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Obesity and Price Sensitivity at the Supermarket

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A Note from the Head of the Hartog School

The so-called Mediterranean diet in Israel is based largely on vegetables. However, despite the availability of great vegetables, Israelis are eating more processed food, and obesity is a serious and growing problem in the country. Shockingly, obesity levels are not far from the very high US levels. And it is not just the US and Israel. Over the last three decades, the number of people suffering from obesity has tripled.

There is empirical evidence that increased obesity is due, in part, to increased caloric consumption. There is also evidence that obesity is especially a problem for those with lower socioeconomic status. But there is another possible factor as well: high-energy density (junk) foods are generally much less expensive per calorie than fresh fruits and vegetables. This is the case in Israel as well.

Using a unique data set in Israel, we find that -- even after controlling for income levels and other factors -- greater food "price-sensitivity" is associated with a higher obesity rate. Further, this affects all income classes and is not just an issue for lower income households.

The research presented herein, suggests that food pricing policy, should take into account price-sensitivity as well as socio-economic classes.

Professor Neil Gandal

Abstract

In this paper, we employ a rich data set at the individual level in order to examine which factors are most highly correlated with obesity. Our main result is that, even after controlling for income levels and other factors, high "price-sensitivity" for food products is associated with high obesity rates. We find that a woman who stated that prices were "not important at all" when purchasing food products had a Body Mass Index (BMI) that was 1.3 units below those who stated that price was "very important." This suggests that the price effect is not trivial and obesity is a problem that is not limited to those with low income levels. A 1.3 unit reduction in the BMI would move approximately 28% of women who are in the "overweight" category to the "normal weight" category and 25% of women who are in the "obese" category to the "overweight" category.

Introduction

Obesity is a serious health condition since excessive body mass is an important risk factor for cardiovascular disease, stroke, hypertension, Type 2 diabetes and some cancers. Over the last three decades, the number of people suffering from obesity has tripled. According to the World Health Organization (WHO) there are over one billion overweight adults, 300 million of whom are obese. Additionally, childhood obesity is a very serious problem and has reached 'epidemic' levels in some countries.[1] The cost of treating obese individuals has put huge strains on government healthcare budgets.

Two competing theoretical approaches try to explain the 'economics of obesity.' According to the first theory, obese individuals are irrational in their decisions due to a lack of health and nutrition information. Proponents of this theory argue that the best way to reduce the problem of obesity is to increase the awareness of the public about the risks associated with obesity. The second approach argues that obesity is a 'rational' outcome of changes in technology and relative prices. Lakdawalla and Philipson (2002) argue that technological innovations have led to weight increases over time in the population by making production (both at home and at work) less demanding physically. They also argue that engaging in physical activity has become more expensive, both in terms of the direct cost, as well as the opportunity cost of time.

Advancements in science and technology (and in some cases subsidies) have made "junk" food less expensive and fruits and vegetables more expensive. Drewnowski and Barratt-Fornell (2004) conducted a simple "experiment" in a Seattle supermarket and found that, *per calorie*, carrots cost virtually five times more than cookies or potato chips and orange juice costs virtually five times as much as soft drinks. The difference (in price per calorie) has been increasing in the U.S. in recent years. Pollan (2007) notes that between 1985 and 2000, fruit and vegetable prices in the US increased by about 40% while the price of soft drinks dropped by 23%. According to Pollan (2007), the change in relative prices is primarily due to the U.S, farm bill, which provides generous subsidies for corn and soy, which are prime ingredients in high-density "processed food." Corn syrup, for example, is the primary ingredient in most soft drinks. The farm bill provides virtually no help to farmers growing fresh produce.

Although the differences vary from country to country, the phenomenon that high-energy density foods are less expensive per calorie than fresh fruits and vegetables is fairly universal.[2] Many authors believe that the high price of fruits and vegetable prevents low-income individuals and families from consuming these foods and that the

[1] See the WHO website: http://www.who.int/dietphysicalactivity/publications/facts/obesity/en/

[2] The phenomenon is not limited to the developed world. Abay (2006) concludes that Egypt's food subsidy program, which reduces price of the dense caloric food, may be in part responsible for increased obesity for women with children.

relatively low price of high density foods has led to an increase in the consumption of the high density foods. According to Drewnowski and Barratt-Fornell (2004), dry snack (or junk) foods like chocolate, French fries, cookies, and candy all contain very little water, and consequently may cause more weight gain than fruits and vegetables. These high-density processed foods are typically much less expensive per calorie than corresponding healthy ones.

There is empirical evidence that increased obesity is due, in part, to increased caloric consumption. In a longitudinal study, Cutler (2003) document that Americans have become increasingly obese over time and argue that the increase is primarily due to increases in food consumption. Using country-level data over time from several developed countries, Bleich et. al (2007) find additional evidence that increased obesity is due to increased caloric consumption. There is also evidence that obesity is a problem for those with lower socioeconomic status. Using longitudinal data from National Longitudinal Survey of Youth, Baum and Ruhm (2007) find that while body weight changes with the age, for a given age, weight is negatively correlated with socioeconomic status and that the differences between the different socioeconomic groups increase with age. Murcott et. al (1993) find survey evidence that the working class mothers preferred "filling" food that was high in fat and sugar content and low in price.

In this paper, we employ a rich data set at the individual level in order to examine which factors are most highly correlated with obesity. We are certainly not the first to write on the issue of obesity (as our discussion in this introduction indicates.) The individual level cross-section data set we employ, however, has several unique features that enable us to examine issues that were not addressed by previous work.

Our data set, which comes from the very thorough 1999-2001 (MABAT) Israeli Health and Nutritional Survey, has the following measures that typically are not available in other data sets: Researchers who built the database we employ *measured* the weight and height of the individuals in the study to calculate the Body Mass Index (BMI). BMI is the most widely used index for body size and is equal to the weight of the individual in kilograms divided by height squared (in meters).

A BMI greater than or equal to 30 is a commonly used proxy for obesity. In most other studies, researchers must rely on self-reported levels of weight and height – and there is evidence from Cawley and Burkhauser (CB 2006) that overweight individuals are more likely to under-report their weight (and hence BMI).[3] We also have data on measured "waist circumference" which is an alternative proxy for obesity. Women with waist circumferences greater than 88 cm in women, and men with waist circumferences greater than 102 cm are considered obese.

[3] We have self-reported data as well and the same effects exist in our data set.

Finally, we have data on *price sensitivity* to food products. Regarding this last point, consumers were asked the following question: When you buy food, how important is price. The range is from 0 to 3, where "0" means that price is "not important at all," "1" means "not too important, "2" means "important," and "3" means "very important." Interestingly enough, our price sensitivity variable is only slightly (negatively) correlated with income levels. Since this is the prime variable of interest and since it is still the case that women make most of the family food purchases in Israel, we conducted the analysis for women.

Our main result is that, even after controlling for income levels and other factors, greater food "price-sensitivity" is associated with a higher obesity rate. We find that women who stated that price was not important at all when purchasing food products had a Body Mass Index (BMI) 1.3 units below those who stated that price was "very important." A reduction of 1.3 units in the BMI for all overweight and obese women would move approximately 28% of women who are in the "overweight" category to the "normal weight" category and would move 25% of women who are in the "obese" category to the "overweight" category.[4] At the average height of women in Israel 163 cm (5' 4"), this would represent a weight loss of 3.5 kg (8 pounds): from 71.4 kg(157 lbs) to 67.7 kg (149 pounds).

Like other studies, we found an income effect as well: individuals with lower household income had higher BMI levels. Based on our estimates, however, the effect was relatively small: a doubling of household income was associated with a reduction in the BMI by just 0.3 units.[5] These results suggest that the "price" effect is not trivial and that obesity problems are not confined just to those with lower socioeconomic status.

It is fair to ask whether BMI greater or equal to 30 is a good proxy for obesity. Using other measures of obesity (that are not available for most studies), CB (2006) found that using BMI to classify obesity resulted in a false-positive rate of 10% for men, i.e., 10% of the men classified as obese by BMI were not obese according to other measures of obesity. In the case of women, however, the false positive rate was less than 2%.

This result is due, in large part, to the fact that, for a given volume, muscle weighs more than fat and, on average, men are much more muscular than women. This suggests that BMI is not an ideal measure of obesity for men, but is indeed a good measure of obesity for women.

Nevertheless, we used waist circumference as an alternative proxy for obesity. This measure is recommended by CB 2006 because, according to Bray, Bouchard, and James (1998), it is not just the amount of fat that matters for health, but rather the location –

4 Since the Mabat study was cross-sectional, this does not imply causality. It just illustrates that a 1.3 unit reduction in the BMI would have a dramatic effect on the percentage of overweight and obese women in Israel.

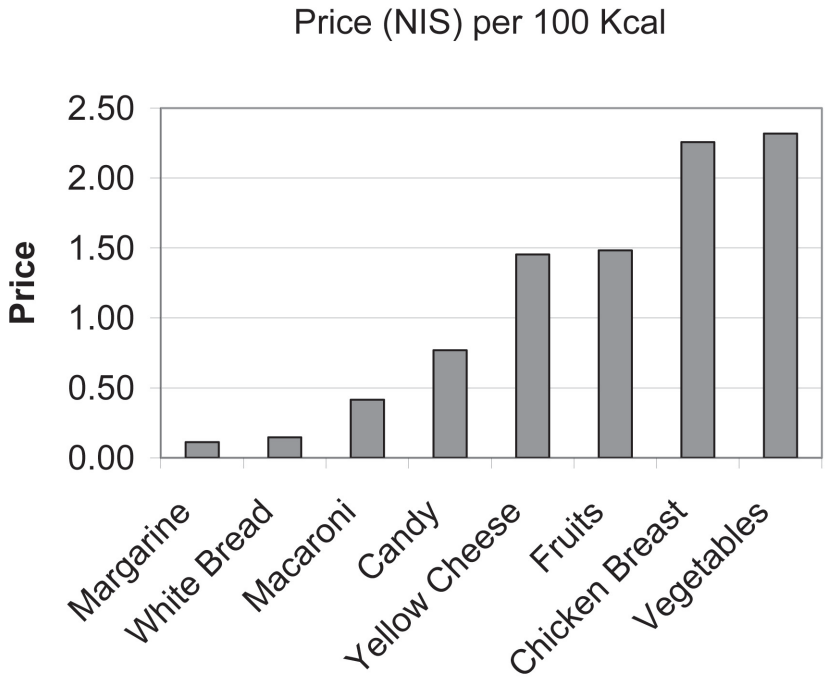
5 Again, this does not imply causality.

and abdominal obesity (a large amount of fat near the internal organs and the waist) is correlated with morbidity. Our results are qualitatively unchanged when we use waist circumference as a proxy for obesity rather than BMI. In this case, we find that women who stated that price was not important at all when purchasing food products had a waist circumference 3.36 cm (1.3 inches) smaller than those who stated that price was "very important." This suggests that our results are robust to using different proxies for obesity.

Data

Like most countries, food prices (per calorie) in Israel are high for fresh produce such as fruit and vegetables relative to the prices of processed foods. Prices per 100 Kcal (for 2001) -- shown in Figure 1 -- are such that vegetables cost roughly three times that of candy (per calorie), while fruits cost more than three times as much as white bread.[6]

Figure 1: Price per Kcal, Israel 2001[7]



The typical measure of obesity is Body Mass Index (or BMI) and it is calculated by dividing individual's weight (in kilograms) by the square of the individual's height in meters. For example, an adult who is 1.76 meters tall (i.e., 5'9.3", which is the average male height in the U.S.) and weighs 70 kilograms (154 pounds) would have a BMI of 22.6. An individual who was as tall, but weighed 85 kilograms (187 pounds) would have a BMI of 27.4. Finally, an individual who was as tall and weighed 100 kilograms (220 pounds) would have a BMI of 32.3. A BMI between 20 and 24.9 is considered normal, while a BMI

[6] The vegetable price index in Table 1 includes frequently consumed vegetables (tomatoes, cucumbers, carrots, squash), while the fruit index includes frequently consumed fruits and the price used is the "in season" price.

[7] Sources: Israeli Ministry of Health for the conversion between weight of food in grams and calories and the Israeli Central Bureau of Statistics for prices per gram. The prices are in New Israeli Shekels (NIS). The average exchange rate during the survey period was approximately $1=4 NIS.

between 25 and 29.9 is considered overweight. A BMI of 30 and above 30 is considered obese. Data from the 1999-2001 MABAT survey in Israel showed that the average BMI for adults was 26.9. Further, 61.9% of all adults are overweight, and 22.6% of all adults are obese. The percent of obese and overweight individuals in Israel is fairly similar to that of the United States. Child obesity is a growing problem in Israel as well.[8]

Variables Employed for the Study

The following variables are available for the study:[9]

Age – Age in years

BMI – "Researcher Measured" Body Mass Index (BMI)

WC – Waist Circumference in centimeters

Majority – a dummy that takes on the value one if the individual is Jewish

Education – the number of years of schooling

Income – the monthly household income in the following ranges

1. Less than 1440 NIS
2. 1440 – 3000
3. 3001-4500
4. 4501-6000
5. 6001-9000
6. 9001-12000
7. 12000-15000
8. 15000-18000
9. 18001-24000
10. Greater than 24,000

[8] Gross et. al (2009) studied more than 1 million (17 year old) male draftees into the Israeli army from 1967 to 2003 and found that obesity levels in this group tripled over that period.

Price sensitivity – The answer to the following question:

When you buy food, how important is price. The range is from 0 to 3, where "0" means that price is "not important at all," "1" means "not too important, "2" means "important," and "3" means "very important."

Active – a dummy variable that takes on the value one if the individual is active. The survey defined active as "having regularly engaged in physical activity during leisure hours, lasting 20 minutes or more (at least three times a week,) that led to rapid breathing and perspiration."

Summary Statistics are shown in Table 2:

Women, N=1124				
Variable	Mean	Std. Deviation	Minimum	Maximum
BMI	27.08	5.47	16.8	47.9
Age	42.86	10.80	25	64
Majority	0.79	0.41	0	1
Education	12.55	3.97	0	22
Price	1.67	0.93	0	3
Income	4.60	1.80	1	10
Active	0.33	0.47	0	1
WC	85.8	12.96	61	140

Table 2: Descriptive Statistics[9]

Table 2 shows that the "average" individual is overweight. Like most of the developed world, BMI levels in Israel are much higher now that they were in the past. In 1986, results from a less thorough survey in Israel indicate that the average BMI of men aged 25-64 was 25.8 (vs. 26.8 in the recent MABAT survey,) while the average BMI of women aged 25-64 was 24.9 (vs. 27.1 in the recent MABAT survey.)[10] The average BMI of women rose by 9% from 1986 to 2001, while the average BMI of men rose by 4% over the same period.

In the case of price sensitivity, 17 percent said that price was not important while buying food products, while 23 percent responded that price was not too important. 44 percent indicated that price was important, while 16 percent indicated that it was very important.

[9] A small number of women listed education levels less than nine years of schooling. Israel has compulsory education through this level, but it is possible that some people leave school early. In any case, removing these few observations has no effect on our results. We are missing data on waist circumference on sixty-six women. Hence waist circumference has 1058 observations.

[10] The 1986 data are from a study that is summarized at the World Health Organization's web site. See http://apps.who.int/infobase/reportviewer.aspx?rptcode=ALL&uncode=376&dm=5&surveycode=101220ae1, last accessed June 2, 2009.

Correlations among these and the other variables are shown in Table 3.

	BMI	Age	Majority	Edu	Price	Income	Active
BMI	1.00						
Age	0.34	1.00					
Majority	-0.12	0.19	1.00				
Education	-0.26	-.27	0.24	1.00			
Price	0.09	0.11	0.19	-0.04	1.00		
Income	-0.18	-.10	0.29	0.50	**-0.12**	1.00	
Active	-0.03	0.08	0.19	0.17	0.02	0.22	1.00

Table 3: Correlations among Variables: Women: (N=1124)

Table 3 shows that the highest correlation (0.50) is between education and income levels. The tables show that the correlation between Price sensitivity for food products (price) and income is negative, as expected. However, the correlation is relatively small: (-0.12).

Analysis

In Table 4, we report the results of a regression with measured BMI as the dependent variable and Age, Majority, Education, Price, Income, and Active as independent variables.

Dependent Variable: Measured BMI		
Independent Variables	Coefficient	T-statistic
Age	0.17	11.16
Majority	-2.06	-5.05
Education	-0.14	-3.14
Price	0.44	2.63
Income	-0.14	-1.40
Active	-0.11	-0.32
Constant	23.27	24.62
Observations	1124	
Adjusted R^2	0.17	

Table 4: Linear Regressions, dependent variable BMI

Table 4 shows, unsurprisingly, that older women have higher BMIs. Other things being equal, a 45 year old woman has a BMI level 1.7 units higher than a 35 year old woman. Majority (Jewish) women have lower BMIs than those of minorities (Christians, Moslem, Druze, etc.). Other things being equal, majority women have a BMI value approximately 2.0 units lower than minority women. Women with higher education have lower BMIs and the effect is statistically significant (-0.14, t=-3.14.) The estimated coefficient is such that four additional years of schooling is associated with a BMI level 0.56 units lower.

The coefficient on income (-0.14, t=-1.40) is negative although not statistically significant. The estimated coefficient on Income is such that an increase in a woman's family income from 7,500 NIS to 16,500 NIS a month is associated with a decrease in her BMI by 0.42 units. Table 4 also shows that those women who are active have a BMI 0.11 units lower than those women who are not active, but this effect is statistically significant.

In the case of price, women who stated that price was very important when buy food products had a BMI approximately 1.3 units (3*0.44) above those who stated that price was not important at all. This suggests that the price effect may even be more important than the income effect.

To get a sense of the magnitude of this price effect, a decrease in BMI by 1.3 units represents a 4.8% reduction at the mean BMI level (27.08) A reduction of 1.3 units in the BMI for all overweight and obese women would move approximately 28% of women who are in the "overweight" category to the "normal weight" category and would move 25%

of women who are in the "obese" category to the "overweight" category. At the average height of women in Israel 163 cm (5' 4"), this would represent a weight loss of approximately 3.5 kg (8 pounds): from 71.4 to 67.7 kg (157 to 149 pounds). Adding a variable to the regression that measures the extent to which the respondent is interested in the relationship between health and nutrition has essentially no effect. That is, other things being equal, the BMI of those who care to a great extent about the relationship between health and nutrition, and those who did not care at all about the relationship between health and nutrition had quite similar BMIs.

An Alternative Proxy for Obesity: waist circumference

As noted in the introduction, a large amount of fat near the internal organs and the waist is correlated with morbidity. When we use waist circumference (in centimeters) as a proxy for obesity instead of BMI, and run the same regression as in Table 4, we have the following results:[11]

Dependent Variable: Measured waist circumference (WC)		
Independent Variables	Coefficient	T-statistic
Age	0.43	11.97
Majority	-6.99	-7.15
Education	-0.42	-3.93
Price	1.12	2.84
Income	-0.30	-1.27
Active	-1.25	-1.61
Constant	78.40	34.92
Observations	1058	
Adjusted R^2	0.22	

Table 5: Linear Regression; dependent variable: Measured waist circumference

Table 5 shows that our results are robust to using waist circumference, rather than BMI, as a proxy for obesity. Table 5 shows that other things being equal, a 45 year old woman has a waist circumference 4.3 centimeters larger (1.7 inches larger) than a 35 year old woman. Majority (Jewish) women have smaller waist circumferences than those of minorities (Christians, Moslem, Druze, etc.). Women with higher education have smaller waist circumferences and the effect is statistically significant. The estimated coefficient is such that four additional years of schooling is associated with a waist circumference that is 1.6 centimeters (0.6 inches) smaller.

[11] We are missing data on waist circumference on sixty-six women. Hence, the regression with waist circumference has 1058 observations. The correlation between BMI and WC is 0.88.

The coefficient on income (-0.30, t=-1.27) is negative although not statistically significant. The estimated coefficient on Income is such that an increase in a woman's family income from 7,500 NIS to 16,500 NIS a month is associated with a decrease in her waist circumference by 0.90 centimeters (0.35 inches). Table 5 also shows that those women who are active have a waist circumference 1.25 centimeters (0.5 inches) smaller than those women who are not active, and this effect is statistically significant (t=-1.61) at the 89% level.

In the case of price, women who stated that price was very important when buy food products had a waist circumference approximately 3.36 centimeters (1.3 inches) larger than those who stated that price was not important at all. Again, this suggests that the price effect may even be more important than the income effect.

Robustness

Nothing changes qualitatively if we exclude minority women from the study. In particular, the price coefficient is virtually unchanged regardless of whether we use BMI or waist circumference as the proxy for obesity. In the first case (when BMI is the dependent variable,) the coefficient on price is 0.46 (t=2.48), virtually the same as in Table 4. In the second case (when waist circumference is the dependent variable,) the coefficient on price is 1.11 (t=2.50), essentially the same as in Table 5. Additionally, nothing changes in our results if we include total quantities/calories consumed as a right-hand side variable in the regression analysis.

When we employ the "log-log" functional form, where all variables (except 0,1 variables) in the regression are in logarithms,[12] we obtain qualitatively similar results, both in the case when BMI is the dependent variable and in the case when waist circumference is the dependent variable. This suggests that our results are robust to alternative functional forms.

It is often thought that obesity is primarily a problem for lower income households. In the case of women in households below (above) the median income, 32% (41%) replied that price was not important at all or not too important, while 68% (59%) replied that price was important or very important when buying food. Hence, there are some differences between the groups regarding price sensitivity to food products. In Table 6, we separately run regressions for those with family income levels below the median family income and for those with income levels above the median family income with measured BMI as the dependent variable.[13] The regressions in Table 6 show that our results on the price sensitivity effect are robust to both high and low incomes. In particular, the coefficient on "price" sensitivity is virtually unchanged. In the case when we use waist circumference as the dependent variable, the coefficient on price is virtually unchanged from Table 5 (1.18, t=2.01) for those with household incomes less than the median income. For those with household incomes greater than the median income, the price coefficient is 0.88 (t=1.67) and is significant at the 90% level of confidence.[14] This suggests that sensitivity to food prices cuts across all income classes and is not just an issue for lower income households.

[12] In the case of Price, Lprice=ln(Price+1), since Price can equal zero.

[13] The number of observations is not exactly equal, because we have income categories.

[14] When we exclude the two highest income classes in the case when waist circumference is the dependent variable, the price coefficient is 0.98 (t=1.82).

Dependent Variable: Measured BMI				
Independent Variables	Women (< median income)		Women (> median income)	
	Coefficient	T-statistic	Coefficient	T-statistic
Age	0.15	7.15	0.18	8.45
Majority	-2.16	-4.00	-1.75	-2.63
Education	-0.19	-3.15	-0.070	-0.90
Price	0.39	1.60	0.45	1.96
Income	0.013	0.05	-0.087	-0.46
Active	0.71	1.39	-0.81	-1.87
Constant	23.76	15.96	21.17	13.13
Observations	550		574	
Adjusted R^2	0.17		0.12	

Table 6: household income (i) below and (ii) above median level

Consumption Patterns

Here, we briefly compare the consumption patterns of (i) women who reported that price is not important at all (price=0) and (ii) women who reported that price is very important (price=3) when purchasing food products. In the case of less healthy (and relatively inexpensive) alternatives, Table 7 below shows that individuals for whom price is a very important factor, eat on average 38% more sugars and 10% more candy and drink 2% more soft drinks than those for whom price is not important at all. In the case of more healthy (and more expensive) alternatives, Table 8 below shows that individuals for whom price is a very important factor, eat on average 7% fewer vegetables and drink 7% more fruit juices.[15] In the case of fruit, however, individuals for whom price is a very important factor eat on average 23% more fruit than those for whom price is not important at all. This final result is likely due in part to the fact that vegetables are 56% more expensive per calorie than fruits in Israel. Although these differences are not statistically significant, these results suggest that women who consider price very important when making food purchases eat a less healthy diet.

Women who answered that price is not important at all (price=0), N=162	
Food category	Mean Quantity (Grams)
Vegetables	214.0
Fruit	159.8
Fruit Juices	29.7
Fats	9.0
Sugars, Sweeteners	22.5
Candy, Chocolate	3.7
Soft Drinks	201.2
Women who answered that price is very important (price=3), N=197	
Food category	Mean Quantity (Grams)
Vegetables	196.0
Fruit	197.4
Fruit Juices	27.7
Fats	9.0
Sugars, Sweeteners	33.3
Candy, Chocolate	4.07
Soft Drinks	206.2

Table 7: Consumption of different types of food, in grams per day

[15] Fruit juices are very expensive in Israel.

Summary Remark

In this paper, we employed a rich data set at the individual level in order to examine which factors are most highly correlated with obesity. The individual level cross-section data set we employed had several unique features, the most important being (i) researcher measured data on proxies for obesity and (ii) data on *price sensitivity* to food products. Our main result is that, even after controlling for income levels and other factors, we find that high "price-sensitivity" for food products is associated with high obesity. Our results suggest that the price effect is not trivial and obesity is a problem that is not limited to those with low income levels.

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