight. I am learning that that means making my diet healthier. I am understanding how to keep myself physically healthy and how to monitor myself."	"I need to eat more slowly and choose healthier food options."	"Control impulses to eat when stressed and enjoy a well-prepared meal and avoiding snacking"
#4, Female	"Weight loss isn't always perfectly predictable. That's not how it works. If I keep on going and coming to meetings I am going to feel better, and my clothes are [already] much looser no matter what the scale says."	"I need to get back to my routine of drinking more water and doing yoga."	"I feel like I've accomplished what I set out to when I get 5,000 steps a day, and once I lose 10 pounds."
#8, Male	"I enjoy the approach of this program because I want to lose weight but I also want to have a diet I can enjoy."	"I want to improve controlling my portions, making healthy food choices, and not losing sight of my goals."	"Losing weight and also having a diet I can enjoy"

#9, Female	<i>"Higher energy levels and physical flexibility due to all the walking."</i>	<i>"Being accurate about measuring my food and making more time for exercise."</i>	<i>"Early weight loss and keeping the weight off"</i>
#10, Female	<i>"The scale has dropped and my clothes don't fit the same and also how I feel, having more energy."</i>	<i>"I could improve my sleep. And portion control of what I eat."</i>	<i>"Losing weight on the scale or [when] your clothes are feeling a little bit looser. Remembering the words that seem to disappear from my head when trying to have a conversation with somebody."</i>

2.3 Supplemental Modification Details and Rationale

Theory of behavior change

Questions informed by Transtheoretical Model (TTM) constructs of Stage of Change (SOC) and Process of Change (POC) [398, 469] modified from Gonzalez-Ramirez et. al. [470] were added as formal intervention checkpoints in group meetings to increase participant self-awareness. Program goals were delivered as open-ended questions, polls and discussion prompts, as well as communicated through participant-led and/or in a flipped classroom structure to increase engagement in the remote format, consistent with the four processes of Motivational Interviewing (MI): experience validation, reframing, summarizing, and deployment of personal insights[53, 471], similarly to the method described in Dineen et.al.[52] and in alignment with the logical framework presented in Hawkes et. al. [472]

Adaptation of program goals and exercise, diet, and weight recommendations for older adults

Daily activity and calorie targets, and successive weight loss goals, are re-evaluated throughout the program.[473, 474]

In contrast to the original DPP which sets uniform minimum activity targets, and weight-category calorie limits irrespective of activity level and weight loss attainment, this adaptation sets physical activity targets first at 5,000 steps/day which can increase to 6,000-10,000 steps per day depending on individual goals. Moderate-Vigorous Physical Activity (MVPA) targets begin at 100 minutes/week and can rise to 150-210+ min/week depending on goals. Exercise recommendations focused on walking/jogging at various intensity levels as the main form of exercise, and although safety practices from the original DPP were included (e.g. warm-ups/cool-downs and stretching), instruction to perform more strenuous physical activity was removed. These changes addressed participant feedback in Beasley, et al. and Lee, et. al. [77, 475] and aimed to reduce risk of injury in this vulnerable population during remote-only delivery. Participants were encouraged to continue or undertake all other exercise with the permission of their doctor.

Concerning diet, calorie targets are initially determined by using participant starting weight, as in DPP, but this modification employed suggested ranges with the DPP target set as the minimum and the next higher level set as the maximum. Ranges are adjusted monthly based on changes in weight (e.g. reduced to support continued weight loss at the same rate) and for activity level (e.g. lower if less active, higher if frequently active). Dietary composition recommendations are modified from the low-fat and low-energy density focus of DPP to emphasize flexibility in dietary patterns, recognizing reduced willingness and physical and financial ability to change dietary patterns among many older adults. [476] Participants were introduced to the healthy Mediterranean Diet, MIND Diet, DASH Diet, and healthy plant-based diet in the first session and were encouraged to follow preferred dietary plans with three main targets: 1) dietary fiber $\geq$ 25-35 grams/day, by adding a daily serving of legumes, increasing whole fruits and vegetables, and eating most/all grains as whole grains;[477] 2) reducing saturated fat by emphasizing lean and plant-based protein foods, and limiting dairy or replacing it with low-fat dairy and/or fortified dairy-alternatives;[478] and 3) maintaining protein intake >50 g/day.[479] Reducing total

dietary fat is a cornerstone of the original DPP, but was presented in this modification as one of several means of reducing total energy intake, and as a prevention strategy against underestimating calories in food logs.

As in DPP, the weight loss goal is -7%, however in this modification but when this goal is achieved participants are encouraged to self-determine continued weight loss or to shift towards weight maintenance. When chosen, subsequent weight loss goals were set as an additional -5-7% of the new body weight, or to a weight that would result in a BMI between 18.5-24.9 kg/m² if that amount was less than a 5% body weight reduction.

Changes to implementation and self-monitoring to support program fidelity and remote delivery

The group sessions are videoconference-based (Zoom, San Jose, CA) including for any necessary make-up sessions. A key advantage to the remote format is the ability to accommodate various schedules, including rescheduling sessions, providing make-up sessions, and/or allowing group members to join other groups to make-up a session they might have missed. [480]

Standardized presentation materials were developed to lead group sessions and to ensure program fidelity (PowerPoint, Microsoft, Redmond, WA). Each session is led by an interventionist using these materials which feature interactive elements to support engagement during sessions [481] and the same materials are utilized across groups, driving fidelity. [72, 76] The presentations use contemporary pedagogical methods including interactive polling, flipped classrooms, participant-generated examples, prompts for open discussions, and deploy theory-informed checkpoints to monitor progress. [481, 482] [483] (Appendix 2.5) All images and examples represented diverse older adults. Group-specific examples were gathered during sessions and used as personalized examples in future prompts to enable group cohesion and connection to the material. [71]

For remote monitoring of physical activity, weight, and dietary intake, participants were given a wearable fitness tracker (Fitbit Inspire 2; Fitbit, San Francisco, CA) and a Wi-Fi-enabled scale (Fitbit Aria Air), which were networked with the corresponding web-based Fitbit dashboard and smartphone application (Fitbit.com, 2022). The dashboard enabled self- and interventionist-monitoring, food logging, automatic heartrate and activity intensity measurement, behavioral cues and reminders, messaging, and other supportive resources for adherence. Participants were asked to wear the fitness tracker daily, and measure body weight daily after voiding when they woke up each morning, and log food daily.

Participant-interventionist interactions

Consistent with MI, and prior MI modifications to the DPP [52, 53, 471, 484], we utilized routine affirmations of participant experiences and choices during flipped classroom time. These provided opportunities to indicate integration of program concepts and to refine constructive action plans within sessions. Self-affirmations were conducted within sessions and in session handouts completed during and after session as homework tasks; and interventionist affirmations were sent in-between sessions via e-mail and using the dashboard to support progress and help increase goal salience.

Detailed progress reports were privately sent to each participant prior to each session. [480] Reports included affirmations, recommendations, and feedback based on weekly data collected remotely. Reports typically included reminders about participant's own described action plans, goal attainment, adherence driving messages, prompts to help prepare them to contribute to a flipped classroom format, and device management assistance.

Participants are linked to each other and to the interventionist on the dashboard. This enables social comparison among peer-participants where goals and activity levels are shared, as well as provides role modeling from the interventionist, and a messaging platform for additional affirmations, questions, and additional peer support outside the scheduled sessions. Additional nudges that encourage social

comparison and comparison to prior week performance are also sent through the mobile application. [67, 485]

2.4 Supplement Validation: Comparing Research Center and Wi-Fi Scales

At baseline, and at two additional time points a fasting duplicate measurement of weight was taken on-site for all participants, with shoes and outer clothing removed, using a calibrated scale at the research center.

At baseline (on-site visit 1), study participants were weighed while fasted at the beginning of the visit, using the center scale, prior to randomization. Individuals randomized into the intervention were then each assigned a wi-fi scale and weighed with the wi-fi scale during intervention onboarding, commonly in the afternoon of their baseline visit. For some participants, intervention onboarding was completed within four days of on-site baseline (mean 1.6 days). Participants in the control group were not assigned a wi-fi scale. The mean(SD) difference in weight between the wi-fi scales and the center scale at baseline was 0.3 kgs. (± 0.47) and with a Pearson Correlation of $Rho > 0.99$. The t-test for differences in paired means was not significant at baseline ($p < 0.06$).

To allow for scheduling flexibility, the protocol allowed for the second on-site study visit to occur within a window up to 28 days before or after the 12 week point of enrollment. The difference in time between three months of intervention exposure and the second on-site visit ranged from 21 days before to 6 days after. All intervention group participants weighed themselves using their wi-fi scale at home in the morning prior to arriving at the study center for their second on-site visit. The mean(SD) difference in weight between date-matched wi-fi scale and center scale was -0.5 kgs (± 0.9) with a Pearson Correlation of $Rho > 0.99$. The t-test for differences in paired means was not significant at the second on-site visit ($p < 0.13$). Mean(SD) weight loss according to the center scale was 5.3% (± 3.1) from baseline to visit two, compared to 6.1% (± 3.6).

The visit window for the third on-site visit was the same as the second, and visits ranged from 1 day before to 12 days after 24 weeks of enrollment. All intervention group participants weighed themselves using their wi-fi scale at home in the morning prior to arriving at the study center for their scheduled third on-site visit. The mean(SD) difference in date-matched weight between wi-fi scale and center scale was -0.5 kgs (± 0.6) with a Pearson Correlation of $Rho > 0.99$. The t-test for differences in paired means was significant for the third on-site visit ($p < 0.04$), apparently due to discrepancies in scale weights for three participants. Mean(SD) weight loss according to the center scale was 8.4% (± 4.1) from baseline to third visit, compared to 9.3% (± 4.1) on the wi-fi scale on the same day. The t-test of difference in mean weight loss from baseline to the third site visit was significant with a small difference in average weight loss between the home scale and the clinic scale (9.5% ± 4.5 vs 9.0% ± 4.4 , $p < 0.004$). Given that three participants appeared to account for the discrepancy, with lower home weights on the day of the clinic visit relative to prior home weights, we speculate that the small difference in weight between first morning scale weight at home and later morning scale weight on the center scale in those individuals was due to fluid intake and/or from non-compliance with the requirement to fast prior to clinic measurements. Further research is needed to investigate the cause of the small (0.5 kg) discrepancy noted here.

2.5 Supplement: Standardized Presentation Materials

The 24 Standardized presentations can be found here: <https://www.mdpi.com/2072-6643/16/7/930/s1>

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Appendix 3: Chapter 3

Supplemental Table 1. Example of Applied Scoring Scheme

	<u>Males</u>			<u>Females</u>		
	Q1	Median	Q3	Q1	Median	Q3
Eggs (ounces)	0.20	0.50	0.90	0.20	0.40	0.70
NOTE: Derived from the National Health and Nutrition Survey (NHANES)—What We Eat in America (WWEIA) and the related Food Patterns Equivalents Database (FPED), with usual intakes describing observed intakes from 2013-2016, calculated using the National Cancer Institute methods for estimating usual intakes.						

PALEO	Q1	Median	Q3	VEGETARIAN	Q1	Median	Q3
Eggs	0.315	0.9	1.44	Eggs	0.07	0.19	0.59
VEGAN	Q1	Median	Q3	WFPB	Q1	Median	Q3
Eggs	0.03	0.06	0.12	Eggs	0.02	0.045	0.1

NOTE: Intakes of eggs within the ADAPT Sample. Respondents following a vegan and WFPB diet overall fall within the first quartile of intake according to the U.S. usual intake reference (above 0 and below 0.2 eggs/day), which would result in most vegans and WFPB diet followers getting one point for egg consumption towards their total adherence score.

Supplemental Table 2. Intake of Restricted Foods in the ADAPT Sample, By Diet

PALEO	min	Q1	Med	Q3	Max
Red Meat	0	1.28	2.10	3.35	12.23
Poultry	0	0.33 5	0.93	1.43 5	5.24
Seafood	0	0.23	0.63	1.34	9.29
Dairy	0	0.14	0.38	0.84	3.60
Eggs	0.0 1	0.31 5	0.9	1.44	2.99
Legumes	0	0.03	0.23 3	0.65	4.42
Grains	0.0 3	0.67	1.33	2.01	6.83
Ref Grains	0.0 3	0.62 5	1.13	1.85 5	5.78
Added Oils	15. 4	39.9 6	55.0 1	68.7 6	134.51
Added Sugar	0.2 2	1.82	2.88	4.88	25.56

VEGETARIAN	min	Q1	Med	Q3	Max
Red Meat	0	0.14	0.23	0.43	1.85
Poultry	0	0.04	0.09	0.16	0.36
Seafood	0	0.01	0.02	0.09	2.64
Dairy	0.05	0.37	0.83	1.57	8.12
Eggs	0	0.07	0.19	0.59	2.86
Legumes	0.18	2.0346 8	3.2649 8	5.6192	28.1 0
Grains	0.41	2.38	3.255	5.5	16.0 5
Refined Grains	0.41	2.03	2.88	4.39	12.1 5
Added Oils	14.2 3	35.01	44.555	62.14	139. 83
Added Sugar	1.27	3.68	5.525	7.92	44.3 9

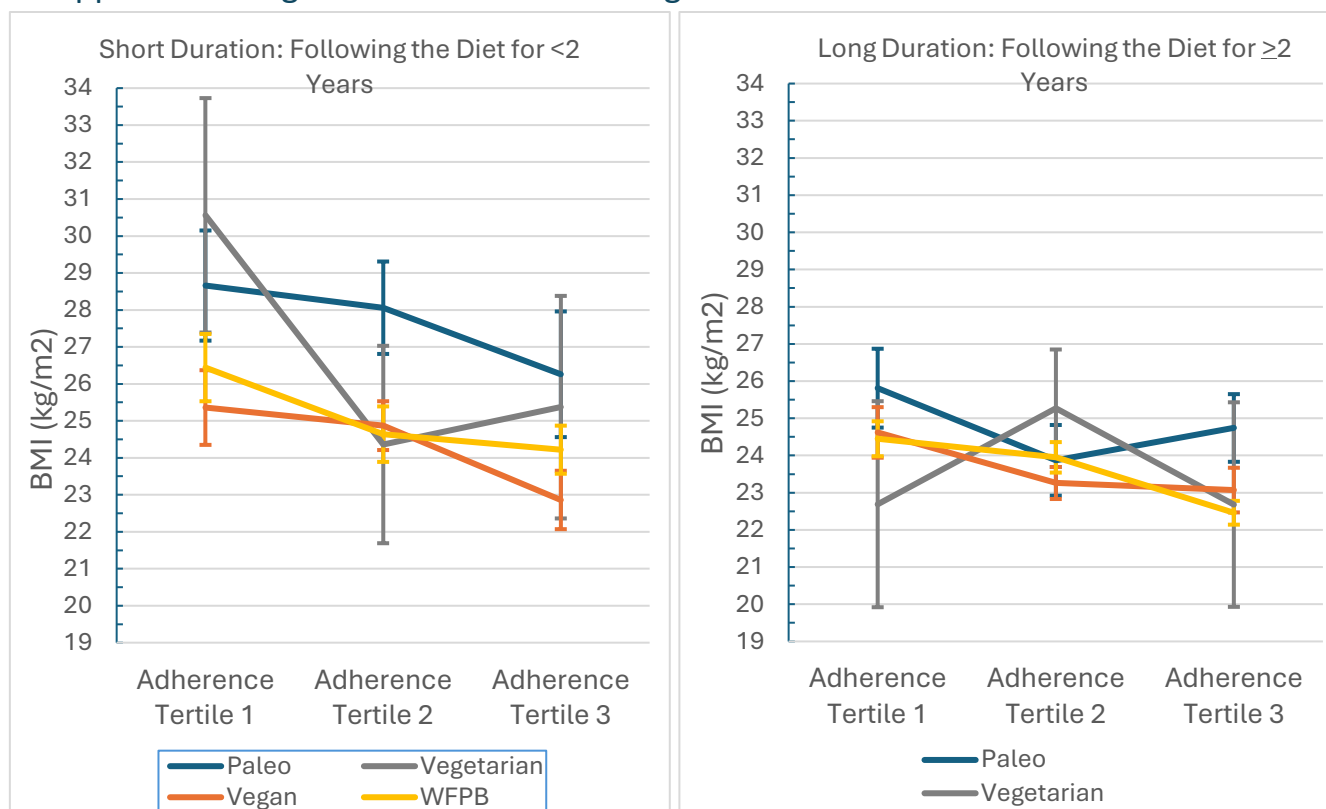
VEGAN	min	Q1	Med	Q3	Max
Red Meat	0	0.11	0.24	0.50	2.70
Poultry	0	0.04	0.08	0.18	1.31
Seafood	0	0	0.01	0.04	1.99
Dairy	0	0.15	0.3	0.54	6.03
Eggs	0	0.03	0.06	0.12	1.93
Legumes	0	2.85 8	4.72 7	7.39 2	33.09
Grains	0	2.48	3.77	5.57	12.71
Refined Grains	0	1.84	2.92	4.35	11.13
Added Oils	3.1 3	24.9 7	38.0 1	50.3 8	165.61
Added Sugar	0.5 3	2.82	4.25	6.85	46.21

WFPB	min	Q1	Med	Q3	Max
Red Meat	0	0.16	0.33	0.62	4.80
Poultry	0	0.04	0.11	0.21	3.22
Seafood	0	0.01	0.02	0.05	5.09
Dairy	0	0.17	0.305	0.55	4.23
Eggs	0	0.02	0.045	0.1	2.03
Legumes	0	3.3949 8	5.7534 2	9.1622 4	41.9 1
Grains	0	2.55	3.795	5.48	20.0 4
Refined Grains	0	1.73	2.76	4.1	16.2 6
Added Oils	0.01	23.73	33.015	46.41	136. 29
Added Sugar	0.33	2.66	4.05	5.87	56.6 8

NOTE: Usual Intakes for participants from the ADAPT study were derived from the National Cancer Institute's Dietary

History Questionnaire-II (DHQ-II). Amounts consumed among all of the food groups restricted among any of the diets included in the study are reported above.

Supplemental Figure 1. Duration Following Diet - Adherence to Diet and BMI.



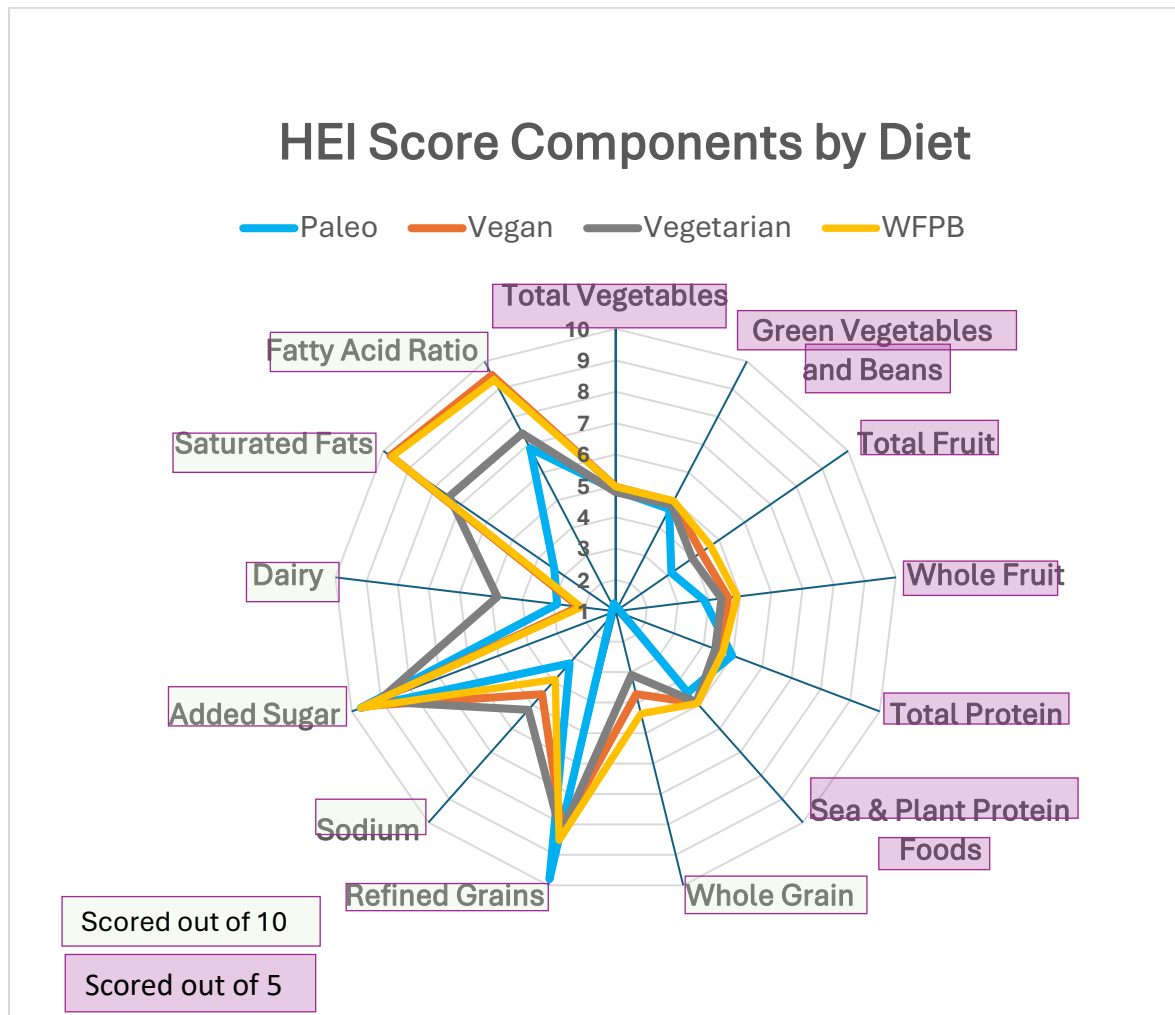
Note: Exploratory analysis using least-square means (SE) adjusted for sex, age, exercise (IPAQ), total energy intake, classified by adherence tertile and stratified by duration following one's diet within diet type groups. In the adjusted model, mean BMI was significantly lower among those with longer diet durations following a WFPB diet (those with shorter duration on diet had a 1.78 point higher BMI on average $p < 0.0001$) and vegan diet (those with shorter duration on diet had a 1.04 point higher BMI on average $p < 0.042$). Those following a Paleo diet had a smaller and not statistically significant higher average for shorter duration (0.85 points higher, $p < 0.37$), and vegetarians of shorter duration had a slightly lower average BMI, which was not statistically significant (-0.29, $p < 0.86$). Visualized above is the least-square means and standard errors within each diet stratified by duration (p for trend $p < 0.0001$). Trends indicate that higher tertiles of adherence for short-term diet followers were significantly associated with reduced BMI, whereas this significant trend was seen only among followers of WFPB and vegan diets among long-term followers. Sample sizes vary across diets, each tertile for short-term among vegans include $n = 38$, for WFPB $n = 98$, vegetarian $n = 7$, and Paleo $n = 24$; for long-term, each tertile included $n = 79$ vegans, $n = 138$ WFPB, $n = 23$ vegetarian, and $n = 22$ Paleo.

Supplemental Figure 2. Heat Map of Average Points Lost by Food Group Components for ADAPT Participants According to the HEI-2015.

	Paleo	Vegan	Vegetarian	WFPB
Sources of HEI Score Point Loss				
Total Vegetables	0.15	0.03	0.21	0.03
Green Vegetables and Beans	0.32	0.05	0.18	0.03
Total Fruit	1.84	0.69	1.03	0.33
Whole Fruit	1.15	0.39	0.6	0.1
Total Protein	0.03	0.44	0.6	0.34
Sea & Plant Protein Foods	0.54	0.08	0.12	0.07
Whole Grain	9.26	6.28	6.91	5.64
Refined Grains	0.2	1.86	1.7	1.48
Sodium	6.78	5.47	4.8	6.09
Added Sugar	0.31	0.47	0.89	0.31
Dairy	7.12	7.82	5.2	7.89
Saturated Fats	6.62	0.27	2.56	0.33
Fatty Acid Ratio	3.14	0.5	2.6	0.67

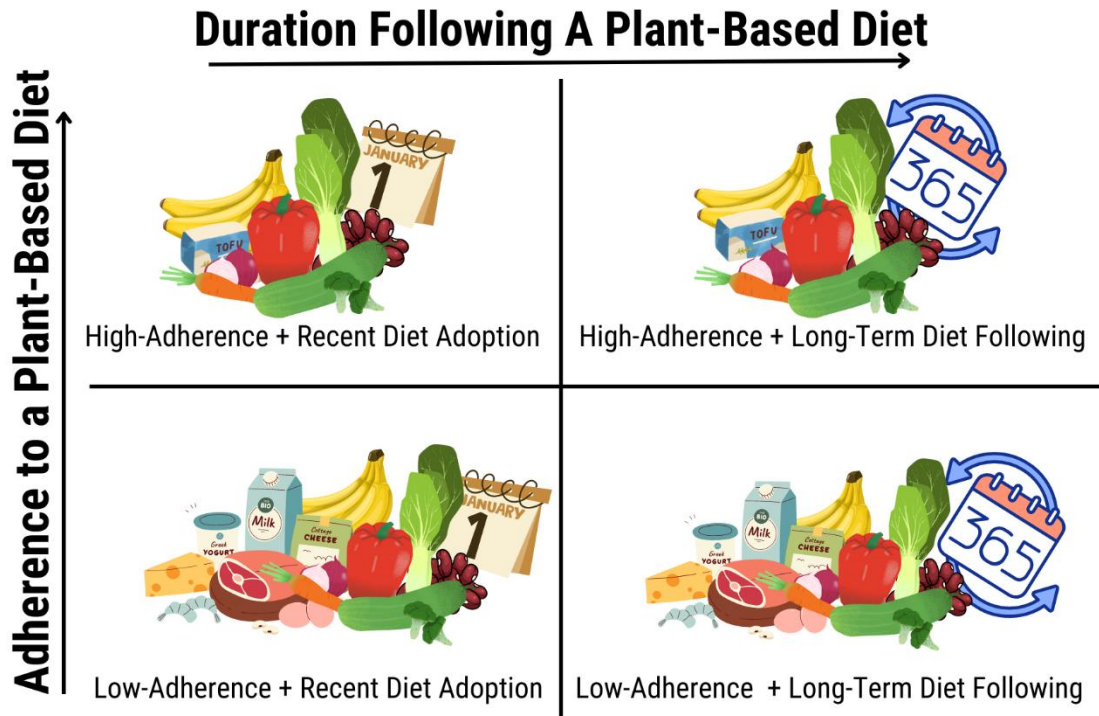
NOTE: The first column details the 13 components used in the HEI-2015 Score (HEI). Rows 1-6 (from Total Vegetables to Sea & Plant Protein) are each worth 5 points, and the remaining components are worth 10 points with a total of 100 possible points from all 13 components. The heat map shows a red color gradient of the relative proportion of points lost from the total points from each component (e.g. 0-5 for Total Fruit and 0-10 for Dairy). The HEI gives points for meeting recommended servings of foods such as vegetables, fruits, dairy, protein, and whole grains, and detracts for intakes that exceed recommended amounts of sodium, added sugar, refined grains, and saturated fat. The Fatty Acid Ratio used by HEI is the sum of polyunsaturated and monounsaturated fatty acids divided by saturated fatty acids ≥ 2.5 .

Supplemental Figure 3. Radar Plot of Average HEI-2015 Score Values By Food Groups Across Diet Types in ADAPT.



NOTE: The HEI-2015 Score (HEI) is the score of 13 food-group components. Spokes on the Radar Plot from 1 to 6 (from Total Vegetables to Sea & Plant Protein) are each worth 5 points, and the remaining components are each worth 10 points, for a total of 100 possible points in the HEI Score. The Fatty Acid Ratio used by HEI is the sum of polyunsaturated and monounsaturated fatty acids divided by saturated fatty acids ≥ 2.5 . The four diets in the ADAPT Study are shown as four different color lines on the radar plot. Values closer to 0 indicate areas where the average intakes for participants in each diet fell short of the Dietary Guidelines for Americans (DGAs), as scored by the HEI criteria; values near 5 for spokes 1-6, or near 10 for spokes 7-13 indicate close adherence to the DGAs. Lower intakes of saturated fat, added sugar, sodium, and refined grains achieve higher scores (approaching the top score of 10), whereas for all other components, a higher score indicates higher intake.

Supplemental Figure 4. Four-Quadrant Chart of High and Low Adherence to a Plant-Based Diet by Duration.



NOTE: Using plant-based diets (vegan and WFPB) as the example, the top left quadrant depicts an individual who is a recent adopter of this diet (<2 years) and adheres very closely to the rules of the diet (in this case, illustrated as the absence of animal-sourced foods). The top right quadrant depicts someone with a high level of adherence and who has been following this diet type for ≥ 2 years. On the bottom, both quadrants depict lower adherence levels (in this case illustrating the inclusion of animal-sourced foods) both among persons who have recently adopted the diet and who report following the diet over longer-term durations