Title

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Permalink

Journal

ISSN

Authors

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Publication Date

2018

DOI

Peer reviewed

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Abstract:

We explored the role of dietary factors, as measured by individual behaviors and neighborhood produce availability, in the relationship between food insecurity and obesity among a representative sample of Latinos in California. We utilized data from the 2012, 2013/2014 California Health Interview Survey and included Latinos aged 18-65 years and under 200% of the federal poverty line (n=5,957). We conducted logistic regressions to first estimate the association between food insecurity and obesity and then examine whether this association remained significant after adjusting for soda and fast food consumption, perceived neighborhood fresh produce environment, and covariates. Latina women, and not men, were significantly more likely to be obese if they were very food insecure (OR=1.51,95% CI=1.04-2.20). After adjusting for diet and neighborhood variables, only neighborhood affordability of fresh produce reduced this significant association. Policy efforts to remediate obesity among food insecurity households should focus on the affordability of neighborhood fresh produce.

Food insecurity is defined as the state of being without relative access to a sufficient quantity of affordable, nutritious food.[1] Food insecurity nationally has declined from 15% in 2011to 13% in 2015 but still remains higher than pre-recession levels in 2007 (11%).[2] Certain racial and ethnic groups experience higher rates of food insecurity, particularly households headed by Latinos.[3] Latinos experienced the highest increase in food insecurity during the recession compared with other racial groups (20% in 2007 versus 27% in 2008). While the prevalence has dropped from the 2008 peak, 22% of Latino households were food-insecure in 2014.[4]

Food insecurity is an important driver of health disparities, not only because the condition is itself socially patterned, but because it is associated with poorer health outcomes, such as cardiovascular disease, type 2 diabetes, gestational diabetes, and poorer self-rated health, particularly among women.[5–7] One health condition related to food insecurity is body weight; individuals who report food insecurity have higher body mass index (BMI)[8] and greater odds of being overweight and obese.[9,10] This appears to be especially true among Latinos. Leung et al. found a significant association between high food insecurity and prevalence of obesity among Latino men (36% higher prevalence compared with those with low food security) and among Latina women (22% higher prevalence compared with those with low food insecurity).[3] Similar relationships were not observed for non-Hispanic Whites, African Americans, or Asian men.[3]

These patterns are troubling, as they suggested a compounded risk for obesity among Latinos, a population that already faces adverse social risk factors for obesity and other related chronic diseases. Nearly 80% of Latino adults are

overweight or obese, compared with 70% of the non-Hispanic Whites.[11] Latinos similarly have a higher prevalence of diabetes compared with non-Hispanic Whites (13% compared with 8%).[12]

The relationship between food insecurity and obesity may initially appear paradoxical, as a scarcity of food would suggest a reduced dietary intake. Yet, researchers have suggested that the mechanisms connecting food insecurity and obesity are a combination of individual-level and environmental factors that underlie unhealthy dietary behaviors.[13,14] These ideas have yet to be tested, however. In this paper, we explore two factors potentially underlying the relationship between high food insecurity and obesity as they pertain to dietary behavior. Specifically, we consider whether individual dietary behaviors or the neighborhood food environment as it pertains to fresh produce can account for the association between food insecurity and obesity. We examine a representative sample of the Latino population in California, with a particular focus on women, as they have among the highest levels of food insecurity as well as the most robust relationship between food insecurity and obesity.[3]

We first consider dimensions of individual consumption of soda and fast food. Some existing studies have shown that food-insecure individuals consume highly palatable foods that are higher in fat, sugar, and sodium, and lower in nutritional quality.[13] Drewnowski and Specter proposed an inverse relationship between energy-dense foods and cost and suggested that economically-constrained individuals may purchase and consume energy-dense foods as a conscious strategy to maximize energy intake while saving money.[15] Alternatively, food insecurity itself is a chronic stressor and these dietary patterns may arise as part of people's coping mechanisms. Under conditions of chronic stress, some individuals cope by

consuming so-called "comfort foods" that serve to decrease brain activities that are induced by stressful situations.[16] The persistent worry or anxiety over food availability for oneself or family members may result in coping responses that involve unhealthful dietary behavior.

Second, we assess the availability and affordability of healthy foods in the neighborhood. Dietary behaviors do not occur in isolation from the larger context that surrounds food choices. The local food environment, particularly in its availability, accessibility, affordability, and quality of healthy foods, has been associated with corresponding dietary behaviors, such as fruit and vegetable consumption, diet quality, and food intake.[17] Given the high correlation between food insecurity and poverty, food-insecure individuals are likely to reside in high-poverty areas that have limited access to healthy and nutritious foods.[18] A number of studies have supported the idea that a lack of access to healthy and nutritious foods in the local environment is associated with higher obesity prevalence.[19-21] In this paper, we explore whether perception of available and affordable fresh produce in the neighborhood food conditions underlie the association between food insecurity and obesity.

Our results provide important insight into potential mechanisms by which food insecurity is associated with obesity among Latinos, a population with a high prevalence of both the risk factor and outcome. Understanding these pathways is crucial to addressing the health disparities this population faces in obesity and related chronic conditions.

Methods

Sample. We analyzed data from The California Health Interview Survey (CHIS).[22] The CHIS is a random-dial telephone survey, representative of California's noninstitutionalized population and is the largest state health survey in the nation. The CHIS oversamples minority racial/ethnic groups and is administered in multiple languages, including Spanish. The survey has a repeated cross-sectional design and we combined data from the 2012, 2013, and 2014 CHIS to ensure a sufficient sample of Latinos. The total number of adult respondents was 60,595. We included Latino adults aged 18-65 years (n=10,640). We further restricted our sample to those with household income less than 200% of the federal poverty line, as this was the income threshold for the CHIS food insecurity questionnaire (n=6,336). We used listwise deletion to handle missing data on our variables, leaving a final analytic sample of 5,957 (men=2,253, women=3,703). The percent missing (6%) is below the range that is considered problematic for missing data biases.[23]

Measures. *Overweight/obese.* Respondents self-reported their height and weight and BMI kg/m^2 was pre-calculated in the CHIS data using the standard formula. [24] The CHIS further identified individuals into the corresponding BMI kg/m^2 categories: underweight (0-18.49), normal (18.5-24.99), overweight (25.0-29.99) and obese (over 30.0). We created a binary variable identifying overweight and obese individuals versus others. There were no missing values for this variable.

Food insecurity. Food insecurity was measured using the United States Department of Agriculture Household Food Security Survey Module six-item form.[25] Questions from this module include: "In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?" and "In the last 12 months, were you ever hungry but didn't eat because you couldn't afford enough food?." These questions were only asked of households with incomes below

200% of the federal poverty level. Raw scores based on the USDA survey range from 0-6 and are traditionally categorized into three groups: 1) low or moderate food insecurity (0-1 points); 2) high food insecurity (2-4 points); 3) very high food insecurity (5-6 points). We created a binary variable of very high food insecurity versus low/moderate/high food insecurity, as previous research has found very food-insecure individuals to display the strongest association with obesity.[3] There was less than 1% missing cases in our sample (n=5).

Dietary behaviors. We included two continuous measures of dietary behaviors: weekly fast food and soda consumption. For soda, respondents were asked how often they drank regular soda or pop that contains sugar. The CHIS survey calculated the corresponding weekly values, which ranged from 0 to 99; we top-coded the responses to 20 to avoid biases from outliers. Under 2% (1.6%) of our sample drank more than 20 sodas/sugary drinks in one week. For fast food, respondents were asked how often they ate fast food in the past seven days. The responses ranged from 0 to 9. There were no missing values for these variables.

Neighborhood Fresh Produce Environment. We included two measures that assessed perceptions of healthy foods in the neighborhood food environment: availability and affordability of fresh fruits and vegetables. For availability, respondents were asked how often they found fresh fruits and vegetables in their neighborhoods: never, sometimes, usually, always, or doesn't shop for fruits or vegetables. We recoded those who said they don't shop for fruits and vegetables as missing and coded the other responses into a binary variable of usually/always versus never/sometimes. There was less than 1% missing in this variable (n=52). For affordability of fruits and vegetables, respondents were asked how often the fresh fruits and vegetables found in their neighborhood were affordable: never,

sometimes, usually, always. There was 5% missing in this variable (n=323). We recoded neighborhood affordability into a binary variable of usually/always versus never/sometimes.

Covariates. We controlled for participation in nutrition assistance programs (i.e., food stamps) in all of our analyses. Several studies have found that participation in food assistance programs is associated with obesity,[26,27] especially among women.[28] Many researchers also suggest that nutritional assistance is a proxy for food insecurity, although the pathways between food assistance and obesity differ slightly from those for food insecurity.[28] By controlling for food stamp participation, our analyses present a more rigorous test of the unique association between food insecurity and obesity, as they account for the overlapping covariance due to food stamp participation.

Nutrition assistance participation was measured by receiving food stamp benefits. The question was only asked of respondents whose total household income was less than 300% of the poverty line, which was within the stipulations of our analytic sample. Responses were either yes (coded as 1) or no (coded as 0).

In our multivariate analyses, we controlled for additional demographic and socioeconomic covariates: age in years; education (less than high school grad, high school grad, some college/college grad); employment (employed versus not employed) and income (less than $20,000, $20,000-$29,999, over $30,000); urbanicity (living in an urban versus rural census tract). We also controlled for variables related to household structure: family type (single no children, married no children, married with children, single with children) and spouse living in the household (yes versus no). We also we included variables related to migration status: nativity/duration (U.S.-born, immigrant less than 10 years U.S. residence,

immigrants 10 years and over U.S. residence); citizenship (U.S. citizen versus not); and English proficiency (use and speak English very well/well versus not well/not well at all). Finally, we included a Mexican ethnicity variable (Mexican versus other); this was the only subgroup identifier in the data.

Statistical analysis. We calculated descriptive statistics, stratified by gender. We conducted Wald tests to identify significant differences by gender. We then calculated weighted bivariate associations between food insecurity and key variables with Wald Tests to identify significant differences across levels of food insecurity by gender.

Based on results from our bivariate associations, we conducted a series of four nested logistic models of Latinas (women) only in our analytical sample. Model 1 established the primary association of interest between food insecurity and overweight/obesity, controlling for all covariates. Model 2 added the two dietary behavior measures of soda and fast food consumption. We compared the odds ratio for the relationship between food insecurity and overweight/obesity between Model 1 and Model 2 to examine whether the relationship was explained by the inclusion of the dietary behavior variables. We subsequently conducted a Wald test of equivalence between the coefficients for food insecurity for Models 1 and 2. Model 3 added the two neighborhood fresh produce variables to Model 1: perception of availability and perception of affordability. We similarly conducted a test of equivalence for the coefficient for food insecurity between Models 1 and 3. Model 4 included both explanatory factors: dietary behaviors and neighborhood fresh produce environment, with all covariates.

We performed all statistical analyses using STATA/IC for Windows statistical software package version 13 (StataCorp LP, College Station, TX, USA). We

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incorporated replicate weights using jackknife replications to account for the complex sampling design and adjusted the weights for combining across three survey waves. We calculated the Wald test of equivalence of regression coefficients on the unweighted data, as this cannot be conducted on survey-weighted models.

Results

      Sample characteristics. We found differences across gender among our analytical sample of Latino adults. In Table 1, a higher percentage of Latino men (71.8%) were employed compared to Latina Women (47.9%, p<.01). A higher percentage of Latina women were single with children (18.3%) compared to Latino men (6.6%, p<.01). Latino men had lower percentages of high food insecurity (12.6%) compared to Latina women (16.1%, p<.01). Latino men also had higher mean weekly consumption rates of fast food and soda (3.7 vs. 2.0, p<.01). There was no difference in the reported availability of fresh produce, although Latino men reported more affordability (70.3%) than women (61.1%, p<.01). Lastly, more Latina women received food stamp benefits than Latino men (23.3% vs. 15.1%, p<.01).

 [**production: please insert Table 1 here**]

      Bivariate results. The bivariate associations reported in Table 2 showed that Latinas who were very food-insecure were more overweight or obese (78.9%) than women who were food-secure or had low food insecurity (70.3%). There were no differences in dietary behaviors by food insecurity, for either soda or fast food consumption. These initial results suggest that these dietary behaviors do not differ by food-insecurity status, but we still include in them in the full multivariate models to account for the possibility that the bivariate relationship is suppressed by another

variable. In regard to the neighborhood fresh produce environment, women who were very food-insecure perceived significantly lower neighborhood availability (72.8%) and affordability (46.5%) of fresh produce compared with women who were not very food-insecure.

[**production: please insert Table 2 here**]

For Latino men, there was no difference in the percent overweight/obese across the food-insecurity categories. Men who were very food-insecure had a lower percentage of neighborhood availability (72.3%) and affordability (40.9%) compared with men who were not very food-insecure. Because the goal of the study was to examine explanatory factors for the relationship between food insecurity and obesity, we limited to our multivariate analyses to women, as there was no significant bivariate association for men.

Multivariate results. Our first model shows that while controlling for covariates, Latinas were significantly more likely to be obese if they were very food-insecure (OR=1.50, 95% CI=1.03-2.19) (Table 3). Models 2 and 3 examined both explanations separately along with covariates. In Model 2, soda consumption was significantly associated with overweight/obesity (OR=1.07, 95% CI=1.02-1.13) although the odds ratio for food insecurity remained nearly the same as Model 1 and significant (OR=1.49, 95% CI=1.02-2.16). In contrast, fast food consumption was not significantly associated with overweight/obesity. A Wald test on the unweighted regression models confirmed that the coefficient for food insecurity in Model 1 was not significantly different from the same coefficient in Model 2 (F=0.18, p=.68).

[**production: please insert Table 3 here**]

In Model 3, the odds ratio between food insecurity and overweight/obesity became non-significant with the addition of the perceptions of neighborhood fresh produce environment (OR=1.32, 95% CI=0.89-1.98). Of the two neighborhood fresh produce environment measures, only neighborhood affordability of fresh produce was statistically associated with overweight/obesity; very food-insecure women had lower odds (OR=0.70, 95% CI=0.53-0.93) of obesity if they were usually or always able to afford fresh produce in their neighborhood. This suggests that perceived affordability of fresh produce accounts for the statistical association between food insecurity and overweight/obesity. A Wald test on the unweighted regression models confirmed that the coefficient for food insecurity in Model 1 was significantly different from the same coefficient in Model 3 (F=4.1, p<.05).

In Model 4, after including soda and fast food consumption, perceptions of fresh produce in the neighborhood, and controlling for all covariates, the odds ratio between food insecurity and obesity became non-significant compared to Model 1. The odds ratios were very similar in Model 3 and Model 4, suggesting that neighborhood affordability of fresh produce was the driving factor that reduced the statistical association between food insecurity and overweight/obesity. In all models, having some college or a college degree and over 10 years residence in the United States were associated with a significantly lower odds of being overweight/obese compared to the respective reference groups.

Discussion

We examined the relationship between food insecurity and overweight/obesity among a representative sample of Latinos in California and found a significant association between the two variables among Latinas only. Using only the sample of

Latinas, we further explored two factors potentially underlying the relationship: consumption of soda and fast food and perceptions of neighborhood availability and affordability of fresh produce. We found only perceptions of neighborhood fresh produce to account for the statistical association between food insecurity and obesity.

While other research using representative datasets have suggested that food-insecure individuals have poorer diets,[13] other smaller studies that focused specifically on Latinas have not found significant differences in diet by food insecurity status.[29] Our study similarly finds no difference in soda and fast food consumption by food-insecurity status, suggesting they have a limited role in the pathway between food insecurity and obesity. While we acknowledge that our dietary measures are narrowly defined, our research adds to growing literature that suggests that food consumption does not differ by food insecurity status among Latina women. Instead, the association between food insecurity and obesity among Latina women seems to be driven by the perceptions of fresh fruits and vegetables in the neighborhood. Latina women who are food insecure may reside in neighborhoods in which the local food choices constrain the consumption of healthy foods. Hence, focusing on individual behaviors among food insecure households alone will not necessarily remediate their obesity risk. Instead, these behaviors are located with a larger context that determines whether and how food insecure Latina women make certain food choices.

It is notable, however, that only neighborhood affordability was significantly associated with obesity and not neighborhood accessibility. These findings reinforce parallel discussions in the broader neighborhood food environment literature that question whether the mere presence of healthy foods is sufficient to induce dietary

changes.[30-32] Affordability, on the other hand, may be a better approximation for consumption, as it encompasses the likelihood of purchasing certain foods as well as perceptions or attitudes towards certain foods.[17] It is alternatively possible that affordability may be a proxy for disposable income, suggesting that it is not the affordability of fresh produce in the neighborhood per se, but rather limited economic means that constrain healthy dietary choices among Latina women.

Our analyses have some limitations. First, we are using cross-sectional data, so we cannot determine causality or direction among the key variables. Our measure of overweight/obesity was determined by self-reported weight and height, which are subject to recall and social desirability biases.[33,34] If overweight and obesity are underestimated in our sample, this makes our results more conservative.

Our measures of dietary behavior and local food environment were limited and likely only capture some of what is encompassed by these concepts. For example, our dietary behaviors were specific to soda and fast food and we cannot generalize based on our findings alone to suggest that diet does not differ between Latina women who are and are not food insecure. Future research could test this idea using more detailed dietary measures, such as a food frequency questionnaire or a 24-hour dietary recall. Similarly, our neighborhood measures were personal perceptions of neighborhoods and may not represent objective neighborhood characteristics. Future research could incorporate objective measures of local food affordability (i.e., food prices). Since our sample of Latinas consisted mostly of Mexican heritage, we cannot generalize our results to other Latinas. Finally, we did not control for the full array of food-related assistance programs because of data availability. For example, we did not include participation in Women Infants and

Children (WIC) food and nutrition service, as it would not apply to a substantial proportion of our sample.

Food insecurity is a risk factor for obesity among Latina women in California. Efforts to address obesity among food-insecure individuals should not solely focus on individual dietary change, but instead encompass community-focused interventions that concern the affordability of fresh foods, even more centrally than their accessibility in terms of proximity. Community-level interventions might include mobile farmers markets or food co-ops, which offer fresh fruits and vegetables at lower cost and decrease the cost of produce in surrounding grocery stores.[35] Other researchers have proposed that policies that regulate food prices or provide subsidies to agriculture or related industries may improve the affordability of fresh produce.[36]

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Table 1: Weighted Sample Description, California Health Interview Survey 2012-2014

	Female (n=3,703)	Male (n=2,254)	
Demographics			
Mean Age	35.1	35.9	
Education, %			
Less than High School	43.7	47.0	
High School Diploma	49.7	47.2	
Some College+	6.6	5.8	
Employed, %	47.9	71.8	**
Household total Annual Income, %			
$0-19,999	46.8	41.5	*
$20,000-29,000	26.6	25.3	
$30,000+	26.6	33.2	**
Family Type, %			
Single No Kids	31.6	38.6	**
Married No Kids	11.9	11.6	
Married with Kids	38.4	43.2	*
Single with Kids	18.3	6.6	**
Duration in US, %			
Born in US	34.8	31.1	
<10 Years	11.7	9.9	
>10 Years	54.9	58.9	*
US Citizen	53.5	47.4	**
English Proficient	48.9	47.5	
Living in an Urban Census Tract, %	90.0	89.3	
Mexican Origin, %	79.2	81.1	
Obesity and Food Insecurity, %			
Obese	34.6	36.2	
Very Food Insecure	16.1	12.6	*
Dietary Behaviors			
Mean weekly soda consumption (Range 0-20$^+$)	2.0	3.7	**
Mean weekly fast food consumption (Range 0-9)	1.6	2.2	**
Neighborhood fresh produce environment, %			
Usually/always available, %	84.8	83.2	
Usually/always affordable, %	61.1	70.3	**

Food Stamp Participation, %

Food stamp participation	23.3	15.1	**

Sample is limited to respondents who identify as Latino, live under 200% of the poverty line, and are under 65 years of age. [+] Top coded at 20. Tests of significance * p<.05, **p<.01. The tests correspond to Wald tests that test the weighted difference in means or proportions between men and women.

Table 2: Weighted Bivariate Associations between Food Insecurity and Dietary Variables, California Health Interview Survey 2012-2014

	Female			Male		
	Food Secure or Low Food Insecurity	Very Food Insecure		Food Secure or Low Food Insecurity	Very Food Insecure	
Overweight or Obese, %	70.7	79.1	*	79.2	74.0	
Dietary Behaviors						
Mean weekly soda consumption	2.0	2.1		3.8	3.6	
Mean weekly fast food consumption	1.6	1.8		2.2	2.1	
Neighborhood fresh produce environment						
Usually/always available, %	86.5	75.7	**	84.3	75.9	
Usually/always affordable, %	72.5	46.5	**	69.7	40.9	**

* p<.05, **p<.01. Tests of significance correspond to Wald tests

Table 3. Odds of Overweight/Obesity among Latina Women, California Health Interview Survey 2012-2014

	Model 1 Food Insecurity, Controls				Model 2 Food Insecurity, Controls, Diet				Model 3 Food Insecurity, Controls, Neighborhood fresh produce				Model 4 Food Insecurity, Controls, Diet, Neighborhood fresh produce			
	OR	[95% CI]			OR	[95% CI]			OR	[95% CI]			OR	[95% CI]		
Food insecurity	1.50	1.03	2.19	*	1.49	1.02	2.16	*	1.32	0.89	1.98		1.31	0.88	1.96	
Dietary behaviors																
Weekly soda consumption					1.07	1.02	1.13	**					1.07	1.01	1.12	*
Weekly fast food consumption					1.06	0.97	1.16						1.07	0.97	1.17	
Neighborhood fresh produce environment																
Usually/always affordable									0.70	0.53	0.93	*	0.70	0.53	0.93	*
Usually/always available									0.91	0.67	1.24		0.94	0.69	1.28	
Covariates																
Currently Receiving Food Stamps	1.13	0.82	1.55		1.11	0.81	1.52		1.20	0.87	1.67		1.18	0.85	1.64	
Year																
2012																
2013	0.87	0.63	1.22		0.87	0.62	1.21		0.89	0.64	1.25		0.89	0.64	1.25	
2014	1.28	0.96	1.72		1.26	0.94	1.70		1.26	0.93	1.70		1.25	0.92	1.69	
Age	1.03	1.02	1.05	**	1.03	1.02	1.05	**	1.03	1.02	1.05	**	1.03	1.02	1.05	**
Educational Attainment																
Less than High School																
High School Diploma	0.87	0.63	1.20		0.86	0.63	1.19		0.97	0.70	1.34		0.96	0.70	1.32	
Some College, College Degree	0.45	0.25	0.80	**	0.48	0.27	0.85	*	0.51	0.29	0.91	*	0.55	0.31	0.96	*

Employed	0.93	0.73	1.20		0.89	0.69	1.14		0.92	0.71	1.19		0.88	0.68	1.14	
Income Category																
Less than 20,000																
20000-29999	0.86	0.64	1.17		0.86	0.63	1.18		0.88	0.65	1.20		0.88	0.65	1.20	
30,000+	0.85	0.60	1.19		0.84	0.61	1.17		0.81	0.57	1.15		0.81	0.58	1.14	
Rural Census Tract	0.96	0.68	1.36		0.93	0.66	1.31		1.01	0.70	1.45		0.97	0.68	1.39	
Family Type																
Single No Children																
Married No Children	1.53	0.77	3.05		1.51	0.76	3.00		1.69	0.84	3.39		1.67	0.83	3.34	
Married with Children	1.50	0.80	2.80		1.44	0.77	2.68		1.70	0.91	3.16		1.65	0.88	3.06	
Single with Children	1.53	1.00	2.33	*	1.48	0.97	2.25		1.53	1.00	2.36		1.48	0.97	2.29	
Spouse in the household	1.01	0.58	1.77		1.05	0.60	1.83		0.92	0.53	1.60		0.94	0.54	1.64	
Duration in the United States																
US-Born																
Under 10yrs	0.60	0.33	1.10		0.63	0.35	1.14		0.60	0.33	1.11		0.63	0.34	1.15	
Over 10yrs	0.56	0.36	0.86	**	0.59	0.38	0.90	*	0.59	0.37	0.92	*	0.62	0.39	0.96	*
US Citizen	0.95	0.63	1.41		0.97	0.65	1.44		0.96	0.64	1.45		0.99	0.66	1.48	
English Language Proficient	0.82	0.55	1.22		0.80	0.54	1.18		0.75	0.50	1.13		0.73	0.49	1.10	
Mexican	0.95	0.69	1.32		0.94	0.68	1.32		0.97	0.69	1.35		0.95	0.68	1.34	

Tests of Significance * $p < 0.05$, **$p < 0.01$