



The East Side Table Make-at-Home Meal-Kit Program is feasible and acceptable: A pilot study

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ABSTRACT

Drawing from marketing literature, shopper solutions and food bundles (that group items to be used together) can promote purchase intention, efficacy, and related outcomes. Similarly, meal kits boxes (food bundles with step-by-step instructions to prepare home-cooked meals) have potential to be an accessible intervention to facilitate healthy, at-home food preparation and intake. This manuscript describes the feasibility, acceptability, and preliminary outcomes of a community-designed and -led program promoting healthy food skills, accessibility, and intake through meal kits. This pilot study was designed using community-based participatory research principles and 60 participants enrolled in the study. Participating families received a free meal kit weekly during the 10-week program. Meal-kit boxes also included language-appropriate recipe cards, step-by-step instructions, and supplemental educational material including links to videos with related food preparation tips and fact sheets about the meal. Data were collected at baseline, post-program, and follow-up (3 months post-program). Specifically, validated measures were used to assess food insecurity, food availability, cooking preparation techniques, self-efficacy, and fruit/vegetable intake. Process data were also collected. Descriptive statistics, paired t-tests, and Wilcoxon sign-ranked tests were used to describe data and evaluate outcomes. Content analysis was used to code open-ended survey responses into categories. Study findings indicated retention rates were high ($\geq 90\%$); 83% made eight or more meal kits. At post-program, significant increases were observed in cooking/meal preparation self-efficacy, cooking techniques, and healthy food availability. At follow-up, only healthy food availability remained significantly higher. Findings suggest that meal-kit programs are feasible and acceptable, and there is a potential for these programs to influence factors important to increasing healthy home-cooked meals and dietary intake. Future research should use more rigorous designs and explore meal-kit dosage.

1. Introduction

Especially for those from underserved backgrounds, lack of time, access to affordable foods, and cooking/food skills may make low-cost, energy-dense, low-nutrient foods appealing (Dinour et al., 2007; Drewnowski, 2004; Horning et al., 2017; Seligman & Schillinger, 2010; Taillie & Poti, 2017) and lead to increased consumption of foods with less healthy nutrient profiles (e.g., prepackaged processed meals; away

from home meals; Brunner et al., 2010; Hartmann et al., 2013; Horning et al., 2017; Mills et al., 2017; Wolfson & Bleich, 2015). Because research has linked these barriers to poor dietary and health outcomes (Caspi et al., 2012; Chen et al., 2016; Monsivais et al., 2014; Reicks et al., 2014; Storfer-Isser & Musher-Eizenman, 2013; Utter et al., 2018), working to increase food access and skills to prepare home-cooked meals within the time constraints of busy at-risk families may be an important intervention target (Garcia et al., 2016; Reicks et al., 2014, 2018).

Abbreviations: Supplemental Nutrition Assistance Program, (SNAP); general linear models, (GLMs); Women, Infants, and Children Special Supplemental Nutrition Assistance Program, (WIC); Expanded Food and Nutrition Education Program, EFNEP; community-based participatory research, (CBPR).

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Within marketing, shopper solutions and food bundles aim to meet customers' needs and time constraints with convenience through the display of related items together (Thomas et al., 2020). Within a grocery store, for example, a shopper solution is a display of all the food items necessary to make a particular recipe to facilitate quick and easy purchases (Thomas et al., 2020). Research findings suggest these shopper solutions positively impact both customer convenience and purchase intent (Thomas et al., 2020). While food purchasing research has not found significant increases in healthy food bundle sales as part of a grocery store intervention (Moran et al., 2019), other food purchasing research suggests that food bundling influences customer convenience and may facilitate healthy purchases and outcomes (Carroll et al., 2018). Thus, aligned with marketing and purchasing research, using a well-designed shopper solution and food bundling strategy within a public health intervention may enhance efforts to improve healthy food access, skills, and intake.

The Social Cognitive Theory (Bandura, 1986) posits a dynamic interplay between personal, behavioral, and environmental factors that lead to outcomes. One construct within these factors, self-efficacy (confidence) in performing a skill or task, is highlighted as particularly influential in impacting subsequent health behaviors and outcomes. Drawing from this theory, meal kits – a shopper solution and food bundle that contain step-by-step instructions, pre-measured ingredients, and foods necessary to easily create home-cooked meals – may facilitate increased convenience, access, and cooking self-efficacy. Meal-kits would increase self-efficacy by providing individuals the opportunity to prepare a healthy meal, follow of a recipe, as well as work with and become familiar with ingredients and new cooking techniques. Additionally, because even temporary meal kit use has the potential to increase self-efficacy, meal kits have long-term potential to impact subsequent behavior and outcomes.

Currently, meal-kit interest is high: a recent Nielson survey found nearly one in ten American consumers had reported recently buying a meal kit and one in four was contemplating a future meal-kit purchase (Neilson, 2018). Moreover, meal kits are becoming more widely available and have become Supplemental Nutrition Assistance Program (SNAP) eligible in some states like Minnesota. Given theorized impact on self-efficacy, public interest, increased availability, and SNAP eligibility, meal kits have potential to facilitate healthy at-home food preparation, self-efficacy, and intake for many. Currently, meal kits, a shopper solution and food bundle, are most often available for purchase within an online or grocery store environment and are widely marketed; however, meal kits can also be used within intervention programs. To date, two studies have used meal kits as an intervention with families. The two studies engaged nine (Utter et al., 2019) and ten (Utter & Denny, 2016) New Zealand families with low incomes. Qualitative interview findings indicated participants enjoyed the free meal-kit program and improved their cooking skills and eating habits as a result of the intensive intervention (Utter & Denny, 2016). Survey findings indicated increased vegetable intake and decreased food insecurity (Utter et al., 2019). These findings, while limited to small homogenous samples, indicate further research is needed to better understand (a) if meal kits impact food preparation techniques, self-efficacy, access, and intake in larger more heterogeneous populations at risk for poor outcomes and (b) if outcomes may be sustained after the completion of the intervention.

If meal-kit interventions are found to be effective, they could be particularly advantageous as a scalable intervention for two main reasons. First, meal-kits are widely available for purchase in many physical and online retail locations and have piqued public interest (e.g., which increases interest in participation), important factors in building up an intervention. Second, outside of the already growing retail presence, meal-kit interventions can be implemented with groups (e.g., within a community organization that serves individuals who may be a higher risk for poorer outcomes or in need of food skills); meal kits can also be added as a complement to existing programming (e.g., within

Extension's Expanded Food and Nutrition Education Program [EFNEP] or Women, Infants, and Children [WIC] programming) or used with at-risk individuals (e.g., within a clinic setting as a prescription for individuals with uncontrolled chronic health conditions like hypertension). Because the intervention is contained within the meal kit itself, meal-kit interventions can be self-paced. Meal-kit interventions also would not necessarily require a cohort, instructor, class schedule, or transportation, which pose barriers to more traditional cooking classes that have been found to increase cooking skills and self-efficacy, which are linked to healthier dietary behaviors (Hasan et al., 2019; Reicks et al., 2014; Wolfson et al., 2020). Additionally, unlike traditional cooking classes or programming targeting improved food access, skills, and intake outcomes, meal kits remain accessible to participants after intervention programs end, because meal-kits are available for purchase by retailers should organizations or participants need or want additional reinforcement of program messages.

This pilot study, designed with community-based participatory research (CBPR) principles, aimed to assess research feasibility, acceptability, and preliminary outcomes (i.e., food preparation techniques, confidence, accessibility, and intake) of the community-designed and -led Meal-Kit intervention program.

2. Methods

2.1. Meal-kit program

In Saint Paul, Minnesota, disparities in food quality, affordability, access, and skills are prevalent (Ramsey County, 2014; United States Department of Agriculture, 2017). These disparities are even more pronounced in the East Side neighborhoods. For example, using a measure of income as social determinant of health, on the East Side, 47% experience poverty at 200% of federal poverty guidelines (Wilder Research, 2020b) compared to 41% in Saint Paul, MN (Wilder Research, 2020a) and 25% in the State of Minnesota (Wilder Research, 2020c). Therefore, a Working Council consisting of 13 organizations of the East Side of St. Paul was convened under the leadership of M Health Fairview to assess challenges to healthy eating in the home (East Side Table, 2019). The assessment identified barriers to home cooking similar to those noted above and by the Minnesota Food Charter (Minnesota Food Charter, 2016), barriers that, in part, can be addressed with improved food skills. Informed by this assessment, M Health Fairview and the Working Council began by brainstorming and reviewing evidence and popular trends on potential solutions.

While many solutions were proposed, cooking classes and meal kits were among leading options. Common barriers to cooking classes (e.g., scheduling and getting people to classes, providing food for practicing skills outside of the class) prevented cooking classes from being a compelling solution. Meal-kits were discussed as a way to address community needs, because the meal kits would provide: food, focus on food skill development at home at the convenience and time of their choice, and the opportunity for families to try meal kits (often perceived as unaffordable from retail locations). Meal kits were also viewed by the group favorably because meal kits were novel, of community interest, and could engage and embrace the cultural diversity within the community. Resulting from these discussions, M Health Fairview and the Working Council developed the community-led and -driven East Side Table Make-at-Home Meal-Kit program (hereafter, Meal-Kit; East Side Table, 2019).

To ensure the program and materials were culturally-engaging, -sensitive, and -relevant to reflect the East Side neighborhood's diversity of cultures, food literacy, age, life situation, and interest in developing food skills, all components of the Meal-Kit program were designed with input from residents and community partners. These components included: menu design, recipe and spice selection (inclusive of discussions on cost of recipes and food items), recipe testing and sampling, meal-kit distribution plan development (delivery vs. pick up,

pick-up locations), length of program, educational materials to enclose within the meal kits, and the cooking skills the recipes should feature. Each week of the 10-week program, participating families received a free meal kit. Each meal kit included ingredients to create one healthy, tasty meal representing the East Side neighborhood's cultural diversity (e.g., Chef Yia Vang's Isaan Laab with Sauteed Mustard Greens; North African Spiced Chicken with Zucchini & Raisin-Sunflower Quinoa; Chicken Fajita Bowl with Lime Rice). The meals were designed to: take 30–45 min to prepare, provide 2–3 servings of vegetables per person and whole grains (which is why some recipes took up to 45 min), flavor foods with herbs and spices over salt and fats, and be prepared using basic cooking equipment (e.g., stove, oven, sheet pan, sauté pan, sauce pan). Finally, a dietitian on the Working Council reviewed all recipes to ensure alignment with dietary guidelines, and recipe nutrition information is available on the East Side Table website. For example, Chef Yia Vang's Isaan Laab with Sauteed Mustard Greens has 380 calories, 10 g of fat, and 25 g of protein per serving (East Side Table, 2019).

Meal-kit boxes also included language-appropriate recipe cards, step-by-step instructions, and supplemental educational material, including links to videos with related food preparation tips and tricks and fact sheets about the meal (e.g., nutrition benefits of ingredients, how to recreate spice blends). Local Crate, a local meal-kit company, donated staff time and materials to pack the meal kits and sold the kits at wholesale food cost to the Meal-Kit program (\$12 per box; 4 servings). Meal-kit program participants picked up their kits each week from a community partner organization of their choice (from a predetermined list) and were provided enough meal kits to ensure all members of their household would be able to eat the meal.

Drawing from the Working Council's and East Side Table's values and commitment to supporting inclusivity and diversity while addressing community-level disparities, eligibility criteria for Meal-Kit program participation were purposefully broad – participants needed to self-identify that they lived, worked, played, went to school, or did business in the East Side neighborhoods. Although the eligibility criteria were broad, because the community partners (e.g., community service providers and organizations primarily serving underserved individuals within the community) were integral in recruitment, the target audience recruited were those most likely to be at risk for poor outcomes. The Meal-Kit program enrolled 115 participants who were recruited by community partners primarily through informational events (e.g., events to describe the program to potential participants that were advertised and held in community partner organizations' spaces), community partner organizations (e.g., staff notifying individuals they worked with about the program), and web-enrollment (e.g., via the Meal-Kit program's website).

2.2. Research recruitment

All enrolled Meal-Kit program participants were offered the opportunity to participate in the pilot research study described herein. Potential participants indicated interest by filling out an information card, stopping at a recruitment table to learn more about the study, or by communicating with the principal investigator. Following requests for more study information, potential research participants were provided an overview of the study, screened for research eligibility (i.e., they were enrolled in the Meal-Kit program, interested in the research, 18 years of age or older, primary food preparer) and offered a time to complete written informed consent and baseline data collection. Sixty participants enrolled in the research study and provided written informed consent, which ran concurrently with the Meal-Kit program. Baseline paper and pen surveys were administered by trained research staff at data collection events at community partner locations. At both post-intervention and follow-up data collection time periods, all 60 participants were contacted and provided the opportunity to take the survey by pen and paper at community locations administered by trained study staff or by a secure online survey via the Research Electronic Data Capture (REDCap)

software platform. The study protocol was approved by the University of Minnesota Institutional Review Board.

2.3. Data collection

Data were collected before the Meal-Kit program (baseline), immediately after the program (post-program), and three months after the program ended (follow-up). Data collected included demographic characteristics and feasibility (retention rates) data. Outcomes were measured using validated psychosocial measures to assess food insecurity, food availability, cooking preparation techniques, and cooking and food preparation self-efficacy (see measurement and psychometric details on Table 1). The National Cancer Institute's All-Day Fruit/Vegetable Screener was used to measure the fruit/vegetable intake outcome (National Cancer Institute Division of Cancer Control and Population Sciences, 2000). Post-program process data to further assess feasibility as well as acceptability included: self-reported number of meal-kits picked up and made (0–10); if meals had been made a second time (yes/no); willingness to recommend the program to friends (yes/no); and perceived healthiness of the meal-kit meals as compared to their typical meals (very healthy to less healthy). Additionally, participants responded to an open-ended survey question: "List at least three things you learned from being in the program."

2.4. Data analysis

Descriptive statistics were used to describe participant characteristics, program process variables, psychosocial measures, and fruit/vegetable intake. Open-ended qualitative survey question responses were coded into categories using content analysis (Hsieh & Shannon, 2005). Paired t-tests were used to assess psychosocial outcomes for changes from baseline to post-program and from baseline to follow-up. Due to the skewed nature of fruit/vegetable intake, Wilcoxon sign-rank tests were used to assess for significant changes in fruit/vegetable intake from baseline to post-program and from baseline to follow-up. To assess for potential differential effects based upon sample characteristics, we also ran these same t-tests and Wilcoxon sign-ranked tests within a subsample of participants who experienced food insecurity at any of the three data collection timepoints ($n = 44$). Because receipt of economic assistance (a proxy for income) is often associated with outcomes, general linear models (GLMs) were used to assess whether post-program outcomes (adjusted for baseline values) were associated with receipt of economic assistance in the full research sample. Significance was set at 0.05 and analyses were performed in SAS Version 9.4.

3. Results

Full demographic data for the research participants are available in Table 2 and are similar to the demographic characteristics of the overall Meal-Kit program participant data (see Table 2). Retention was 54/60 (90%) at post-program and 55/60 (92%) at follow-up. Over the course of the program, weekly meals were provided to feed 230 individuals (60 research participants and their 170 household members). Program participation was high; at post-program, 48/54 (89%) reported *picking up* eight or more meal kits and 45/54 (83%) reported *making* eight or more meal kits. While participants received the meal-kit boxes for free with this program, at post-program, participants assessed how affordable they felt the meal-kit recipes were if they were to make the meal again; most participants found the meal-kit recipes to be very affordable (12/54, 22%) or affordable (39/54, 72%), although a few perceived the recipes as unaffordable (3/54, 6%). In comparison to meals they typically made, many participants perceived the healthiness of the meal kit recipes to be very healthy (22/54, 41%) or mostly healthier (28/54, 52%); however, a few reported meal-kit recipes were somewhat less healthy (3/54, 6%) or less healthy (1/54, 2%) than the meals they typically made. Some participants reported making meal-kit recipes a

Table 1
Key psychosocial measures used to assess outcomes of the East Side Table Make-at-Home Meal Kit program.

Measure (original psychometrics). ^{citation}	Example item from the measure	No. items	Response options	Scale alphas in study sample		
				pre	post	follow-up
Cooking and Food Preparation Self-Efficacy ($\alpha = 0.90$). ^(Lahne et al., 2017)	I am confident creating meals from the ingredients have on hand.	13	7 point ^a	$\alpha = 0.90$	$\alpha = 0.90$	$\alpha = 0.91$
Cooking Techniques ($\alpha = 0.91$). ^(Condrasky et al., 2011)	Preparing fresh or frozen green vegetables (eg, broccoli, spinach).	14	5 point ^b	$\alpha = 0.88$	$\alpha = 0.91$	$\alpha = 0.89$
Negative Cooking Attitude ($\alpha = 0.85$). ^(Condrasky et al., 2011)	Cooking is frustrating.	4	5 point ^a	$\alpha = 0.91$	$\alpha = 0.82$	$\alpha = 0.89$
Food Insecurity (^c Alpha not provided; 97% sensitive 83% specific to gold standard food insecurity measure). ^(Hager et al., 2010)	Within the past 12 months we worried whether our food would run out before we got money to buy more.	2	3 point ^c	$\alpha = 0.85$	$\alpha = 0.89$	$\alpha = 0.92$
Healthy Food Availability ($\alpha = 0.89$). ^(Flocke et al., 2017)	The fresh fruits and vegetables in your neighborhood are of high quality.	4	5 point ^a	$\alpha = 0.81$	$\alpha = 0.78$	$\alpha = 0.82$

Note. Items were summed for scale scores. Responses were coded so higher scores indicated a higher trait (e.g., higher food insecurity, higher self-efficacy). Number of response options are listed in the table, and superscripts note what the response options were.

^a From strongly disagree to strongly agree.

^b From not at all confident to extremely confident.

^c From never true for me to always true for me.

Table 2
East Side Table Make-at-Home Meal-Kit Research Participant Characteristics (N = 60) and comparison to the wider Meal-Kit program participants inclusive of those who did and did not choose to participate in research (N = 115) for data that is available.

Participant Characteristics	Research	Overall Program
	n (%)	n (%)
Age		
Less than 18		1 (1%)
18-34	17 (28%)	42 (40%)
35-44	26 (43%)	34 (32%)
45-54	9 (15%)	17 (16%)
55 and older	8 (13%)	12 (11%)
Gender		
Female	56 (93%)	98 (93%)
Male	4 (7%)	7 (7%)
Economic Assistance Use		
Yes	35 (58%)	NA
No	25 (42%)	NA
Survey Language		
Spanish	3 (5%)	NA
English	57 (95%)	NA
Race/Ethnicity		
Participants identifying from Diverse Racial/Ethnic Background(s)	38 (66%)	75 (74%)
Participants identifying as white/Caucasian	20 (34%)	27 (27%)
Household Size		
1-2	12 (20%)	25 (24%)
3-4	33 (56%)	51 (49%)
5-6	8 (14%)	16 (15%)
7 or more	6 (10%)	13 (12%)

Note. Economic assistance use = participant reported receiving one or more of the following income-based programs: Supplemental Nutrition Assistance Program (SNAP), Women Infants and Children Special Supplemental Nutrition Assistance Program (WIC), Nutrition Assistance Program for Seniors, Minnesota Family Investment Program, Energy Assistance, Child Care Assistance Program, Medical Assistance. NA=Not available. All available data provided.

second time (20/54, 37%). Nearly all participants (52/54, 96%) reported they would recommend the program to a friend.

Three categories of findings emerged from the open-ended survey question: "List at least three things you learned from being in the program." First, participants learned new, or became more confident with cooking/kitchen skills (e.g., knife skills, sautéing, following a recipe), as exemplified by "[I learned] how to prepare meals, follow instructions and if doesn't come out right or mess up its okay." Second, participants learned to try and cook new foods (e.g., whole grains like quinoa, legumes like chickpeas, vegetables like chard, culturally diverse meals), as

represented by "[I learned] the use of ingredients I've never tried before and the experience of trying new foods." Finally, participants learned to cook with spices. For example, "[I learned] how to make/use spice blends from around the world."

Comparing post-program and baseline scores, paired *t*-test results indicated significantly higher self-efficacy related to cooking and food preparation, cooking techniques, and healthy food availability (Table 3). At follow-up, only healthy food availability remained significantly higher. Results of subgroup analyses for those who experienced food insecurity at any of the three data collection timepoints (n = 44) trended similarly to those of the full study sample although significance attenuated (Table 4). In the GLM models, adjusted for baseline values, economic assistance use was only significantly associated with higher food insecurity ($p < 0.01$) at post program for those who reported receiving economic assistance (Least Squares Mean = 1.7), compared to those who did not (Least Squares Mean = 1.0).

4. Discussion

Our pilot research study showed high retention and meal-kit program participation rates, suggesting feasibility of recruitment and retention of participants. Process data indicated acceptability with high levels of program participation and satisfaction. Change in outcomes is not a key goal of pilot studies because limited statistical power can lead to inaccurate conclusions or misconstrue findings (Arain et al., 2010; Kistin & Silverstein, 2015; Lancaster et al., 2004; Leon et al., 2011). However, it still remains common to preliminarily evaluate outcomes to help assess potential for intervention impact in a future fully-powered trial to study intervention efficacy, but pilot results must be considered with particular caution and should not be used to determine efficacy of an intervention. Our preliminary findings of this pilot did not indicate significantly increased fruit and vegetable intake; however, both qualitative and quantitative findings of increased cooking confidence, cooking techniques, and food availability immediately after the program suggest meal-kit programs may have the potential to influence factors important to increasing healthy, home-cooked meals in the short-term. These findings align with qualitative and survey findings of two small, intensive, meal-kit studies with nine (Utter et al., 2019) and ten (Utter & Denny, 2016) families. Of note, the number of meals provided to participants by the Meal-Kit programs differed considerably; the present study provided 10 meals over 10 weeks and the intensive studies delivered 20 meals over 4 weeks or 40 meals over 8 weeks (Utter & Denny, 2016; Utter et al., 2019). Understanding the meal-kit dose (number and frequency) that yields the best engagement and outcomes is crucial to designing meal-kit interventions; it is possible a program with more meals kits (e.g., 2 per week versus 1 per week) or that

Table 3

T-test or Wilcoxon Sign-Ranked differences in outcomes of the East Side Table Make-at-Home Meal Kit program.

Outcome	Post - baseline Paired Mean Diff (SD)	<i>p</i>	Follow-up - baseline Paired Mean Diff (SD)	<i>p</i>
Cooking and Food Preparation Self-Efficacy ^a	2.9 (10.8)	0.05	2.4 (10.3)	0.09
Cooking Techniques ^a	2.6 (7.0)	<0.01	0.7 (8.0)	0.51
Negative Cooking Attitude ^a	0.2 (2.8)	0.64	-0.1 (3.3)	0.75
Food Insecurity ^a	0.0 (1.0)	0.78	0.1 (1.1)	0.44
Healthy Food Availability ^a	1.1 (3.3)	0.02	1.1 (3.1)	0.01
Fruit/Vegetable Intake (Servings) ^b	0.5 (4.8)	0.57	-1.3 (5.4)	0.01

Note.

^a T-test was used to assess if the change was significant.^b Wilcoxon Sign-Ranked Test was used to assess if the change was significant, as responses were skewed.**Table 4**

T-test or Wilcoxon Sign-Ranked differences in outcomes of the East Side Table Make-at-Home Meal Kit program with a subsample of participants who are food insecure at any time point (n = 44).

Outcome	Post - baseline Paired Mean Diff (SD)	<i>p</i>	Follow-up - baseline Paired Mean Diff (SD)	<i>p</i>
Cooking and Food Preparation Self-Efficacy ^a	3.1 (11.8)	0.10	2.7 (11.9)	0.11
Cooking Techniques ^a	2.8 (7.5)	0.02	0.8 (8.7)	0.56
Negative Cooking Attitude ^a	0.2 (3.0)	0.69	-0.2 (3.6)	0.68
Food Insecurity ^a	0.0 (1.1)	0.79	0.1 (1.2)	0.45
Healthy Food Availability ^a	0.9 (3.5)	0.11	1.0 (3.3)	0.07
Fruit/Vegetable Intake (Servings) ^b	0.8 (5.1)	0.51	-1.1 (5.8)	0.03

Note.

^a T-test was used to assess if the change was significant.^b Wilcoxon Sign-Ranked Test was used to assess if the change was significant, as responses were skewed.

continues over a longer duration (e.g., 12 weeks versus 8 weeks) would result in more sustained behavior change.

While the aforementioned intensive studies (Utter & Denny, 2016; Utter et al., 2019) and our study both targeted diverse families and individuals with low-incomes, our Meal-Kit program was also available to anyone who lived, worked, played, worshiped, or went to school in the community. This inclusivity was intentional and resulted in a diverse, heterogeneous sample of participants. As such, findings may indicate meal-kit programs could be relevant to diverse populations across the lifespan and income levels because economic assistance was not associated with any post-program outcomes except food insecurity. However, heterogeneity also likely increased complexity in assessing for changes in outcomes, as groups with similar characteristics (e.g., cultural background, economic status, age of children) may have benefited differently, which could confound aggregate results. Heterogeneity also potentially complicated program messaging, as it is possible that program messages could have been more helpful if further individualized (e.g., parents with small children may have experienced different concerns/barriers than parents with adolescents or adults without children). As such, future meal-kit programs should consider accounting for heterogeneity; for example, by tailoring messaging and/or stratifying recruitment based on participant characteristics to ensure enough power to perform subgroup analyses. Although underpowered in the present pilot, we did run analyses with a subsample of our participants (those who experienced food insecurity at any of the three data collection time points; n = 44). Results trended similarly to that of the whole study sample, indicating that generally those with food insecurity may respond similarly to that of the full, more heterogeneous study population. However, larger randomized studies with food insecure and secure populations are needed in order to understand meal-kit benefits on subpopulations. Ultimately, choices around sample inclusion criteria should be made together with a CBPR team to achieve a participatory design that balances the benefits and potential risks of conducting research in the community.

While our immediate post-program pilot findings aligned with previous small scale research (Utter & Denny, 2016; Utter et al., 2019), unique to our meal-kit research was the follow-up assessment three

months after the program ended. This follow-up data collection period helped us to assess the feasibility of longitudinal assessment of outcomes and also provided preliminary insights on potential sustainability of outcome changes. Findings were opposite from the sustained outcomes theorized. For example, the improved cooking-related outcomes in our pilot study at post-program did not remain statistically higher than baseline at the three-month follow-up. It is plausible that lack of sustained change may have been due to: the small sample size of our pilot study not powered to detect change, insufficient program dose, lack of a control group, and/or seasonal effects impacting food prices or stress levels, such as changes in financial resources (follow-up data collection occurred around December 2018) that could make it more difficult to maintain a new skill/behavior. As such, designing a well-timed, more intensive program may help facilitate sustained confidence and behavior change over time. While the Social Cognitive Theory (Bandura, 1986) highlights the importance of self-efficacy, other factors within this theory (e.g., personal, behavioral and environmental characteristics such as personal/family goal commitments, outside obligations like work or activities, family food preferences, home food environments) were not assessed and should be considered to facilitate the success of future meal-kit intervention programming. Additionally, because 69% of our participants identified with some level of food insecurity at baseline, facilitating connections to local resources to address food insecurity may also be an important meal-kit intervention component to consider.

Although no immediate changes were observed in fruit and vegetable intake after the program was over (again which may have been a result of low statistical power), we did observe that fruit and vegetable intake significantly decreased at the three-month follow-up data collection period. We believe it is unlikely that this decrease in fruit and vegetable intake is the result of a delayed intervention effect from participation in a program that ended three months prior. However, this preliminary finding emphasizes the need for further fully-powered research with a control group to assess whether this change is related to program participation or rather is related to other potential factors listed above (e.g., winter/holiday seasonal impacts on food availability, food affordability, and/or change in financial resources). For example, if

future meal-kit research finds participation leads to poorer long-term outcomes, it is critical from a population health perspective to understand this potential for harm because meal-kits, a shopper solution and food bundling strategy, are of interest to the public, are widely marketed, and are becoming increasingly available in retail settings. On the contrary, if fully-powered, future, meal-kit intervention program research trials are found to be effective in enhancing self-efficacy and health behaviors and outcomes aligned with the Social Cognitive Theory (Bandura, 1986), meal-kits may prove to be a scalable public health intervention for researchers, health care systems, and community-based service providers, alike. Additionally, these future research findings would also be of interest to meal-kit marketers and retailers as findings may expand audiences for meal kits beyond individual customers to other audiences and settings (e.g., clinics, community organizations).

This pilot study is not without limitations: the small sample limited statistical power and prohibits evaluation of intervention efficacy, there was no comparison group, and the 60 who self-selected into the research may not represent all of the 115 meal-kit program participants affecting generalizability. Additionally, while all measures used for this study were previously validated with solid psychometrics, these measures were self-reported and future research would benefit from more rigorous and objective measurement of key outcomes. Finally, without a comparison group, we were unable to assess how the program compares to other programs/interventions (e.g., cooking programs) designed to influence similar outcomes; future research should assess whether meal-kit programs are cost-effective in producing similar or better outcomes than other related programs/interventions (e.g., cooking programs).

Our pilot study findings suggest that future meal-kit research is feasible, acceptable, and needed, because meal kits are becoming more widely available, are eligible for SNAP in states like Minnesota, and could be utilized in scalable interventions if found to be successful in fully-powered rigorous trials. Additionally, researchers should explore meal-kit dose (i.e., number and frequency) and whether program outcomes differ across populations.

Ethical statement

The research protocols used for the study described in this manuscript were reviewed and approved by the Institutional Review Board at the University of Minnesota. The research was conducted in accordance with the Declaration of Helsinki.

Author contributions

Horning: Designed the study in partnership with community partner Hill, led all aspects of the study, completed quantitative data analysis and independent qualitative analysis coding, drafted manuscript, revised manuscript.

Hill: Designed the study in partnership with Horning, reviewed manuscript for accuracy and substantially contributed to manuscript revision.

Martin: Assisted with data collection, manuscript drafting, reviewed manuscript for accuracy and substantially contributed to manuscript revisions.

Hassan: Assisted with data collection, manuscript drafting, independent qualitative data analysis coding, reviewed manuscript for accuracy and substantially contributed to manuscript revisions.

Petrovskis: Assisted with data collection, manuscript drafting, reviewed manuscript for accuracy and substantially contributed to manuscript revisions.

Laura Bohan: Assisted with the development of the study, manuscript drafting, reviewed manuscript for accuracy and substantially contributed to manuscript revisions.

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