Effects of Family, Friends, and Relative Prices on Fruit and Vegetable Consumption by African American Youths

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Motivation

Basic facts:

- Youths consume **less** FV than recommended by DGA 2010
- Youths' FV intake is on **downward trajectory**
- African Americans have **lowest** FV intake among all U.S. ethnicities
- African American youths are **hard-to-reach** population

Unhealthy food choices and eating contribute to **obesity epidemic** and have detrimental physiological and socioeconomic effects

Growing public interest in policy interventions to:

- Shift diets toward **energy light** and **nutrient rich** foods
- Exploit **social network effects** to amplify policy effectiveness
- Change relative food prices using taxes and subsidies

Research Goals and Policy Relevance

Research focus: **FV intake** by African American youths

First goal: investigate **social network effects** in FV intake:

- Does **parent's intake** affect **youth's intake**?
- Does **friend's intake** affect **youth's intake**?

Second goal: quantify effects of **relative FV prices** on FV intake

Policy relevance:

- Our results can help policymakers and practitioners design policies, programs, and interventions to **improve public health**

Theoretical Background

Standard **utility maximization** framework (Cawley, 2004):

- Individual makes choices about work, leisure, home production, production of health, **consumption of food** and other goods
- Choices are constrained by budget, time, biology
- Food intake affects utility directly and indirectly (via health status)

We augment this framework by incorporating **social interactions**

Brock & Durlauf (2001):

- Utility may directly depend on choices and characteristics of **social network members**, as opposed to dependence arising solely through intermediation of markets

Social Network Effects

Classification is due to Manski (1993)

Endogenous effect: impact of **behavior** of social network members on individual's own behavior

Endogenous effect is associated with **social multiplier**

Contextual effect: impact of **characteristics** of social network members on individual's behavior

Correlated effect: similarity of behaviors within social network may result from:

- Sorting according to unobservable preferences
- Common unobservable environmental factors

Related Literature

Growing literature on social networks and spread of obesity:

- Christakis & Fowler (2007), Renna et al. (2008), Trogdon et al. (2008), Ali et al. (2011), Fortin & Yazbeck (2011)

Focus group and experimental studies in nutrition literature:

- Neumark-Sztainer et al. (1999), Epstein et al. (2001), Salvy et al. (2011)

Literature on impact of food prices on BMI:

- Chou et al. (2004), Auld & Powell (2009), Powell (2009), Beydoun et al. (2011)

Econometric Model: Notation

Youth: *Y*, friend: *F*, parent: *P*

Together, *Y*, *F*, and *P* comprise a **triplet**: *t*

Unobservable food intake **levels**: $w^*_{Y,t}, w^*_{F,t}, w^*_{P,t}$

Observable food intake **frequencies**: $w_{Y,t}, w_{F,t}, w_{P,t}$

Observable characteristics: $x_{Y,t}, x_{F,t}, x_{P,t}$

Unobservable errors: $\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t}$

$$\left(\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t}\right)' | x_t \sim \text{i.i.d. } N(\mathbf{0}, \mathbf{\Sigma}),$$

$x_t = x_{Y,t} \cup x_{F,t} \cup x_{P,t}$; $\mathbf{\Sigma} \neq \mathbf{I}_3$, in general

Explanatory variables

Econometric Model: Equation System

Simultaneous equation model:

$$\begin{cases} w^*_{Y,t} = w^*_{F,t} \cdot \gamma_{FY} + w^*_{P,t} \cdot \gamma_{PY} + x'_{Y,t} \cdot \beta_Y + \epsilon_{Y,t} \\ w^*_{F,t} = w^*_{Y,t} \cdot \gamma_{YF} + x'_{F,t} \cdot \beta_F + \epsilon_{F,t} \\ w^*_{P,t} = w^*_{Y,t} \cdot \gamma_{YP} + x'_{P,t} \cdot \beta_P + \epsilon_{P,t} \end{cases}$$

In matrix form:

$$\left(w^*_{Y,t},\ w^*_{F,t},\ w^*_{P,t}\right) \cdot \mathbf{\Gamma} + x'_t \cdot \mathbf{B} = \left(\epsilon_{Y,t},\ \epsilon_{F,t},\ \epsilon_{P,t}\right)$$

We adopt an **ordered response** setting:

$$w_{Y,t} = j \Leftrightarrow \alpha_Y(j) < w^*_{Y,t} \leq \alpha_Y(j+1) \text{ for } j = 1, 2, \ldots, 5$$

Thresholds are $\alpha_Y(1) \leq \cdots \leq \alpha_Y(6)$

We treat $w_{F,t}$ and $w_{P,t}$ analogously

Identification and Estimation

Identification is similar to Maddala & Lee (1976), involves normalization and exclusion restrictions

Normalization

Solve for **reduced form**:

$$\left(w^*_{Y,t}, w^*_{F,t}, w^*_{P,t}\right) = x'_t \cdot \mathbf{\Pi} + \left(v_{Y,t}, v_{F,t}, v_{P,t}\right)$$

$$\mathbf{\Pi} = -\mathbf{B\Gamma}^{-1},\ (v_{Y,t},\ v_{F,t},\ v_{P,t})' \mid x_t \ \sim\ i.i.d.N(\mathbf{0},\ \mathbf{\Omega}),\ \mathbf{\Omega} = (\mathbf{\Gamma}^{-1})'\ \mathbf{\Sigma\Gamma}^{-1}$$

Solve for **likelihood contribution** of triplet *t*:

$$L_t\ (\boldsymbol{\theta})\ \equiv\ L\ (w_{Y,t},\ w_{F,t},\ w_{P,t} \mid x_t;\ \boldsymbol{\theta})$$

Likelihood contribution

Estimate parameters by **ML**: $\widehat{\boldsymbol{\theta}}_{MLE}\ =\ \mathrm{argmax}_\theta\ \mathbf{\Sigma}_{t=1}^{T}\ \ln L_t\ (\boldsymbol{\theta})$

Data Sources

Family and Community Health Study (**FACHS**):

- Unique ongoing panel survey of African American youths
- Originated in 1997 as a study of 10-12 y.o.'s in GA and IA
- **Wave 4** (May 2005–June 2007) added best same-sex friend of youth
- Contains demographic and behavioral data, including FV intake
- Data similar to NHANES and CPS samples of African Americans

Quarterly Food-at-Home Price Database (**QFAHPD**):

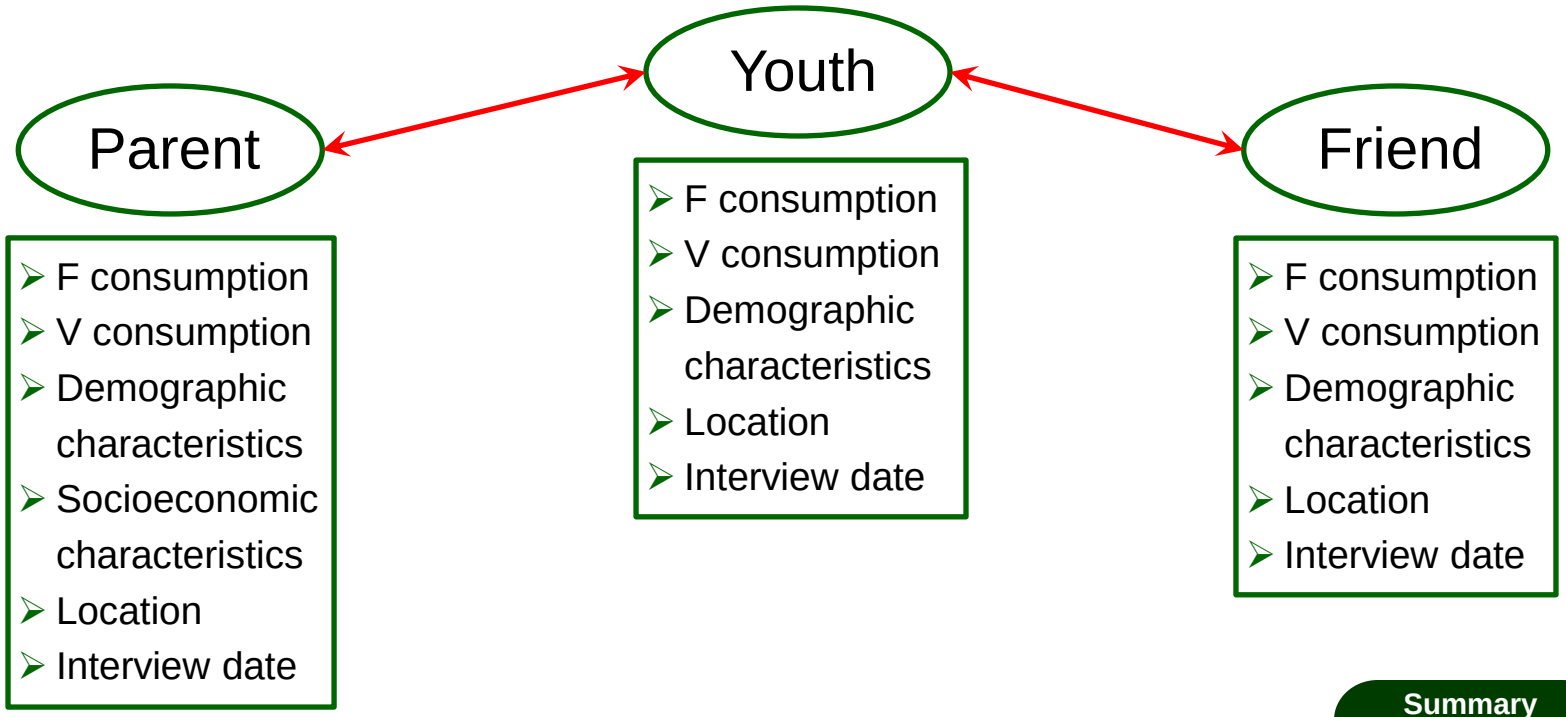
- Compiled by ERS, based on Nielsen Homescan survey
- Contains prices in $ per 100 grams of food as purchased
- Includes 52 separate food groups: **3 F groups**, **12 V groups**
- Covers 35 geographic market areas (contiguous U.S.)

Food groups

Social Network Characteristics

We link together a youth, his/her parent and best friend

Sample: **502** youth-parent-friend **triplets**



Summary statistics

Fruit Consumption

During the past seven days, how many times did you eat a whole piece of fruit (for example, an apple, orange or banana) or drink a glass of 100% fruit juice (do not count punch, Kool-Aid, or sports drinks)?

Answer	**Youth, %**	**Friend, %**	**Parent, %**
(1) none	12.75	14.94	10.96
(2) less than once a day (1-6 times)	26.49	24.70	23.71
(3) once a day	30.48	30.88	40.24
(4) 8-12 times	11.55	8.37	6.77
(5) twice a day (or more)	18.73	21.12	18.33
Total	100.00	100.00	100.00

Vegetable Consumption

During the past seven days, how many times did you eat vegetables like green salad, carrots or potatoes (do not count French fries, fried potatoes, or potato chips)?

Answer	Youth, %	Friend, %	Parent, %
(1) none	13.75	14.94	3.19
(2) less than once a day (1-6 times)	26.10	26.29	20.52
(3) once a day	37.85	35.86	43.82
(4) 8-12 times	8.17	7.77	8.96
(5) twice a day (or more)	14.14	15.14	23.51
Total	100.00	100.00	100.00

Results: Fruit Consumption

	Youth: $w^*_{Y,t}$		Friend: $w^*_{F,t}$		Parent: $w^*_{P,t}$	
	Coeff.	**Std. Err.**	**Coeff.**	**Std. Err.**	**Coeff.**	**Std. Err.**
Endogenous Effects						
$\hat{\gamma}_{FY}$	0.285	(0.182)	$\hat{\gamma}_{YF}$ -0.251	(0.243)	$\hat{\gamma}_{YP}$ 0.382**	(0.192)
$\hat{\gamma}_{PY}$	0.620**	(0.142)				
Effects of Explanatory Variables						
constant	1.658**	(0.592)	1.584**	(0.442)	0.495	(0.345)
y_age x 10^{-1}	-0.400	(0.358)				
y_age2 x 10^{-2}	-0.184**	(0.051)				
y_male	0.038	(0.071)	0.084	(0.100)		
f_age x 10^{-1}			-0.028	(0.190)		
f_age2 x 10^{-2}			-0.029	(0.027)		
f_black			0.186	(0.135)		
p_age x 10^{-1}					0.229**	(0.049)
p_age2 x 10^{-2}					-0.015**	(0.001)
p_higher_educ	0.134	(0.107)			0.026	(0.103)
p_married	-0.195*	(0.105)			0.216*	(0.107)
p_poverty	-0.050	(0.114)			0.152	(0.112)
relative_price	-0.594	(0.486)	-0.717*	(0.416)	-1.012*	(0.548)

* and ** denote significance at 10% and 5% level, respectively

Results: Vegetable Consumption

	Youth: $w^*_{Y,t}$		Friend: $w^*_{F,t}$		Parent: $w^*_{P,t}$	
	Coeff.	**Std. Err.**	**Coeff.**	**Std. Err.**	**Coeff.**	**Std. Err.**
Endogenous Effects						
$\hat{\gamma}_{FY}$	-0.351	(0.273)	$\hat{\gamma}_{YF}$ -0.168	(0.384)	$\hat{\gamma}_{YP}$ 0.234	(0.386)
$\hat{\gamma}_{PY}$	0.586**	(0.250)				
Effects of Explanatory Variables						
constant	2.147**	(1.090)	1.204**	(0.562)	0.271	(0.413)
y_age x 10^{-1}	-1.256**	(0.057)				
y_age2 x 10^{-2}	0.319**	(0.075)				
y_male	-0.006	(0.099)	0.071	(0.095)		
f_age x 10^{-1}			0.328*	(0.177)		
f_age2 x 10^{-2}			-0.037**	(0.018)		
f_black			0.123	(0.119)		
p_age x 10^{-1}					0.524**	(0.059)
p_age2 x 10^{-2}					-0.045**	(0.002)
p_higher_educ	0.052	(0.093)			0.012	(0.105)
p_married	-0.039	(0.128)			0.320**	(0.110)
p_poverty	0.006	(0.094)			-0.010	(0.122)
relative_price	-1.559*	(0.902)	-1.352†	(0.839)	0.485	(0.672)

* and ** denote significance at 10% and 5% level, respectively; †denotes significance at 11% level

Public Policy Implications

FACHS sample is comparable to NHANES and CPS samples:

- Results may apply to broader population of African American youths

Estimates indicate existence of **social multipliers** in FV intake within African American families:

- Policy interventions should exploit social networks effects

No evidence for endogenous effects between youths and friends:

- Peer-group interventions may be less effective than family-based ones

Reducing relative FV prices via subsidies may increase FV consumption, but effects are statistically weak

Thank you!

Questions?

Explanatory Variables

Variable in x_t	$x_{Y,t}$	$x_{F,t}$	$x_{P,t}$	Description
constant	√	√	√	Constant term
y_age	√			Age of *Y*
y_age2	√			Age squared of *Y*
y_male	√	√		Indicator of male gender of *Y* and *F*
f_age		√		Age of *F*
f_age2		√		Age squared of *F*
f_black		√		Indicator of African American race of *F*
p_age			√	Age of *P*
p_age2			√	Age squared of *P*
p_higher_educ	√		√	Indicator of college education of *P*
p_married	√		√	Indicator of married *P*
p_poverty	√		√	Indicator of *P* in poverty
relative_price	√	√	√	Relative fruit or vegetable price

Back to notation

Normalization

Variances of $\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t}$ are not identifiable ⇒ normalize $\boldsymbol{\Sigma}$:

$$\boldsymbol{\Sigma} = \begin{pmatrix} 1 & \rho_{YF} & \rho_{YP} \\ \rho_{YF} & 1 & \rho_{FP} \\ \rho_{YP} & \rho_{FP} & 1 \end{pmatrix}$$

One unknown threshold per triplet member is unidentifiable ⇒ fix the following thresholds:

$$\alpha_Y\,(2) \;=\; \alpha_F\,(2) \;=\; \alpha_P\,(2) \;=\; 0$$

Remark:
Nine thresholds are estimated:

$$\{\alpha_Y\,(j),\ \alpha_F\,(j),\ \alpha_P\,(j)\,\}_{j=3}^{5}$$

Back to identification/estimation

Likelihood Contribution

Parameters $\boldsymbol{\theta} = \left(\{\alpha_Y(j), \alpha_F(j), \alpha_P(j)\}_{j=3}^{5}, \rho_{YF}, \rho_{YP}, \rho_{FP}, \gamma_{FY}, \gamma_{PY}, \gamma_{YF}, \beta'_Y, \beta'_F, \beta'_P\right)'$

Partition $\boldsymbol{\Pi}$ as $\boldsymbol{\Pi} = [\pi_Y, \pi_F, \pi_P]$; π_Y, π_F, π_P are known functions of $\boldsymbol{\theta}$

Likelihood contribution of triplet t:

$$L_t(\boldsymbol{\theta}) = L\left[w_{Y,t}, w_{F,t}, w_{P,t} \middle| \boldsymbol{x}_t; \boldsymbol{\theta}\right] = \Pr\left[\alpha_Y(w_{Y,t}) < w^*_{Y,t} \le \alpha_Y(w_{Y,t}+1), \alpha_F(w_{F,t}) < w^*_{F,t} \le \alpha_F(w_{F,t}+1), \alpha_P(w_{P,t}) < w^*_{P,t} \le \alpha_P(w_{P,t}+1) | \boldsymbol{x}_t; \boldsymbol{\theta}\right] =$$

$$= \Pr\left[\alpha_Y(w_{Y,t}) - \boldsymbol{x}'_t \cdot \pi_Y < \nu_{Y,t} \le \alpha_Y(w_{Y,t}+1) - \boldsymbol{x}'_t \cdot \pi_Y, \alpha_F(w_{F,t}) - \boldsymbol{x}'_t \cdot \pi_F < \nu_{F,t} \le \alpha_F(w_{F,t}+1) - \boldsymbol{x}'_t \cdot \pi_F, \right]$$
$$\alpha_P(w_{P,t}) - \boldsymbol{x}'_t \cdot \pi_P < \nu_{P,t} \le \alpha_P(w_{P,t}+1) - \boldsymbol{x}'_t \cdot \pi_P | \boldsymbol{x}_t; \boldsymbol{\ell}$$

$$= \int_{\alpha_Y(w_{Y,t})-\boldsymbol{x}'_t\cdot\pi_Y}^{\alpha_Y(w_{Y,t}+1)-\boldsymbol{x}'_t\cdot\pi_Y} \int_{\alpha_F(w_{F,t})-\boldsymbol{x}'_t\cdot\pi_F}^{\alpha_F(w_{F,t}+1)-\boldsymbol{x}'_t\cdot\pi_F} \int_{\alpha_P(w_{P,t})-\boldsymbol{x}'_t\cdot\pi_P}^{\alpha_P(w_{P,t}+1)-\boldsymbol{x}'_t\cdot\pi_P} f\left(\nu_{Y,t}, \nu_{F,t}, \nu_{P,t} \middle| \boldsymbol{x}_t; \boldsymbol{\theta}\right) d\nu_{P,t} d\nu_{F,t} d\nu_{Y,t},$$

$f\left(\nu_{Y,t}, \nu_{F,t}, \nu_{P,t} \middle| \boldsymbol{x}_t; \boldsymbol{\theta}\right)$ is **trivariate normal density**

Back to identification/estimation

Fruit and Vegetable Groups in QFAHPD

Fruit groups	Vegetable groups
Fresh/frozen whole fruit	Fresh/frozen dark green vegetables
Canned whole fruit	Canned dark green vegetables
Fruit juice	Fresh/frozen orange vegetables
	Canned orange vegetables
	Fresh/frozen starchy vegetables
	Canned starchy vegetables
	Fresh/frozen other-nutrient dense vegetables
	Canned other–nutrient dense vegetables
	Canned other–mostly water vegetables
	Fresh/frozen/dried legumes
	Canned/processed legumes

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Characteristics of Youths and Friends in FACHS

Characteristic	Mean	Std. Dev.	Min	Max
Youth				
Age in years	19.28	0.83	16.85	21.89
Indicator of male gender	0.42	0.49	0	1
Indicator of African American race	0.96	0.20	0	1
Friend				
Age in years	19.87	3.34	13.54	51.59
Indicator of male gender	0.42	0.49	0	1
Indicator of African American race	0.84	0.36	0	1

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Continue

Characteristics of Parents in FACHS

Characteristic	Mean	Std. Dev.	Min	Max
Age in years	45.06	7.68	32.56	88.87
Indicator of male gender	0.05	0.22	0	1
Indicator of African American race	0.92	0.27	0	1
Indicator of no high school degree	0.18	0.38	0	1
Indicator of high school degree	0.34	0.47	0	1
Indicator of some college education	0.35	0.48	0	1
Indicator of bachelor's/higher degree	0.14	0.35	0	1
Indicator of married parent	0.36	0.48	0	1
Indicator of poverty	0.28	0.45	0	1

Back to social network

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