



Barriers to healthy food access: Associations with household income and cooking behavior

Julia A. Wolfson^{a,*}, Rebecca Ramsing^b, Caroline R. Richardson^c, Anne Palmer^b

^a Department of Health Management and Policy, University of Michigan School of Public Health, Ann Arbor, MI, United States of America

^b Center for a Livable Future, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, United States of America

^c Department of Family Medicine, University of Michigan, Ann Arbor, MI, United States of America

ABSTRACT

To examine how barriers to healthy food access and household income are associated with cooking and eating behaviors we fielded a nationally representative survey among 1112 adults in the United States in 2015. The survey included measures of barriers to accessing healthy food, household income, and frequency of cooking and eating meals, cooking practices, and other eating behaviors. We used multivariable poisson regression to examine the association of household income and barriers to healthy food access with cooking and eating behavior outcomes. We find that low income was associated with higher barriers to accessing healthy food (barriers) and that both income and barriers were associated with differences in cooking frequency/practices, and consumption behaviors. In interaction models, cooking and eating behaviors did not vary based on barriers for the lowest income level (< \$25,000). In the middle income level (\$25,000–\$59,000), barriers were associated with cooking breakfast (3.35 vs. 2.64 times/week, $p = 0.03$) and lunch (3.32 vs. 2.56 times/week, $p = 0.02$) more frequently compared to those who never/rarely encountered barriers. At the highest income level (\geq \$60,000), barriers were associated with less frequently eating breakfast (4.29 vs. 5.11 times/week, $p < 0.001$) and lunch (4.77 vs. 5.56, times/week, $p < 0.001$) compared to those who never/rarely encountered barriers. Barriers to healthy food access are related to both household income and cooking and eating behaviors important for diet quality and healthy eating. Targeted interventions to address time available to shop, and the price, selection and quality of healthy foods, are necessary.

1. Introduction

Increasing access to healthy food has been a priority in interventions aiming to address poor diet quality and diet related diseases (Story et al., 2008). Recommendations to cook more frequently at home to improve diet quality and decrease risk of obesity have also become prominent in recent years, and were featured in the 2015 *Dietary Guidelines for Americans* (US Department of Health and Human Services and US Department of Agriculture, 2015). To date, however, little research has investigated the relationships among the barriers affecting an individual's access to healthy food, household income, and cooking behaviors.

Access to healthy food is posited to be an important determinant of diet quality and obesity risk, but is not well understood. Food access is multidimensional and includes physical access to stores (distance and density), affordability and quality of available food, and access to culturally appropriate foods (Rose et al., 2010). In an effort to improve rates of obesity and diet related diseases, particularly in low-income communities with low access to healthy food, policies and programs designed to improve neighborhood food environments (often by locating a new grocery store in a neighborhood or stocking produce in

small/corner stores) have received substantial investment of resources (United States Department of Agriculture, n.d.). However, evidence documenting the relationship between food access and diet quality or diet related health outcomes has been mixed (Cobb et al., 2015; Dubowitz et al., 2015; Ghosh-Dastidar et al., 2014; Vaughan et al., 2017). One reason may be due to methodological limitations of research projects, such as cross sectional design, reliance on incomplete or inaccurate data sets, and limited ability to characterize food access in a way that accounts for the built environment or actual food shopping and purchasing patterns (Cobb et al., 2015; Ver Ploeg et al., 2014). In addition to physical access, other factors that are important for understanding the relationship between food access and food procurement, food preparation, food consumption choices, and diet related health outcomes are often not examined. These factors include: lack of time to grocery shop and prepare food, transportation barriers, lack of affordable or high quality food (Ver Ploeg et al., 2014). Other studies report that educational achievement and nutritional knowledge play a greater role in explaining nutritional disparities than food environments (Allcott et al., 2017).

In-home food preparation (i.e. cooking), a key intermediate step between food access and consumption, is associated with healthier diets

* Corresponding author at: Department of Health Management and Policy, University of Michigan, 1415 Washington Heights, M3240, Ann Arbor, MI 48109, United States of America.

E-mail address: jwolfson@umich.edu (J.A. Wolfson).

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(Mills et al., 2017; Wolfson, 2015), but the extent to which cooking at home is practiced is determined by a complex set of factors (Mills et al., 2017; Wolfson et al., 2016a; Wolfson et al., 2016b). Not all cooking is healthy, and lack of access to healthy ingredients, particularly high quality and affordable produce, dairy, meat, and fish can be a barrier to cooking healthy meals (Wolfson et al., 2016a). Home food preparation often involves convenience foods, particularly highly processed products that are high in calories, fat, sugar and salt and ubiquitous in many food environments (Poti et al., 2016; Harris and Shiptsova, 2007). Such processed convenience products help consumers prepare meals at home and mitigate barriers such as lack of time (Monsivais et al., 2014) and access to (or high cost and perishability of) scratch or fresh ingredients (Wolfson et al., 2016a), but can have negative effects on diet quality and health (Moubarac et al., 2013). These barriers are particularly salient for low-income populations (Engler-Stringer et al., 2011). Low income populations are more likely to live in areas with limited access to healthy food, and face greater barriers to accessing healthy food (Beaulac et al., 2009). Some evidence suggests that cooking skills and frequency has declined more in low income populations compared to higher income populations (Smith et al., 2013), whereas other studies show that low-income groups cooking frequently (Virudachalam et al., 2013).

Access to healthy food may be important for shaping cooking frequency and behaviors, but to date, little research has explicitly examined the relationship between food access and cooking practices. Greater insight is needed in order to better understand the relationship between food access and diet quality/diet related disease risk, as well as for developing interventions to strengthen in-home cooking capacity. In this study we examine barriers to healthy food access within a nationally representative sample and explore how income and food access barriers are associated with cooking frequency and cooking practices. We hypothesized that low-income individuals would have more barriers to healthy food access and that food access would be associated with less frequent cooking at home overall, less frequent scratch cooking, and more frequent use of convenience foods.

2. Methods

We fielded a web-based survey in April 2015 to measure perceptions, attitudes, and practices related to cooking behavior. One set of questions aimed to assess the impact of barriers to healthy food access. Where possible, previously validated items were used (Centers for Disease Control, 2010), and original survey questions we developed were informed by seven focus groups conducted with community members recruited from neighborhoods with high and low food access in Baltimore, MD (Wolfson et al., 2016a). The survey instrument was reviewed by content area experts and was pilot tested before entering the field.

The survey was fielded online using the GfK KnowledgePanel (GfK, 2013). More information about the survey panel and the specific response rates is available elsewhere (Wolfson et al., 2016b; GfK, 2013). Briefly, the GfK KnowledgePanel is an online panel of approximately 55,000 US adults who are recruited through equal probability, address-based sampling from a sampling frame covering 97% of US households (including households with unlisted telephone numbers or without landlines) (GfK, 2013). The GfK panel, and the study specific sample for our survey were selected using probability based sampling and complex survey weights are used to ensure the final survey samples are representative of the US population (GfK, 2013). Our survey was fielded among 1568 GfK Panel members (aged ≥ 18 years, English speaking), of whom 1137 completed the survey. No additional inclusion criteria were applied. Twenty-four individuals who completed the survey in < 4 min were excluded; resulting in a final sample size of 1112 and a survey completion rate of 73%. The weighted and unweighted distribution of the sample compared to national rates is available elsewhere (Wolfson et al., 2016b). Participants did not receive an incentive

for completing this survey, but GfK panel members are rewarded on a point-based system for completing surveys in which they can redeem points for various items or for cash. This study was approved by the Johns Hopkins University Institutional Review Board (IRB #6027).

2.1. Measures

2.1.1. Barriers to healthy food access

We asked respondents to rate how frequently they encountered eight barriers (identified based on prior research) (Zachary et al., 2013) to accessing healthy food on a five-point Likert scale from 1 = never to 5 = always. Specifically we asked, “How often do the following situations make it difficult for you to get healthy foods (healthy food includes fruits and vegetables, whole grains, beans and legumes, low-fat dairy, and lean meats)?” Then, we asked, in a randomized order, about the following eight barriers: distance to the respondent's usual grocery store, lack of transportation, hours their usual grocery store is open, price, physical disabilities, time available to go shopping, selection of items available at their usual grocery store, and the quality of items available at their usual grocery store. In addition to examining the barriers separately, we created a composite ‘barriers to access’ measure (Cronbach's alpha for the eight barrier measures = 0.85) by summing the responses to all eight barriers and then categorizing as never or rarely (1 to 16) or sometimes, often or always (17 to 40).

2.1.2. Household income

GfK records the household income of participants in their intake survey when they enroll in the Knowledge Panel, and updates that information annually. Income of participants ranges from $< \$5000$ to $\geq \$175,000$. We categorized household income into a three category variable where 1 = $< \$25,000$, 2 = $\$25,000$ – $\$59,000$ and 3 = $\geq \$60,000$.

2.1.3. Cooking and eating frequency and behaviors

We asked respondents how many times per week they, or someone in their household cooked breakfast, lunch, and dinner; and the frequency (0–7 times) with which they ate those meals. We also asked the frequency of cooking meals using scratch or fresh ingredients, packaged or boxed ingredients, frozen products (such as frozen vegetables, fish or meats), and recipes. We asked how many times (0–21) in the past 7 days the respondent ate frozen meals or frozen pizzas, ate fast food, ate at dine-in/site down restaurants, or ate carryout, take-out or delivery. Finally, we asked how many minutes they, or someone in their household, typically spends cooking dinner (and cleaning up after dinner) on weekdays and on weekends.

2.1.4. Socio-demographic covariates

Covariates included sex, age (18–29, 30–44, 45–59, ≥ 60), race/ethnicity (White, Black, Hispanic, Other), education (less than high school, high-school diploma, some college, college degree or more), participation in the Supplemental Nutrition Assistance Program (SNAP) or the Special Supplemental Nutrition Assistance Program for Women, Infants, and Children (WIC), employment status (working vs. not working), body mass index (BMI) (normal, overweight, obese), whether the respondent is the primary grocery shopper for their household, and cooking perceptions (e.g. cooking includes only scratch ingredients, convenience products, not using heat). Cooking perceptions were identified based on factor analysis of 18 items, using the same sample, but described in detail elsewhere (Wolfson et al., 2016b). Respondents were presented with 18 statements about cooking and asked to rate on a 7-point Likert scale how strongly they agreed or disagreed that they would say they have cooked dinner if they had done those things. Then, we conducted a factor analysis, and included the mean scores of the 14 items that loaded on to each of the 3 factors identified.

2.2. Analysis

We used cross tabulations with Pearson's chi-squared tests to describe the characteristics of the study sample overall and by the frequency of encountering barriers to healthy foods. Then, we examined the unadjusted distribution (never, rarely, or sometimes/often/always) of responses to each access barrier by household income using cross tabulations. Next, we used multivariate, poisson regression analyses to examine the association of household income and barriers to healthy food access with frequency of cooking meals, cooking behaviors, and eating practices. Negative binomial, multivariate regression was used for the time spent cooking dinner outcomes. All models were adjusted for income, barriers, gender, age, race/ethnicity, education, SNAP/WIC status, employment status, and whether the respondent was the primary grocery shopper. Models for frequency and time spent cooking meals also adjusted for cooking perceptions. Model covariates were selected based on prior literature (Mills et al., 2017; Wolfson, 2015; Wolfson et al., 2016b; Virudachalam et al., 2013). We used post-estimation margins commands to calculate the mean, predicted frequency of all outcomes by household income and barriers to healthy food access, while holding other covariates at their mean. Finally, we added an interaction term between income and access barriers to all models to examine if the relationship between access barriers and cooking/eating outcomes differed based on level of income. All analyses used survey weights (using the svyset and svy: commands in Stata) provided by GfK to produce nationally representative estimates, and excluded individuals with missing data for the included questions (0.5%–1.0%). Analyses were conducted in 2018 using the statistical analysis software Stata, version 13. Significance was considered at $p < 0.05$.

3. Results

The characteristics of the study sample, are shown in Table 1 overall and by frequency of encountering barriers to accessing healthy food. Compared to their representation in the sample overall, younger people aged 18–29 (28%), and aged 30–44 (28%), non-Hispanic Black (13%), and Hispanic (20%) people were more likely to encounter barriers to healthy food access at least sometimes. Higher education was associated with less frequent barriers to healthy food ($p < 0.001$) as was being higher income ($p < 0.001$).

Fig. 1 displays the unadjusted distribution of the frequency of encountering individual barriers to healthy food by income level. For all income levels, price was the most frequent barrier (sometimes/often/always: $< 25,000$ (67.5%); $\$25,000$ – $\$25,999$ (63.1%); $\geq \$60,000$ (45.5%)). Lack of time to shop was experienced similarly across income levels with 35.6%–37.6% citing time as a barrier at least sometimes. All other barriers we inquired about were experienced most frequently by people with lower incomes.

Table 2 presents the results of multivariable regression analyses estimating cooking and eating behaviors by household income. Dinner was the most frequently cooked meal at all income levels, and people with household income between $\$25,000$ – $\$59,000$ cooked dinner more frequently than those with income $\geq \$60,000$ (4.61 vs. 4.26 times/week, $p = 0.03$). Lower income households were more likely to cook with packaged/boxed products ($< \$25,000$ vs. $\geq \$60,000$: 1.65 vs. 1.17 times/week, $p = 0.02$; $\$25,000$ – $\$59,000$ vs. $\geq \$60,000$: 1.44 vs. 1.17 times/week, $p = 0.03$) and with frozen products ($\$25,000$ – $\$59,000$ vs. $\geq \$60,000$: 2.50 vs. 2.10 times/week, $p = 0.01$). People in the lowest income group ($< \$25,000$) spend the least amount of time cooking dinner on both weekdays ($< \$25,000$ vs. $\$25,000$ – $\$59,000$: 44.92 vs. 58.15 min, $p < 0.001$; $< \$25,000$ vs. $\geq \$60,000$: 44.92 vs. 53.37 min, $p = 0.03$) and weekends ($< \$25,000$ vs. $\$25,000$ – $\$59,000$: 44.56 vs. 56.12 min, $p = 0.004$; $< \$25,000$ vs. $\geq \$60,000$: 44.56 vs. 53.86 min, $p = 0.02$).

Table 3 presents the associations between cooking and eating behaviors and frequency of encountering barriers to accessing healthy

Table 1
Demographic characteristics of the study sample by frequency of encountering barriers to healthy food access, Home Cooking Survey, 2015 (N = 1112).

	TOTAL	Rarely/ never	Sometimes/ often/always	P for diff ^a
	N (%)	N (%)	N (%)	
Total (n [%])	1105 (100)	809 (71)	296 (29)	
Sex (n [%])				
Male	540 (48)	407 (49)	133 (45)	
Female	565 (52)	402 (51)	163 (55)	0.298
Age (n [%])				
Age 18–29	186 (21)	115 (18)	71 (28)	< 0.001
Age 30–44	246 (26)	173 (25)	73 (28)	
Age 45–59	332 (27)	249 (28)	83 (25)	
Age 60+	341 (27)	272 (29)	69 (20)	
Race (n [%])				
Non-Hispanic White	790 (66)	602 (69)	188 (58)	0.016
Non-Hispanic Black	104 (11)	72 (11)	32 (13)	
Hispanic	124 (15)	77 (13)	47 (20)	
Other	87 (8)	58 (7)	29 (9)	
Education (n [%])				
< High school diploma	94 (12)	51 (9)	43 (20)	< 0.001
High school diploma	317 (30)	233 (30)	84 (28)	
Some college	319 (29)	242 (30)	77 (26)	
Bachelor's degree or higher	375 (29)	283 (31)	92 (26)	
Household income (n [%])				
Under \$25,000	177 (18)	107 (14)	70 (26)	< 0.001
\$25,000–\$59,000	323 (31)	236 (31)	87 (31)	
\$60,000+	605 (51)	466 (55)	139 (42)	
SNAP and WIC status (n [%])				
Received SNAP or WIC	136 (15)	71 (11)	65 (25)	< 0.001
Did not receive SNAP or WIC	966 (85)	736 (89)	230 (75)	
Employment status (n [%])				
Working	639 (58)	472 (59)	167 (55)	0.234
Not working	466 (43)	337 (41)	129 (46)	
Primary grocery shopper (n [%])	588 (53)	456 (56)	132 (44)	0.001
Body Mass Index ^b				
Normal	330 (32)	245 (33)	85 (30)	0.513
Overweight	361 (34)	266 (35)	95 (33)	
Obese	351 (34)	253 (33)	98 (37)	
Cooking perceptions ^c (n [%])				
F1: Scratch cooking	917 (81)	699 (86)	218 (71)	< 0.001
F2: Convenience foods	350 (32)	267 (33)	83 (28)	0.100
F3: Heat	504 (45)	380 (47)	124 (41)	0.083

Notes: 7 people did not respond to at least one of the access barriers question, and are excluded from this analysis. Cross tabulations used survey weights provided by GfK.

^a Difference based on chi-squared test.

^b Healthy weight [BMI (kg/m²) 18.5–24.99], Overweight (BMI 25–29.99), Obese (BMI ≥ 30).

^c Cooking perceptions and percentages reports the number and percent of respondent who agree that factor “counts” as cooking based on a mean score of ≥ 5 on the items that load onto each factor.

food. There were no significant differences in frequency of cooking breakfast, lunch, and dinner. However, people who encountered barriers to accessing healthy food at least sometimes used packaged/boxed products (1.61 vs. 1.24 times/week, $p = 0.01$) and frozen products (2.53 vs. 2.10 times/week, $p = 0.004$) more frequently than those who never or rarely encountered barriers. Encountering barriers to accessing healthy food at least sometimes was also associated with less frequent consumption of breakfast (4.48 vs. 4.84 times/week, $p = 0.05$) and lunch (4.92 vs. 5.33 times/week, $p = 0.01$) than those who never or rarely encountered barriers.

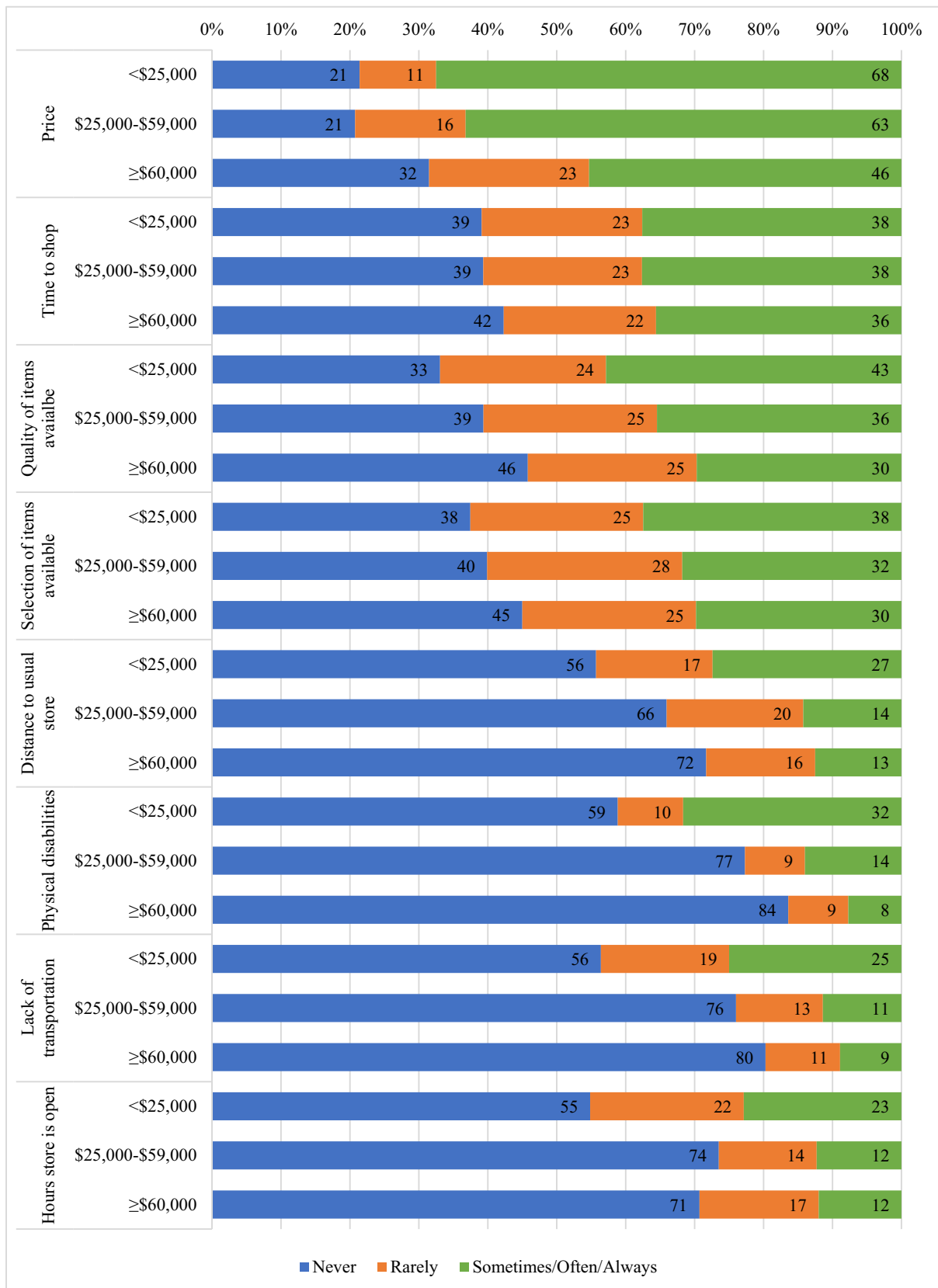


Fig. 1. Frequency of encountering barriers to healthy food access by household income, Home Cooking Survey, 2015 (N = 1112).

Table 2
Predicted mean cooking and eating behaviors by household income, Home Cooking Survey, 2015 (N = 1112).

	Household income					
	< \$25,000		\$25,000–\$59,000		≥ \$60,000	
	Mean	(SEM)	Mean	(SEM)	Mean	(SEM)
Cooking frequency^a						
Breakfast	2.68	0.20	2.85	0.15	2.80	0.11
Lunch	2.49	0.19	2.79	0.14	2.69	0.11
Dinner	4.67	0.21	4.61 [†]	0.13	4.26	0.10
Cooking practices^a						
Use scratch/fresh ingredients ^c	2.66	0.21	3.02	0.14	2.86	0.10
Use packaged/boxed products ^d	1.65	0.17	1.44 [†]	0.11	1.17 [*]	0.08
Use frozen products ^e	2.12	0.17	2.50 [†]	0.11	2.10	0.09
Used a recipe	1.49	0.17	1.64	0.12	1.70	0.09
Eating behavior						
Breakfast	4.28	0.24	4.72	0.15	4.90 [*]	0.11
Lunch	4.65	0.22	5.25 [*]	0.12	5.36 [*]	0.10
Dinner	5.66	0.19	6.30 [*]	0.08	6.17 [*]	0.08
Ate frozen meals or frozen pizza ^f	2.05	0.14	1.85	0.08	1.79	0.07
Ate fast food ^f	2.51	0.19	2.58	0.17	2.47	0.09
Ate at dine-in/sit down restaurants ^f	1.90	0.15	2.11	0.11	2.16	0.07
Ate carryout, take-out or delivery ^f	1.81	0.12	1.93	0.09	1.92	0.06
Average time spent cooking^g						
Weekday	44.87	3.11	58.63 [*]	2.27	53.11 [*]	1.83
Weekend	44.55	3.16	56.72 [*]	2.39	53.53 [*]	1.85

Note: Models are adjusted for income, gender, age, race/ethnicity, education, SNAP/WIC status, employment status, and primary grocery shopper status. Survey weights are used to generate nationally representative estimates. Models asking about cooking frequency and practices were also adjusted for perceptions of the meaning of cooking.

- * Difference from “< \$25,000” significant at $p < 0.05$.
- † Difference between “\$25,000–\$59,000” and “≥ \$60,000” significant at $p < 0.05$.
- ^a Cooking and eating frequency of meals and cooking practices ranged from 0 to 7+ days per week.
- ^c Such as fresh vegetables, or raw meats.
- ^d Such as boxed macaroni and cheese, Hamburger Helper, or Rice-a-Roni.
- ^e Such as frozen vegetables, fish or meats.
- ^f Measured as number of times (0–21) in the past 7 days.
- ^g Measured in minutes. Open response with allowable responses ranging from 0 to 720.

Table 4 shows the results from models including an interaction between income and barriers to accessing healthy food. For the lowest income level (< \$25,000), cooking and eating behaviors did not vary based on access barriers. In the middle income level (\$25,000–\$59,000), encountering barriers to accessing healthy food was associated with cooking breakfast (3.35 vs. 2.64 times/week, $p = 0.03$) and lunch (3.32 vs. 2.56 times/week, $p = 0.02$) more frequently compared to those who never/rarely encountered barriers. In addition, among those with income \$25,000–\$59,000, barriers to healthy food access was associated with more frequent cooking with scratch/fresh ingredients ($p = 0.01$), packaged/boxed ingredients ($p = 0.04$), frozen products ($p = 0.04$), and recipes ($p < 0.001$). At the highest income level (≥ \$60,000), those who encountered barriers to accessing healthy food cooked more frequently with boxed/packed products (1.58 vs. 1.05 times/week, $p = 0.004$), frozen products (2.42 vs. 1.97 times/week, $p = 0.02$), and less frequently ate breakfast (4.29 vs. 5.11 times/week, $p < 0.001$) and lunch (4.77 vs. 5.56, times/week, $p < 0.001$) compared to those who never/rarely encountered barriers to healthy food.

Table 3
Predicted mean cooking and eating behaviors by frequency of encountering barriers to healthy food access, Home Cooking Survey, 2015 (N = 1112).

	Frequency of encountering barriers to buying healthy food			
	Rarely/never		Sometimes/often/always	
	Mean	(SEM)	Mean	(SEM)
Cooking frequency^a				
Breakfast	2.80	0.09	2.79	0.14
Lunch	2.63	0.09	2.81	0.14
Dinner	4.42	0.09	4.49	0.13
Cooking practices^a				
Use scratch/fresh ingredients ^c	2.85	0.09	2.93	0.14
Use packaged/boxed products ^d	1.24 [*]	0.07	1.61	0.11
Use frozen products ^e	2.10 [*]	0.07	2.53	0.12
Used a recipe	1.53 [*]	0.07	1.91	0.13
Eating behavior				
Breakfast	4.84 [*]	0.10	4.48	0.16
Lunch	5.33 [*]	0.08	4.92	0.14
Dinner	6.17	0.06	6.00	0.11
Ate frozen meals or frozen pizza ^f	1.76 [*]	0.05	2.08	0.09
Ate fast food ^f	2.45	0.08	2.64	0.15
Ate at dine-in/sit down restaurants ^f	2.11	0.06	2.07	0.10
Ate carryout, take-out or delivery ^f	1.84	0.05	2.06	0.11
Average time spent cooking^g				
Weekday	51.84	1.31	56.69	2.97
Weekend	51.88	1.42	55.55	2.74

Note: Models are adjusted for income, gender, age, race/ethnicity, education, SNAP/WIC status, employment status, and primary grocery shopper status. Survey weights are used to generate nationally representative estimates. Models asking about cooking frequency and practices were also adjusted for perceptions of the meaning of cooking.

- * Difference between “Rarely/never” and “Sometimes/often/always” significant at $p < 0.05$.
- ^a Cooking and eating frequency of meals and cooking practices ranged from 0 to 7+ days per week.
- ^c Such as fresh vegetables, or raw meats.
- ^d Such as boxed macaroni and cheese, Hamburger Helper, or Rice-a-Roni.
- ^e Such as frozen vegetables, fish or meats.
- ^f Measured as number of times (0–21) in the past 7 days.
- ^g Measured in minutes. Open response with allowable responses ranging from 0 to 720.

4. Discussion

In this study we examined barriers to healthy food access encountered by adults in the US, how barriers vary based on household income. We also examined differences in cooking and eating behaviors based on income and barriers to accessing healthy food. We find that Americans face several barriers to accessing healthy food, primarily affordability of food and lack of time and that income and barriers to healthy food access were associated with differences in cooking and eating practices- particularly the use of convenience foods.

Our findings are consistent with previous research on the multi-dimensional nature of food access, and evidence that high food prices and lack of time are primary barriers individuals face when procuring food (Ver Ploeg et al., 2014). Our findings are also consistent with recent evidence showing differences in home cooking based on socio-economic status (Virudachalam et al., 2013; Taillie, 2018). These results underscore the importance of additional research on home cooking as a determinant of dietary intake and the need for greater understanding of the strategies that people use to navigate structural and environmental barriers to cooking (healthfully) at home. The present study illustrates

Table 4
Interactions between mean cooking and eating behaviors by frequency of encountering barriers to healthy food access, Home Cooking Survey, 2015 (N = 1112).

	Never/rarely						Sometimes/often/always					
	< \$25,000		\$25,000–\$59,000		≥ \$60,000		< \$25,000		\$25,000–\$59,000		≥ \$60,000	
	n = 107		n = 236		n = 466		n = 70		n = 87		n = 139	
	Mean	(SEM)	Mean	(SEM)	Mean	(SEM)	Mean	(SEM)	Mean	(SEM)	Mean	(SEM)
Cooking frequency^a												
Breakfast	2.91	0.27	2.64*	0.17	2.86	0.13	2.45	0.28	3.35	0.28	2.57	0.21
Lunch	2.40	0.24	2.56*	0.16	2.74	0.13	2.70	0.27	3.32	0.27	2.48	0.19
Dinner	4.72	0.26	4.48	0.15	4.28	0.11	4.65	0.32	4.92	0.25	4.17	0.19
Cooking practices^a												
Use scratch/fresh ingredients ^c	2.78	0.26	2.84*	0.16	2.80	0.11	2.92	0.33	3.70	0.29	2.66	0.20
Use packaged/boxed products ^d	1.68	0.20	1.28*	0.12	1.05*	0.08	1.51	0.23	1.78	0.20	1.58	0.17
Use frozen products ^c	2.04	0.19	2.36*	0.13	1.97*	0.10	2.25	0.28	2.92	0.24	2.42	0.16
Used a recipe	1.46	0.20	1.38*	0.13	1.63	0.10	1.71	0.27	2.37	0.26	1.72	0.18
Eating behavior												
Breakfast	4.37	0.30	4.64	0.17	5.11*	0.13	4.11	0.35	4.90	0.28	4.29	0.22
Lunch	4.73	0.29	5.22	0.14	5.56*	0.10	4.47	0.32	5.33	0.25	4.77	0.19
Dinner	5.67	0.25	6.34	0.08	6.24	0.08	5.59	0.29	6.20	0.17	6.00	0.16
Ate frozen meals or frozen pizza ^f	1.98	0.17	1.78	0.10	1.67*	0.07	2.25	0.21	2.03	0.17	2.07	0.14
Ate fast food ^f	2.38	0.18	2.48	0.15	2.45	0.11	2.74	0.36	2.80	0.36	2.47	0.18
Ate at dine-in/sit down restaurants ^f	1.87	0.16	2.10	0.11	2.19	0.09	1.92	0.25	2.14	0.24	2.06	0.11
Ate carryout, take-out or delivery ^f	1.81	0.13	1.81	0.09	1.86	0.07	1.88	0.20	2.21	0.24	2.04	0.12
Average time spent cooking^g												
Weekday	42.80	3.05	58.03	2.65	51.49	1.81	48.84	6.45	59.85	4.25	57.41	4.20
Weekend	43.49	3.78	54.86	2.70	52.88	1.98	47.25	5.34	61.39	5.16	54.65	3.89

Note: Models are adjusted for interactions between income and access, gender, age, race/ethnicity, education, SNAP/WIC status, employment status, and primary grocery shopper status. Survey weights are used to generate nationally representative estimates. Models asking about cooking frequency and practices were also adjusted for perceptions of the meaning of cooking.

* Within the same income category, difference between “Never/rarely” and “Sometimes/often/always” significant at $p < 0.05$.

^a Cooking and eating frequency of meals and cooking practices ranged from 0 to 7+ days per week.

^c Such as fresh vegetables, or raw meats.

^d Such as boxed macaroni and cheese, Hamburger Helper, or Rice-a-Roni.

^e Such as frozen vegetables, fish or meats.

^f Measured as number of times (0–21) in the past 7 days.

^g Measured in minutes. Open response with allowable responses ranging from 0 to 720.

that even at different income and barriers to healthy food access, and the interaction between the two, are associated with differences in cooking and eating behaviors that are important for diet quality and health outcomes (Mills et al., 2017; Wolfson, 2015; Futrell Dunaway et al., 2017; Adams and Mills, 2017).

More fully understanding barriers to accessing healthy food are important for public health interventions to improve diets, particularly among low-income communities. We find that frequently cited barriers such as price, time to shop, the quality of items available, and selection of items, more so than distance to usual store, could potentially influence the kind of foods prepared at home and the methods of preparation, or the decision to cook at home at all, in ways that would negatively effect diet quality. Indeed, our findings suggest that encountering barriers to healthy food is associated with more frequent use of convenience foods (even among respondents with higher incomes), many of which are highly processed and high in calories, fat, sugar and salt (Poti et al., 2015).

Notably, we see some differences in frequency of consuming breakfast and lunch but few differences in frequency of cooking meals at home or consumption of meals away from home in fast food or sit down restaurant (or take-out) based on income or barriers to food access. This suggests that while frequency of cooking meals may be similar, barriers to healthy food access and income status may influence the types of food being prepared and the frequency of skipping meals, which is consistent with some prior evidence (Engler-Stringer et al., 2011; Smith et al., 2014; Coleman-Jensen et al., 2016). It is also notable that we do not observe differences in cooking and eating behaviors among the lowest income group (< \$25,000) based on barriers to accessing healthy food. This suggests that for this group, the food

environment is less of a factor in shaping cooking and eating behaviors than income (or perhaps other unobserved factors such as cooking skills). Our finding that low income is associated with less time spent cooking, but that at all income levels, more barriers is not associated with time spent cooking is somewhat counter intuitive and should be a focus of future research to better understand strategies people who face numerous barriers to accessing healthy food use to procure and prepare meals. Similarly, the findings from the interaction models, that at the middle income level, more barriers was associated with higher cooking frequency and greater cooking from scratch as well as greater cooking with packaged/boxed and frozen products is also somewhat counter-intuitive and should be investigated further.

Research, policy, and practice have increasingly focused on efforts to improve both access to healthy food and home cooking as a means to improve diet quality and reduce the burden of diet related diseases in the US. Several policies and initiatives at federal, state and local levels have provided funds for locating new food outlets in low-access neighborhoods though recent evaluations have shown that increasing physical access is insufficient for improving purchasing decisions, diets and diet related diseases (Dubowitz et al., 2015; Ghosh-Dastidar et al., 2017). Particularly for low-income families who may have additional barriers to accessing healthy food, price, time and the quality and selection of available foods in their neighborhood limit their ability to procure and then prepare healthy meals at home. It is therefore essential to consider all dimensions of food access (particularly quality, selection, convenience, and affordability of foods) in efforts to improve access to healthy foods in low-income, low-access communities.

Innovative and mixed-methods study designs that take advantage of new technologies and multiple methods of measurement of the food

environment are warranted to accurately and comprehensively measure food access. Policies and programs that increase demand for healthier food by improving the affordability and selection of foods available and that build the skills necessary for the public to navigate an often complex and difficult food environment in order to procure and prepare healthy food are needed. Improving food access without also building the skills necessary to procure and prepare food is unlikely to result in improvements in cooking practices, eating behavior, and the burden of diet related diseases. Cooking skills education programs could more explicitly address food access barriers and promote strategies for food procurement and preparation that enable individuals to identify and use high-quality, low-priced ingredients (particularly produce) when resources (both time and money) are limited. Cooking skills education in schools could incrementally build core food and cooking knowledge and skills among young people. While most everyone face at least some barriers to accessing healthy food, barriers are much greater among low-income populations. This highlights the importance of investing in low-income communities, via strong anti-poverty programs (e.g. raising the minimum wage, job training), and a robust social safety net.

4.1. Study limitations

Our findings should be considered within the context of several limitations. First, our data are cross-sectional and, therefore, do not allow for causal inferences. Second, all measures are self reported which makes them potentially subject to self-reporting, recall, and social-desirability bias. We were not able to objectively measure the food environment, assess barriers, or assess cooking behavior. However, we did include measures of cooking perceptions as covariates in our models to account for variation in the way individuals interpret the meaning of cooking (Wolfson et al., 2016b); this should mitigate some of the concerns regarding the self-reported cooking measures. Third, we do not know where or how respondents acquired food, or at what type of food outlets they encountered barriers. Fourth, we did not measure dietary intake or diet quality which makes examination of the relationship between access to healthy food, cooking practices, and diet beyond the scope of this paper and a topic for future research. Fifth, we asked cooking behavior questions about the previous 7 days, but that time frame may not have reflected typical behavior for all participants. Finally, we did not assess cooking knowledge or cooking skills which evidence suggests also influence cooking frequency and practices (Mills et al., 2017), and may have introduced omitted variable bias into our analysis and biased the results toward the null.

5. Conclusion

Public discourse and the academic literature increasingly view home cooking as an opportunity for intervention to promote healthy eating. Though more research is needed in order to better understand the connections between the food environment and cooking practices and the relationship between home cooking and diet quality, our findings suggest that barriers to access and home cooking are inter-related and should be addressed in tandem, particularly among lower income Americans.

Conflicts of interest

None.

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