

Impact of a farmers' market healthy food subsidy on the diet quality of adults with low incomes in British Columbia, Canada: a pragmatic randomized controlled trial

Michelle L. Aktary¹, Sharlette Dunn², Tolulope Sajobi², Heather O'Hara³, Peter Leblanc³, Gavin R. McCormack^{1,2,4,5}, Stephanie Caron-Roy¹, Kylie Ball⁶, Yun Yun Lee¹, Sara Nejatnamini², Raylene A. Reimer¹, Bo Pan⁷, Leia M. Minaker⁸, Kim D. Raine⁹, Jenny Godley^{2,10}, Shauna Downs¹¹, Candace I. J. Nykiforuk⁹, Dana Lee Olstad^{1,2*}

¹Faculty of Kinesiology, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada; ²Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, 3280 Hospital Drive NW, Calgary, AB T2N 4N1, Canada; ³British Columbia Association of Farmers' Markets, 203-2642 Main Street, Vancouver, BC V5T 3E6, Canada; ⁴School of Architecture, Planning and Landscape, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada; ⁵Faculty of Sport Sciences, Waseda University, 2 Chome-579-15 Mikajima, Tokorozawa, Saitama 359-1192, Japan; ⁶Deakin University, Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Geelong 3216, Australia; ⁷EPICORE Centre, University of Alberta, Suite 362, Heritage Medical Research Centre, University of Alberta Edmonton, AB T6G 2S2, Canada; ⁸School of Planning, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada; ⁹School of Public Health, University of Alberta, 3-300 Edmonton Clinic Health Academy, 11405-87 Avenue, Edmonton, AB T6G 1C9, Canada; ¹⁰Department of Sociology, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada; ¹¹School of Public Health, Rutgers University, 683 Hoes Lane W, Piscataway, NJ 08854, USA.

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*Corresponding author:

Dr. Dana Lee Olstad

Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, 3280 Hospital Drive NW, Calgary, AB T2N 4N1, Canada

(403) 210-8673

dana.olstad@ucalgary.ca

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Data described in the manuscript, code book, and analytic code will be made available upon email request to the corresponding author.

Abbreviations: ASA24-Canada-2018: Automated Self-Administered 24-Hour Dietary Assessment Tool Canada; BMI: body mass index; BC: British Columbia; CI: confidence interval; CONSORT: Consolidated Standards of Reporting Trials; FMNCP: Farmers' Market Nutrition Coupon Program; HEI-2015: Healthy Eating Index 2015; RCT: randomized controlled trial; REDCap: Research Electronic Data Capture; TEE: total energy expenditure; TEI: total energy intake; US: United States

1 **Abstract**

2 **Background:** Adults with low incomes have lower diet quality than their higher income
3 counterparts. In Canada, the British Columbia Farmers' Market Nutrition Coupon Program
4 (FMNCP) provides coupons to low-income households to purchase healthy foods in farmers'
5 markets.

6

7 **Objective:** To examine the impact of the FMNCP on the diet quality of adults with low incomes.

8

9 **Design:** In a pragmatic randomized controlled trial conducted in 2019, adults with low incomes
10 (≥ 18 years) were randomized to an FMNCP intervention (n=143) or a no-intervention control
11 group (n=142). The FMNCP group received 16 coupon sheets valued at \$21/sheet over 10–15
12 weeks to purchase healthy foods from farmers' markets. Participants completed a questionnaire
13 and two 24-hour dietary recalls at baseline (0 weeks), immediately post-intervention (10–15
14 weeks), and 16 weeks post-intervention (26–31 weeks). Diet quality was calculated using the
15 Healthy Eating Index-2015 (HEI-2015). Linear mixed-effects regression assessed differences in
16 HEI-2015 total (primary outcome) and component scores (secondary outcomes) between the
17 FMNCP and control groups at post-intervention and 16 weeks post-intervention. Subgroup
18 analyses examined program impacts by sex and age group (18-59 years, ≥ 60 years).

19

20 **Results:** There were no significant differences in HEI-2015 total scores between the FMNCP
21 and control groups at post-intervention (-0.07; 95% confidence interval (CI) -4.07, 3.93) or 16
22 weeks post-intervention (1.22; 95% CI -3.00, 5.44) overall or among subgroups. There were no
23 significant between-group differences in HEI-2015 component scores at post-intervention,

24 although there were significant differences in component scores for dairy and fatty acids at 16
25 weeks post-intervention.

26

27 **Conclusion:** The FMNCP did not significantly improve diet quality among adults with low
28 incomes over the study period. Further research is needed to explore whether higher subsidy
29 amounts or a longer intervention period is needed to meaningfully improve diet quality among
30 adults with low incomes.

31

32 **Key words:** Randomized controlled trial, diet quality, Healthy Eating Index, low-income, adults,
33 farmers' market, healthy food subsidy, 24-hour dietary recall

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47 **Introduction**

48 In high-income countries such as Canada (1) and the United States (US) (2), populations with
49 low incomes have poorer diet quality than their higher income counterparts. These dietary
50 inequities have persisted and even widened in some cases over the past several decades (1, 2).
51 Dietary inequities increase the burden of nutrition-related chronic diseases among populations
52 with low incomes and thus are a key contributor to health inequities (3).

53
54 Farmers' markets offer a unique opportunity to support healthy dietary patterns by increasing
55 access to fresh, local produce (4) and enhancing nutrition- and food-related knowledge through
56 interactions with vendors (5-7). Within this context, farmers' market fruit and vegetable subsidy
57 programs are growing in interest as policy interventions to improve fruit and vegetable intake
58 among populations with low incomes (5, 8, 9). Evidence from US studies suggests that farmers'
59 market fruit and vegetable subsidies are associated with increased fruit and vegetable
60 consumption among adults with low incomes (5, 10-13). However, while these studies suggest
61 that farmers' market fruit and vegetable subsidies may improve fruit and vegetable intake, they
62 used study designs that cannot show causality. Furthermore, previous studies examined
63 associations between farmers' market fruit and vegetable subsidies and fruit and vegetable intake
64 alone, rather than overall diet quality, which can better capture the multidimensionality of dietary
65 intake (14). All but one study used brief fruit and vegetable screeners rather than dietary
66 assessment instruments that capture more detailed dietary intakes with less bias, such as 24-hour
67 dietary recalls (15). Most previous studies also failed to examine the sustainability of program
68 impacts. Examining whether potential changes in diet quality are maintained after healthy food
69 subsidies end can shed light on possible underlying mechanisms of action. For instance, if any

70 improvements in diet quality are not sustained after the subsidies end, then the underlying
71 mechanisms may be primarily economic. However, if any improvements in diet quality are
72 sustained, this may indicate that subsidies also acted as cognitive nudges or led to shifts in food
73 preferences. Alternatively, or in addition, such a finding may indicate that the program enhanced
74 participants' food and nutrition knowledge, such as through nutrition skill-building or via
75 interactions with food vendors. To our knowledge, no published randomized controlled trials
76 (RCT) have examined the impacts of farmers' market healthy food subsidies on diet quality
77 among adults with low incomes.

78

79 The British Columbia (BC) Farmers' Market Nutrition Coupon Program (FMNCP) is the largest
80 and longest running government-funded farmers' market food subsidy program in Canada (16-
81 18). While program participants have reported consuming more fruits and vegetables and fewer
82 highly processed foods since participating in the FMNCP (19), program impacts have not yet
83 been rigorously examined. Accordingly, we undertook a pragmatic RCT to examine the impacts
84 of the FMNCP on the diet quality (primary outcome), diet quality component scores, sense of
85 community, mental well-being, household food insecurity, malnutrition risk (secondary
86 outcomes), and subjective social status (exploratory outcome) of adults with low incomes
87 immediately following the FMNCP (post-intervention) and 16-weeks post-intervention. This
88 paper reports findings pertaining to overall diet quality and diet quality component scores.

89

90 **Methods**

91 *Program overview*

92 The FMNCP was established in 2007 and is delivered as a collaborative partnership among the
93 BC Association of Farmers' Markets, the BC Ministry of Health, the Provincial Health Services
94 Authority, local farmers' markets, and community partners. The program is primarily funded by
95 the BC Ministry of Health, with additional financial support provided by local community
96 organizations (20). The aim of the FMNCP is to increase access to healthy local foods for low-
97 income families and older adults in order to improve their diet quality and overall health (17).
98 While the FMNCP has continued to expand each year, reaching 15,862 individuals across 78 BC
99 communities in 2019, many low-income households remain on waiting lists to access the
100 program. This pragmatic RCT was conducted alongside the existing FMNCP to examine
101 program impacts as it is normally delivered. The program was scaled up to accommodate an
102 additional 285 individuals from program wait lists for this study. Participants from the existing
103 FMNCP were not enrolled as it would have been unethical to randomize existing participants to
104 a control group that received no coupons.

105

106 *Study design*

107 This was a parallel-group pragmatic RCT in which participants were randomized 1:1 to the
108 FMNCP intervention group or a no-intervention control group. This study was conducted in
109 accordance with the Tri-Council Policy Statement and the Declaration of Helsinki. Ethical
110 approval was obtained from the Conjoint Health Research Ethics Board at the University of
111 Calgary (REB18-0508; Calgary, Alberta, Canada), University Ethics and Compliance at Rutgers
112 University (FWA00003913; Newark, New Jersey, US), and the Office of Research Ethics at the
113 University of Waterloo (ORE #40724; Waterloo, Ontario, Canada). This study is described in
114 accordance with the Consolidated Standards of Reporting Trials (CONSORT) statement (21).

115 Full study details have been published elsewhere (22). Deviations from the pre-registered study
116 protocol are detailed in the online supplementary materials (**Supplementary methods**).

117

118 *Participants, recruitment, and eligibility*

119 From May to August 2019, community partners (non-profit organizations, such as pregnancy
120 outreach and community services agencies) recruited study participants from among their
121 existing clients on the FMNCP wait list and through social media and flyer advertisements.

122 Adults with low incomes aged 18 years or older were eligible to participate if they: 1) had not
123 previously participated in the FMNCP; 2) met community-specific FMNCP annual household
124 income eligibility cut-offs (in many communities this was < CDN \$18,000/year; however, these
125 thresholds were higher in communities with higher costs of living); 3) had ≤ 8 people living in
126 the home, including the participant (to limit dilution of program impacts due to larger households
127 sharing foods purchased with the coupons); 4) were the primary food shopper for the household;
128 5) did not self-report dementia or Alzheimer's disease; 6) were able to speak, read, and write in
129 English (or had someone to assist them); and 7) did not expect to move or to have any changes in
130 their household income or composition prior to study completion. Eligible participants
131 completed a screening questionnaire at a community partner site and provided voluntary
132 informed consent to participate in the study prior to completing baseline data collection.

133

134 *Sample size calculation*

135 The sample size calculation used a minimally important difference in HEI-2015 scores based on
136 an RCT that examined the impact of a fruit and vegetable subsidy on the diet quality of adults
137 with low incomes (23). This study found that HEI-2010 scores were 4.7 points higher among

138 those in the intervention group compared to those in the control group at post-intervention (23).
139 Assuming a type I error of 5%, potential design effects of 10%, and an attrition rate of 30% by
140 16-weeks post-intervention, a target sample size of 264 participants was calculated to detect a
141 5.0-point difference in HEI-2015 scores with 80% power. This difference is equivalent to, for
142 example, an additional 1.1 cup equivalents of vegetables per 1,000 kcal/day (24).

143

144 ***Randomization***

145 An independent statistician generated a concealed blocked randomization sequence, using sex
146 (male, female), geographic location (rural, urban), pregnancy, and breastfeeding as blocking
147 variables. Following baseline data collection, the study research coordinator (SD) randomized
148 participants using REDCap (Research Electronic Data Capture), a secure, web-based data
149 collection and management application (25). SD communicated group allocation to participants
150 and community partners via email. Participants could not be blinded to their group assignment
151 but were blinded to the study's specific objectives. Researchers who collected and analyzed the
152 data remained blinded to participant group allocation.

153

154 ***Intervention***

155 Sixteen community partners from communities across BC (5 rural and 11 urban) provided
156 coupons to study participants. Participants in the FMNCP group received coupons to purchase
157 fresh fruits and vegetables, dairy, meat, poultry, fish, eggs, nuts, and cut herbs at BC farmers'
158 markets and were invited to attend nutrition skill-building activities, such as cooking classes. The
159 frequency and types of nutrition skill-building activities vary by community partner and thus,
160 consistent with the existing FMNCP, participation in the nutrition skill-building activities was

161 not required. Community partners normally provide households with one coupon sheet valued at
162 \$21/sheet (7 coupons in \$3 denominations) each week for 16 weeks (totalling \$336); however, to
163 allow for a longer recruitment period, participants received the intervention over 10-15 weeks
164 rather than 16 weeks. Participants received double the number of coupons during some weeks to
165 ensure they received the full 16 weeks' worth of coupons. Coupons were distributed from June to
166 October 2019 and were redeemable at any point during the farmers' market season until
167 November 2019. For the duration of the study, those in the control group did not receive coupons
168 and were not eligible to participate in the nutrition skill-building activities. Participants in the
169 control group were invited to participate in the FMNCP during the subsequent 2020 farmers'
170 market season (19).

171

172 *Data collection*

173 The FMNCP and control groups completed data collection at baseline (time 1; 0 weeks May-
174 August 2019), post-intervention (time 2; 10–15 weeks, two weeks before farmers' market
175 closures, October-November 2019), and 16 weeks post-intervention (time 3; 26–31 weeks,
176 February-March 2020). At each time point, participants completed an online questionnaire and
177 an online 24-hour dietary recall at a community partner site or a location of their choice (e.g., at
178 home). Participants received an email invitation to complete a second dietary recall 2–5 days
179 later (15). Community partners were trained to assist participants in completing data collection.
180 Participants also had the option to complete data collection over the telephone with a researcher.
181 To encourage survey completion, participants received cash incentives valued at CDN \$20 at
182 time 1 and CDN \$40 at each of time 2 and 3.

183

184 *Sociodemographic characteristics and health-related information*

185 The questionnaire was administered via REDCap and collected data on baseline
186 sociodemographic characteristics including age, sex, height, race/ethnicity, years lived in
187 Canada, and community of residence. At each time point, participants also reported their marital
188 status, household size, number of children living in the home, perceived physical health,
189 pregnancy, breastfeeding, smoking status, weight, highest educational level, employment status,
190 total annual household income before taxes, and main source of income. Information on
191 secondary and exploratory outcomes (sense of community, mental well-being, household food
192 insecurity, malnutrition risk, and subjective social status) was also collected (22) and will be
193 reported in future publications. At post-intervention only, participants reported whether they
194 received coupons and attended nutrition skill-building activities, and the frequency and amount
195 of their own money spent and the types of foods purchased at farmers' markets.

196

197 *Dietary intake*

198 Participants reported all foods and beverages consumed from midnight to midnight the previous
199 day using the validated (26, 27) Automated Self-Administered 24-hour Dietary Assessment Tool
200 for Canada (ASA24-Canada-2018) (28). The ASA24-Canada-2018 is an online, self-
201 administered 24-hour dietary recall developed by the US National Cancer Institute, modified to
202 reflect the Canadian food supply (29). The ASA24 collects dietary recalls using an adapted
203 version of the Automated Multiple Pass Method (27), which has been shown to reduce
204 underreporting and memory-associated issues with dietary reporting (30).

205

206 Studies have suggested that the ASA24 is suitable for multiethnic (31) and low-income (32)
207 populations; however, a previous study conducted with FMNCP participants identified several
208 challenges associated with independently using the ASA24 (33). Thus, researchers were made
209 available via email or a toll-free study helpline to assist participants in completing data
210 collection. Interrater reliability in conducting dietary recalls over the phone and entering data
211 into the ASA24-Canada-2018 at each time point among researchers remained high, with an
212 intraclass correlation of 0.98.

213
214 Researchers made up to four attempts to contact participants who failed to initiate data collection
215 or who had incomplete responses or potentially implausible dietary intakes. Previously
216 established cut-offs were used to identify participants to contact to further investigate the
217 plausibility of dietary intake data (i.e., <500 kcal/d or >3,500 kcal/d for females and <800 kcal/d
218 or >4,000 kcal/d for males (34)). Researchers manually entered missing data for those who were
219 successfully contacted. For instance, at baseline, post-intervention, and 16 weeks post-
220 intervention, researchers assisted 21.8% (n=62), 17.2% (n=47), and 22.4% (n=57) of
221 participants, respectively, who had not initiated or who had potentially implausible dietary
222 recalls. At each time point, we were unable to contact 3.5% (n=10), 3.7% (n=10), and 4.7%
223 (n=12) of participants whose dietary recalls were potentially implausible; however, given the
224 day-to-day variability in dietary intakes (35), all reported dietary intakes were retained unless
225 confirmed incomplete by the participant.

226

227 *Coupon distribution and redemption*

228 Community partners recorded the number of coupons distributed to each participant, allowing
229 researchers to track overall coupon distribution and redemption. However, the corresponding bar
230 code to track participant-specific coupon distribution and redemption was not consistently
231 recorded. Farmers' market vendors tracked which foods were purchased with coupons (e.g.,
232 fruits and vegetables) by using check boxes on the back of each coupon. Thus, we had data
233 pertaining to overall, but not participant-specific, coupon distribution and redemption.

234

235 *Data analysis*

236 *Diet quality*

237 Diet quality was calculated using the validated (36) Healthy Eating Index-2015 (HEI-2015)
238 using dietary intake data obtained from the ASA24-Canada-2018. HEI-2015 scores reflect
239 adherence to the 2015-2020 Dietary Guidelines for Americans (24), which coincide closely with
240 recommendations in Canada. The HEI-2015 has shown predictive validity (36), and HEI scores
241 have been associated with indicators of socioeconomic position (37) and chronic disease (38).
242 The National Cancer Institute's simple scoring algorithm was used to calculate HEI-2015 total
243 and component scores (24). Unlike other HEI-2015 scoring methods, the simple scoring
244 algorithm provides HEI-2015 scores at the individual level and can therefore accommodate
245 covariates in regression models (24). HEI-2015 scores were calculated using SAS macros
246 provided by the National Cancer Institute by summing component scores for adequacy (total
247 fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods,
248 seafood and plant proteins, fatty acids) and moderation (refined grains, sodium, added sugars,
249 saturated fats) components. For adequacy components, a higher score indicates higher intake,
250 whereas, for moderation components, a higher score indicates a lower intake (24). HEI-2015

251 total scores can range from 0-100, with a higher score indicating a higher diet quality (24). At
252 each time point, HEI-2015 scores were averaged when two recalls were available (n=211 to
253 249), otherwise a single recall was used (n=14 to 43).

254

255 *Statistical analyses*

256 Descriptive statistics summarized participant characteristics and HEI-2015 scores by intervention
257 group at each time point.

258

259 Linear mixed effects models were used to analyze differences in HEI-2015 total and component
260 scores for the FMNCP and control groups at post-intervention and 16 weeks post-intervention.

261 Models included group, time, and a group by time interaction as fixed effects. Random effects
262 accounted for repeated measures within participants, and a random slope for time using an
263 unstructured covariance matrix allowed each participants' intake to vary across time. Model
264 assumptions, such as normality and linearity of residuals, were met. Mixed models computed
265 maximum likelihood estimates for missing data, under a missing at random assumption. Data
266 were analyzed using an intention-to-treat approach in which participants were analyzed within
267 the groups to which they were randomized regardless of dropout or adherence to their assigned
268 intervention group.

269

270 To increase the precision of effect estimates (39), models were adjusted for blocking variables
271 (sex, geographic location, pregnancy, and breastfeeding), age, highest educational level,
272 race/ethnicity, marital status, body mass index (BMI), smoking status, perceived physical health,
273 number of household members, children living in the home, and the day on which the dietary

274 recalls were completed (i.e., both weekend (Friday to Sunday), both weekday, or one weekend
275 and one weekday).

276
277 Previous studies have suggested that the use of and response to farmers' market fruit and
278 vegetable subsidies may vary according to individual level factors such as age (40) and sex (41).
279 Thus, two *a priori* subgroup analyses were conducted to examine between-group differences in
280 HEI-2015 total scores by sex and age group at post-intervention and 16 weeks post-intervention.
281 Age was categorized as adults (18-59 years) and older adults (≥ 60 years) to align with age
282 groups used in the existing FMNCP.

283

284 ***Missing data***

285 Baseline variables with missing values ranged from 0.4% (perceived physical health) to 10.9%
286 (race/ethnicity). A total of 22 (7.72%) and 41 (14.4%) HEI-2015 scores were missing at post-
287 intervention and 16 weeks post-intervention, respectively. Missing HEI-2015 scores and
288 participant dropout were included as indicator variables in separate logistic regression models (0
289 = missing/dropout, 1 = observed/remained in study). Predictors of missing outcome measures
290 and participant dropout were examined separately, as some participants who remained in the
291 study had missing outcomes. Models included covariates used in the primary analysis and other
292 potential predictors of missingness including total annual household income, main source of
293 income, and years lived in Canada.

294

295 Statistical analyses were conducted in Stata (version 15.1, StataCorp), R (version 4.1.0, R
296 Foundation for Statistical Computing, Vienna), and SAS (version 9.4.40 Cary, NC: SAS
297 Institute). Statistical significance was set at a p-value of <0.05.

298

299 *Sensitivity analyses*

300 We conducted multiple sensitivity analyses. First, missing HEI-2015 scores were imputed using
301 multiple imputation with chained equations under a missing at random assumption. Fifteen
302 imputations were performed (42). Imputation models included HEI-2015 total scores and all
303 baseline covariates from the linear mixed model. Predictive mean matching was used for
304 continuous variables and logistic and multinomial logistic regressions were used for binary and
305 categorical variables, respectively.

306

307 Second, the ratio of reported total energy intake (TEI) to predicted total energy expenditure
308 (TEE) was included in the models as a continuous variable to adjust for dietary intake
309 misreporting (43-45). TEE was calculated using validated equations developed by the Institute of
310 Medicine, accounting for participants' age, sex, height, weight, and physical activity level (46).
311 We assumed a low physical activity level of 1.5 (45). These equations were developed to predict
312 TEE of non-pregnant or breastfeeding adults with BMIs 18.5 or higher; therefore, we excluded
313 pregnant and breastfeeding females and participants classified as underweight (BMI<18.5)
314 (n=42) from these sensitivity analyses (45, 46). Participants whose reported energy intake was
315 beyond ± 1 SD from their TEI:TEE were classified as under- or over-reporters of dietary intake
316 (43). Note while researchers used simple thresholds (i.e., <500 kcal/d or >3,500 kcal/d for
317 females and <800 kcal/d or >4,000 kcal/d for males (34)) to identify participants with potentially

318 implausible intakes for follow-up during data collection, TEI:TEE was used for this sensitivity
319 analysis as it is a recommended method to estimate and adjust for dietary intake misreporting
320 (43-45).

321

322 Using self-reported data from the questionnaire, we conducted per-protocol and as-treated
323 analyses to examine the extent to which contamination of the intervention groups may have
324 affected study outcomes. The per-protocol analysis included participants who adhered to their
325 group allocation (i.e., participants in the FMNCP group who reported receiving coupons (n=139)
326 and participants in the control group who reported not receiving coupons (n=116)). In an
327 additional per-protocol analysis, we considered both coupon receipt and nutrition skill-building
328 attendance. This analysis included participants in the FMNCP group who reported receiving
329 coupons (n=139) and participants in the control group who reported not receiving coupons nor
330 attending nutrition skill-building activities (n=97). This per-protocol analysis did not exclude
331 participants in the FMNCP group who did not attend nutrition skill-building activities, as
332 attendance is not a requirement in the existing FMNCP. In the as-treated analysis, participants
333 were analyzed according to the intervention actually received. That is, participants who received
334 coupons were analyzed as part of the FMNCP group (n=165) and participants who did not
335 receive coupons were analyzed as part of the control group (n=120). Participation in nutrition
336 skill-building was not considered because our aim was to assess the FMNCP as delivered, and in
337 the existing FMNCP, nutrition skill-building activities are not a requirement of program
338 participation.

339

340 Finally, a small number of participants completed one (n=20) or both (n=8) dietary recalls two
341 weeks or more after farmers' market closures and thus program impacts may have been missed
342 for some. Therefore, a sensitivity analysis was conducted whereby participants who completed
343 dietary recalls two weeks or more after farmers' market closures were excluded.

344

345 **Results**

346 A total of 285 adults completed baseline data collection and were randomized to the FMNCP
347 intervention (n=143) or the no-intervention control group (n=142). At post-intervention, 272
348 participants remained in the study (95.4%), while 254 participants remained at 16 weeks post-
349 intervention (89.1%; **Figure 1**). Dropout rates were similar between intervention groups.

350 Participants were more likely to drop out from the study if they were widowed, had lived more
351 years in Canada, or smoked occasionally. Participants were less likely to drop out if their main
352 source of income was from social assistance or 'other' sources (e.g., refugee sponsorship). HEI-
353 2015 scores were more likely to be missing among those who were widowed and had lived more
354 years in Canada, and less likely to be missing among those who relied on social assistance as
355 their main source of income) (**Supplementary results: Supplementary Table 4**).

356

357 *Participant characteristics*

358 Participant characteristics at baseline are described in **Table 1**. Similar to participants in the
359 existing FMNCP (47), most were female (90.5%), under 60 years of age (79.7%; mean age 43
360 years), and had children < 19 years living in the household (65.9%). The majority of participants
361 self-identified as White (37.7%) or South and West Asian (35.0%). Thirty-nine percent of
362 participants reported a total annual household income of < \$20,000/year, 39.8% reported a high

363 school education or less, 56.1% were married or common-law, 86.7% were non-smokers, and
364 68.0% reported their health as ‘good’ or better. The mean baseline HEI-2015 total score was 60.2
365 out of a possible 100, similar to that of a nationally representative sample of adult females with
366 low incomes living in Canada (mean HEI-2015 score 59.1) (1).

367

368 *Coupon distribution and redemption*

369 Community partners distributed 85.0% of coupons to participants over the study period (13,580
370 coupons distributed out of 15,820 allocated coupons), with lower distribution rates primarily
371 attributable to participants not picking up the coupons. The coupon redemption rate at farmers’
372 markets was 99.1% (13,463 coupons were redeemed out of 13,580 coupons distributed).

373

374 Four participants (2.8%) in the FMNCP group reported that they did not receive any coupons,
375 while 26 participants (18.3%) in the control group reported receiving coupons. Given that the bar
376 code numbers for the coupons distributed to participants were not consistently recorded, we were
377 unable to verify how many coupons these 26 participants received.

378

379 *Food purchasing*

380 Based on data provided by farmers’ market vendors, participants primarily used coupons to
381 purchase vegetables (39.0%), fruit (17.6%), meat and fish (11.1%), eggs (10.1%), with fewer
382 coupons redeemed to purchase dairy (3.7%), cut herbs (0.5%), and nuts (0.02%).

383

384 Farmers’ market food purchasing data obtained from the questionnaire showed that 62.1% of
385 participants in the FMNCP group reported purchasing food from farmers’ markets at least once

386 per week (using FMNCP coupons or their own money) (**Supplementary results:**
387 **Supplementary Tables 1 to 3**). Nearly half of the participants in the FMNCP group (48.8%)
388 reported spending some of their own money (excluding coupons) at a farmers' market once per
389 month or more during the season. Among those who reported spending their own money, 47.7%
390 spent over \$10 during their most recent farmers' market visit. Participants in the FMNCP group
391 reported primarily using their own money to purchase vegetables (33.3%), 'other' food items
392 (e.g., breads, baked goods) (22.6%), meat (15.5%), and fruit (14.3%). Few participants used their
393 own money to purchase dairy (4.9%), eggs (4.9%), cut herbs (1.2%), and nuts (0.0%).

394
395 Among participants in the control group, 17.0% reported purchasing foods at a farmers' market
396 at least once per week, with 73.6% reporting spending over \$10 during their most recent farmers'
397 market visit. Participants in the control group reported purchasing primarily vegetables (58.5%),
398 fruits (17.0%), and other food items (11.3%). Few participants used their own money to purchase
399 dairy (5.7%), meat (5.7%), eggs (1.9%), and nuts (0.0%).

400

401 *Nutrition skill-building activities*

402 Only 35.7% (n=45) of participants in the FMNCP group reported attending nutrition skill-
403 building activities. Moreover, while those in the control group were meant to be excluded, 24.4%
404 (n=29) reported attending nutrition skill-building activities during the study period.

405

406 *Diet quality*

407 There were no significant differences in adjusted HEI-2015 total scores between the FMNCP and
408 control groups at post-intervention (-0.07; 95% confidence interval (CI) -4.07, 3.93)) or 16

409 weeks post-intervention (1.22; 95% CI -3.00, 5.44) (**Table 2**). Unadjusted and adjusted estimates
410 of all variables included in the models are available in the **supplementary results**
411 (**Supplementary Table 5**). Subgroup analyses did not reveal any significant between-group
412 differences in HEI-2015 scores by sex or age group (**Supplementary results: Supplementary**
413 **Table 6**). There was a trend towards higher HEI-2015 scores among the FMNCP and control
414 groups at post-intervention in unadjusted models; however, this trend was attenuated in fully
415 adjusted models (**Supplementary results: Supplementary Table 5**).

416
417 There were no significant differences in HEI-2015 component scores at post-intervention;
418 however, there was a trend for intake of refined grains (-1.15; 95% CI -2.34, 0.04; p=0.06) and
419 whole fruit (0.60; 95% CI -0.06, 1.26, p=0.07) to be higher in the FMNCP group compared to
420 the control group at post-intervention (**Table 2**). Note that although the signs are the opposite of
421 one another they both signify higher intake in the FMNCP group because refined grains are a
422 moderation component (and therefore reverse scored), while whole fruits are an adequacy
423 component. In addition, dairy intake was significantly higher (1.47; 95% CI 0.31, 2.62) and fatty
424 acid intake was significantly lower (-1.30; 95% CI -2.57, -0.04) among those in the FMNCP
425 group at 16 weeks post-intervention. Both components are adequacy components.

426 427 *Sensitivity analyses*

428 Approximately 60% of participants misreported their dietary intake at each time point when
429 examined using TEI:TEE, with no differences between groups. Effect estimates after adjusting
430 for dietary intake misreporting remained non-significant, with slightly wider confidence intervals
431 (**Supplementary results: Supplementary Table 7**). Similarly, the effect estimates from the

432 imputed models and the per-protocol and as-treated analyses remained non-significant. Estimates
433 from analyses that excluded participants who completed one (n=20) or both (n=8) dietary recalls
434 two or more weeks following market closures also remained non-significant.

435

436 **Discussion**

437 To our knowledge, this is the first published RCT to examine the impact of a farmers' market
438 healthy food subsidy on the diet quality of adults with low incomes. There were no significant
439 differences in HEI-2015 total scores between groups at post-intervention or 16 weeks post-
440 intervention. Similarly, subgroup analyses did not reveal significant between-group differences
441 in HEI-2015 scores by sex or age group. There were no significant between-group differences in
442 HEI-2015 component scores post-intervention, although there were significant differences in
443 component scores for dairy and fatty acids at 16 weeks post-intervention.

444

445 Although we are unaware of any published RCTs that have examined the impacts of farmers'
446 market healthy food subsidies on diet quality, prior RCTs have examined the impacts of healthy
447 food subsidies redeemable at multiple retailers, including farmers' markets, on the diet quality of
448 adults with low incomes (23, 49, 50). For instance, Olsho et al. (23) found that HEI-2010 scores
449 were 4.7 points higher among adults with low incomes receiving a 30% incentive for fruit and
450 vegetable purchases for 12 months compared to those in a no-intervention control group (23).
451 The study also found significant differences in several HEI-2010 component scores (e.g., total
452 fruit) (23). Conversely, Basu et al. (50) found that among adults with low incomes receiving
453 vouchers valued at \$20/month for 6 months, HEI-2015 scores significantly improved among
454 those receiving weekly unrestricted vouchers but not among those receiving fruit and vegetable-

455 only vouchers (50). Finally, a meta-analysis of healthy food subsidy interventions in any setting
456 found a significant increase in fruit and vegetable purchases but not fruit and vegetable
457 consumption among populations with low incomes (51). However, the meta-analysis did not
458 examine impacts on diet quality.

459

460 Overall, the evidence suggests that healthy food subsidies may improve diet quality in some
461 circumstances but not in others. However, findings across studies cannot be directly compared
462 due to variations in study populations, subsidy type and amount, intervention location and
463 duration, and data collection methods. In order to determine whether and how healthy food
464 subsidies can be leveraged to improve diet quality in adults with low incomes, future studies
465 should consider 1) examining the role of underlying contextual factors (e.g., intervention
466 location), 2) conducting a dose-response analysis to examine whether program impacts depend
467 on the amount of subsidy received, and 3) using consistent data collection methods to better
468 support cross-study comparisons (52).

469

470 Several factors might account for our null findings. First, the value of FMNCP coupons may
471 have been inadequate to produce meaningful changes in diet quality. In 2017, the estimated cost
472 of food for a family of four in BC was \$1,019/month (53). According to this estimate, the
473 FMNCP subsidy of \$84/month contributed 8.2% to a household's monthly food cost, which may
474 have been insufficient to improve diet quality (54). Moreover, food prices in farmers' markets
475 are often higher than in more conventional food retailers such as supermarkets (55-57), which
476 may have limited how much food participants could purchase with the coupons. Second,
477 participants may have made their usual healthful food purchases at farmers' markets using

478 FMNCP coupons, rather than from their usual food retailers with their own funds. Food
479 purchasing data from all food retailers may have provided further information on how
480 households adjusted their food budget upon receiving the FMNCP coupons.

481
482 Foods purchased with the coupons may have also been shared amongst all household members.
483 In particular, evidence suggests that adults attempt to shield children from experiences of
484 household food insecurity by compromising their dietary intake to prioritize children's
485 nutritional needs (58-60). Thus, future studies should examine the impacts of farmers' market
486 healthy food subsidies on the diet quality of all household members, particularly children. The
487 program length of 10-15 weeks may have also been too short for diet quality to substantially
488 change. Indeed, findings from our longitudinal qualitative investigation among FMNCP
489 participants suggest that a larger and longer-term subsidy may have better supplemented
490 participants' food budgets (6, 61). However, other studies have found positive impacts on diet
491 quality from food subsidy programs of similar duration (49).

492
493 Several other factors may have contributed to our findings. First, some participants may not have
494 received the full subsidy amount as not all allocated coupons were distributed, and some
495 participants reported sharing their coupons with a friend or others in the community (6).
496 However, this pragmatic RCT was designed to assess the effectiveness of the FMNCP in the real
497 world. For this reason, fidelity was imperfect, as might be expected under real-world conditions
498 of delivering a population-level intervention. Moreover, we ruled out other potential
499 explanations for our null findings, such as contamination, through multiple sensitivity analyses.
500 Second, several community partners did not offer nutrition skill-building activities. Nutrition

501 skill-building may have augmented the impact of the coupons, although the evidence remains
502 mixed in this respect (62, 63).

503
504 Reasons underlying the significant differences in HEI-2015 component scores for dairy and fatty
505 acids at 16 weeks post-intervention are unclear. However, our food purchasing data indicate that
506 few participants used the coupons or their own money to purchase dairy or nuts (a source of
507 unsaturated fatty acids), suggesting that these findings may be spurious. Given the increased
508 likelihood of type I errors due to multiple comparisons, these findings should be interpreted
509 cautiously.

510
511 Limitations of this study should be considered. Dietary intake data were self-reported and may
512 be affected by misreporting (15). However, our sensitivity analysis showed similar outcomes
513 after adjusting for dietary intake misreporting. Data collection required computer and internet
514 access and literacy, which may have hindered some participants from accessing or accurately
515 completing the surveys (31). However, many participants completed data collection by telephone
516 or with a community partner, which may have mitigated data loss or inaccuracies. We collected
517 data from the primary food shopper in the household, precluding examination of program
518 impacts among other household members. We were unable to examine participant-specific
519 coupon distribution and redemption; however, as nearly all coupons were distributed and
520 redeemed, the lack of participant-specific data was relatively inconsequential. Finally, some
521 participants in the control group reported attending nutrition skill-building activities. However, it
522 is possible that they considered any skill-building activity (e.g., pregnancy classes) in their
523 response, rather than those specific to nutrition (e.g., cooking classes).

524
525 Despite these limitations, this study fills important knowledge gaps (51, 64). We undertook a
526 rigorously designed longitudinal RCT to examine the impact of the BC FMNCP on the diet
527 quality of adults with low incomes and found no significant differences in HEI-2015 scores. We
528 collected 24-hour dietary recalls using the validated ASA24-Canada-2018 (26, 32). Twenty-four-
529 hour dietary recalls capture dietary intake data with less bias than other dietary assessment
530 instruments (15, 65). We examined overall diet quality, rather than fruit and vegetable intake
531 alone, using the validated HEI-2015 (35). Examining program impacts on diet quality at 16
532 weeks post-intervention allowed examination of longer-term program outcomes. Our retention
533 rate was high at 89.1%, as was the 99.1% coupon redemption rate. Finally, study participants
534 were recruited from the FMNCP waitlist and shared similar characteristics to those in the
535 existing FMNCP. Therefore, while findings may not represent all adults with low incomes,
536 findings may be generalizable to broader program participants.

537

538 *Policy implications*

539 Despite the potential for healthy food subsidy programs to supplement household food budgets,
540 these programs alone are unlikely to produce measurable and long-term improvements in diet
541 quality as they are generally short-term and provide small subsidies (6, 66). In addition, these
542 programs operate under the assumption that poor diet quality among populations with low
543 incomes is a food-related issue rather than a symptom of material deprivation (66). To
544 effectively improve diet quality among populations with low incomes, food subsidy programs
545 should be implemented in tandem with policies that address the structural processes driving the

546 inequitable distribution of income and other social determinants of health, such as policies that
547 improve employment incomes and that increase access to education and affordable housing (67).

548

549 **Conclusion**

550 Despite growing interest in farmers' market healthy food subsidy programs as a means to
551 improve diet quality among populations with low incomes, this study demonstrated that the BC
552 FMNCP did not significantly improve the diet quality of adults with low incomes during the
553 study period. Further evidence is needed to elucidate whether higher subsidy amounts and
554 longer-term support may better support healthier dietary patterns among adults with low
555 incomes.

556

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566

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570 CIJN, DLO) contributed to study design, interpreted the data, and critically edited and approved
571 the final manuscript.

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Figure 1. CONSORT flow diagram of Farmers' Market Nutrition Coupon Program study participants (n=285)

Table 1. Baseline characteristics of adults with low incomes (n=285) in the British Columbia Farmers' Market Nutrition Coupon Program study

Characteristics	FMNCP (n = 143) n (%)	Control (n = 142) n (%)	Total (n = 285) n (%)
Age group			
18 to 59 years	112 (78.3)	115 (81.0)	227 (79.7)
60+ years	31 (21.7)	27 (19.0)	58 (20.4)
Sex			
Male	13 (9.1)	14 (9.9)	27 (9.5)
Female	130 (90.9)	128 (90.1)	258 (90.5)
Pregnant			
Yes	8 (5.6)	7 (4.9)	15 (5.3)
No	135 (94.4)	135 (95.1)	270 (94.7)
Breastfeeding			
Yes	12 (8.4)	12 (8.5)	24 (8.4)
No	131 (91.6)	130 (91.6)	261 (91.6)
Geography			
Urban	122 (85.3)	121 (85.2)	243 (85.3)
Rural	21 (14.7)	21 (14.8)	42 (14.7)
Race/ethnicity ¹			
White	47 (36.4)	50 (39.1)	97 (37.7)
Black	3 (2.3)	5 (3.9)	8 (3.1)
East or southeast Asian	14 (10.9)	11 (8.6)	25 (9.7)
South or west Asian	46 (35.9)	44 (34.4)	90 (35.0)
Indigenous	15 (11.6)	10 (7.8)	25 (9.7)
Other	4 (3.1)	8 (6.3)	12 (4.7)
Number of household members			
Single person	16 (11.4)	30 (21.1)	46 (16.3)
2 to 4 people	98 (69.5)	93 (65.5)	191 (67.5)
5 to 8 people	27 (19.2)	19 (13.4)	46 (16.6)
Children living in the home			
Yes	96 (67.6)	91 (64.1)	187 (65.9)
No	46 (32.4)	51 (35.9)	97 (34.2)
Annual household income			
Less than \$20,000	47 (37.9)	51 (41.1)	98 (39.5)
\$20,000 to \$39,999	41 (33.1)	15 (36.3)	86 (34.7)
\$40,000 to \$59,999	22 (17.7)	14 (11.3)	36 (14.5)
More than \$60,000	14 (11.3)	14 (11.3)	28 (11.3)
Educational attainment			
High School diploma or less	56 (40.3)	55 (39.3)	111 (39.8)
Some post-secondary or trade	44 (31.7)	40 (28.6)	84 (30.1)
Bachelor's degree	26 (18.7)	19 (13.6)	45 (16.1)
Graduate degree	12 (8.6)	25 (17.9)	37 (13.3)
Other	1 (0.7)	1 (0.7)	2 (0.7)
Marital status			
Married or common-law	74 (53.2)	83 (58.9)	157 (56.1)
Divorced	14 (10.1)	6 (4.3)	20 (7.1)
Separated	16 (11.5)	12 (8.5)	28 (10.0)
Single (never married)	25 (18.0)	32 (22.7)	57 (20.6)
Widowed	10 (7.2)	8 (5.7)	18 (6.4)
Self-reported physical health			
Poor	13 (9.2)	13 (9.2)	26 (9.2)
Fair	36 (25.4)	29 (20.4)	65 (22.9)

Good	65 (45.8)	69 (48.6)	134 (47.2)
Very good	22 (15.5)	24 (16.9)	46 (16.2)
Excellent	6 (4.2)	7 (4.9)	13 (4.6)
Smoking			
Not at all	125 (87.4)	122 (85.9)	247 (86.7)
Occasionally	5 (3.5)	9 (6.3)	14 (4.9)
Daily	13 (9.1)	11 (7.8)	24 (8.4)
Dietary intake misreporting (n=234)			
Plausible reporter	46 (40.7)	45 (37.2)	91 (38.9)
Potential underreporter	64 (56.6)	73 (60.3)	137 (58.6)
Potential overreporter	3 (2.7)	3 (2.5)	6 (2.6)
	mean (SD)	mean (SD)	mean (SD)
Age (years)	43.7 (16.0)	41.5 (16.2)	42.6 (16.1)
BMI (kg/m ²)	27.5 (5.4)	26.2 (6.3)	26.8 (5.9)
Years lived in Canada	25.0 (22.5)	24.1 (22.3)	24.5 (22.4)
HEI-2015 Total and component scores			
Total score (0-100)	60.1 (14.3)	60.4 (14.7)	60.2 (14.5)
Total vegetables (0-5)	3.9 (1.6)	4.0 (1.5)	3.9 (1.5)
Greens and beans (0-5)	3.0 (2.3)	2.9 (2.3)	3.9 (2.3)
Total fruits (0-5)	2.9 (2.1)	2.8 (2.1)	2.8 (2.1)
Whole fruits (0-5)	2.9 (2.3)	3.1 (2.2)	3.0 (2.2)
Whole grains (0-10)	4.4 (4.0)	4.6 (4.2)	4.5 (4.1)
Dairy (0-10)	5.9 (3.5)	6.1 (3.4)	6.0 (3.4)
Total protein foods (0-5)	4.2 (1.4)	4.2 (1.4)	4.2 (1.4)
Seafood and plant proteins (0-5)	2.8 (2.2)	2.9 (2.2)	2.9 (2.2)
Fatty acids (0-10)	5.7 (3.7)	5.5 (3.6)	5.6 (3.7)
Sodium (0-10) ²	3.8 (3.4)	3.4 (3.5)	3.6 (3.4)
Refined grains (0-10) ²	6.3 (3.7)	5.8 (3.6)	6.1 (3.7)
Saturated fats (0-10) ²	6.1 (3.6)	6.7 (3.3)	6.4 (3.5)
Added sugars (0-10) ²	8.4 (2.6)	8.4 (2.2)	8.4 (2.4)

¹Response options included Arab, Black, Chinese, First Nations (Status & Non-Status), Japanese, Korean, Latin American, Metis, South Asian, Southeast Asian, West Asian, White, and Other. Race/ethnicity was recategorized to reduce the number of categories.

²Higher score indicates a lower intake.

FMNCP, Farmers' Market Nutrition Coupon Program; HEI-2015, Healthy Eating Index-2015

Table 2. Differences in mean Healthy Eating Index-2015 total and component scores between the FMNCP and control groups at post-intervention and 16 weeks post-intervention (n=285)¹

HEI-2015 total and component scores (maximum score)	Post-intervention				16 weeks post-intervention			
	FMNCP mean (SEM)	Control mean (SEM)	β (95% CI)	p	FMNCP mean (SEM)	Control mean (SEM)	β (95% CI)	p
HEI-2015 total score (100)	63.6 (1.3)	62.1 (1.3)	-0.07 (-4.07, 3.93)	0.97	62.0 (1.4)	59.2 (1.4)	1.22 (-3.00, 5.44)	0.57
Adequacy components								
Total vegetables (5)	4.3 (0.1)	4.1 (0.1)	0.09 (-0.37, 0.55)	0.70	4.2 (0.1)	4.1 (0.1)	-0.05 (-0.61, 0.50)	0.85
Greens and beans (5)	3.3 (0.2)	2.9 (0.2)	-0.07 (-0.84, 0.69)	0.85	3.4 (0.2)	3.0 (0.2)	-0.09 (-0.88, 0.70)	0.82
Total fruits (5)	3.4 (0.2)	3.0 (0.2)	0.34 (-0.29, 0.98)	0.29	2.8 (0.2)	2.6 (0.2)	0.25 (-0.43, 0.93)	0.48
Whole fruits (5)	3.6 (0.2)	3.1 (0.2)	0.60 (-0.06, 1.26)	0.07	3.3 (0.2)	2.8 (0.2)	0.71 (-0.04, 1.46)	0.06
Whole grain (10)	4.9 (0.4)	4.3 (0.3)	-0.05 (-1.16, 1.05)	0.92	5.3 (0.4)	3.9 (0.4)	0.61 (-0.63, 1.84)	0.34
Dairy (10)	5.7 (0.3)	6.0 (0.3)	-0.20 (-1.29, 0.89)	0.72	6.4 (0.3)	5.1 (0.3)	1.47 (0.31, 2.62)	0.01
Total protein (5)	4.3 (0.1)	4.2 (0.1)	0.31 (-0.12, 0.74)	0.15	4.2 (0.2)	4.2 (0.2)	0.21 (-0.27, 0.69)	0.39
Seafood and plant proteins (5)	3.2 (0.2)	3.0 (0.2)	-0.04 (-0.78, 0.71)	0.92	3.1 (0.2)	2.9 (0.2)	-0.10 (-0.90, 0.70)	0.81
Fatty acids ² (10)	6.0 (0.4)	5.8 (0.4)	-0.27 (-1.47, 0.94)	0.67	5.2 (0.4)	6.0 (0.4)	-1.30 (-2.57, -0.04)	0.04
Moderation components³								
Sodium (10)	3.2 (0.3)	3.7 (0.3)	-0.30 (-1.45, 0.84)	0.61	2.9 (0.3)	3.8 (0.3)	-0.69 (-1.86, 0.48)	0.25
Refined grains (10)	6.2 (0.3)	6.8 (0.3)	-1.15 (-2.34, 0.04)	0.06	6.3 (0.4)	5.7 (0.4)	0.08 (-1.25, 1.40)	0.91
Saturated fats (10)	6.6 (0.3)	6.5 (0.3)	0.53 (-0.51, 1.57)	0.32	6.1 (0.3)	6.4 (0.3)	0.07 (-0.98, 1.13)	0.89
Added sugars (10)	8.9 (0.2)	8.7 (0.2)	0.18 (-0.56, 0.92)	0.63	8.8 (0.23)	8.5 (0.2)	0.21 (-0.55, 0.97)	0.59

¹Linear mixed effects models included group, time, and a group by time interaction as fixed effects. Random effects included repeated measures within participants, and a random slope for time using an unstructured covariance matrix. Models adjusted for baseline sex, pregnancy, breastfeeding, geographic location, age, highest educational level, race/ethnicity, marital status, body mass index, smoking status, perceived physical health, number of household members, children living in the home, and the day on which the dietary recalls were completed.

²Ratio of poly- and monounsaturated fatty acids to saturated fatty acids.

³Higher score indicates a lower intake.

Note: p-value for group by time interaction. Bold font indicates statistically significant differences (p<0.05).

FMNCP, Farmers' Market Nutrition Coupon Program; HEI-2015, Healthy Eating Index-2015