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Jason Nagata
University of Pennsylvania

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Jason Nagata[1], Kent Bream[2] and Frances Barg[2]
[1]Health and Societies Program, Department of History and Sociology of Science and
[2]Department of Family Medicine and Community Health,
University of Pennsylvania, Philadelphia, Pennsylvania 19104

Abstract

This study illuminates the associations of body mass index (BMI), socio-economic status (SES), and related behavioral practices including marriage, market visits, and meal consumption among the Tz'utujil Maya of Santiago Atitlán, Guatemala. Semi-structured interviews of 54 adults in Santiago Atitlán were conducted in 2007. The stratified sample was designed to be representative of the seven regional *cantones* of Santiago Atitlán. BMI was positively associated with years of schooling, income, and literacy, all measures of SES. In addition, BMI was found to be significantly positively correlated with the behavioral practices of marriage, market visits per week, and drinking bottled water. A multiple linear regression model with BMI as the dependent and income, schooling, married, market visits, and bottled water consumption as independent variables is presented and found to be significant. The important behavioral practices highlighted here help to explain how BMI and SES are positively associated, and can inform future public health interventions regarding obesity and malnutrition.

Introduction

Obesity is a rising problem in Latin America, especially as subsistence economies transition to market-based economies. In Mexico, the prevalence of obesity or

overweight is over 50% among men and 60% among women (Fernald et al., 2004). In many low-income and transitional countries in Latin America, obesity and overweight prevalence has been found to be as high as or higher than in developed nations (Filozof et al., 2001). In Guatemala, the prevalence of obesity and overweight increased from 34.1% in 1995 to 44.9% in 2002 (Garnier et al., 2005). Because obesity rates in Latin America have been on the rise in recent years, obesity and overweight prevalence is predicted to currently be higher than 44.9% in Guatemala. Obesity and overweight are major risk factors for many chronic conditions, including coronary heart disease (Eckel and Krause, 1998), type II diabetes mellitus (Larsson et al., 1981), hypertension (Dyer & Elliott, 1989), and selected cancers (Chute et al., 1991). In addition to obesity, malnutrition is a major health problem in Guatemala, especially among children. The prevalence of chronic child malnutrition in Guatemala was 44% in 2000 (Marini & Gragnolati, 2003). The obesity-malnutrition dichotomy presents unique challenges to the communities affected by them.

Obesity and chronic child malnutrition are significant health problems in Santiago Atitlán, Guatemala, a town comprised primarily of the Tz'utujil Maya. Located on the southwest shore of Lake Atitlán, the village lies at an altitude approximately one mile high and has a population of 30,821. Santiago Atitlán is geographically divided up into seven *cantones*, or neighborhood zones. Residents of Santiago Atitlán are referred to as Atitecos. The primary language for 94% of the residents is Tz'utujil; however, 54% of the villagers speak and 13% read some Spanish (Schram & Etzel, 2005).

The relationship between body-mass index (BMI) and socio-economic status (SES) has been studied in both developing and developed nations, including in Latin

America. In developed countries, BMI and SES are often negatively correlated (Sobal & Stunkard, 1989). For example, BMI and SES are negatively correlated in Mexico, a relatively wealthy Latin American nation, according to a national nutrition survey in 1999 (Barquera et al, 2003). Conversely, in many developing nations, BMI and SES are often positively correlated. Other than in Mexico, a positive association between BMI and SES has been established in all other Latin American countries (Martorell et al., 1998). In Guatemala, for instance, better education is positively correlated with obesity (Martorell et al, 1998). Although correlation differences between BMI and SES exist at the macro level in developed versus developing nations, smaller populations within these nations can differ from national trends. In Mexico, low-income populations demonstrate a positive correlation between BMI and SES, which differs from national Mexican trends (Fernald, 2007).

We conducted an analysis of BMI and SES among the mainly Tz'utujil Maya population of Santiago Atitlán to determine if the town has similar trends to the rest of Guatemala. Because of the prevalence of poverty and malnutrition in Santiago Atitlán, indicating its status as a developing region, we predicted that BMI and SES would be positively correlated. A further question we pursued includes what behavioral practices including marriage, number of children, market visits, and drinking water source may mediate the association between BMI and SES.

In Tehran, married women are 1.31 times more likely to be obese than non-married women (Azadbakht & Esmailzadeh, 2007). BMI has been found in Northern Italy to be directly associated with marriage and number of children (Tavani et al. 1994).

This study determines to what extent marital status and number of children are associated with BMI in Santiago Atitlán.

Based on participant observation in Santiago Atitlán, behavioral practices specific to the town are also hypothesized to influence BMI. First, the frequency of visits to the village market may be associated with BMI. An indoor market located near the village's central plaza opens daily and provides most of the food for the residents of Santiago Atitlán. Individual vendors sell produce, meat, and prepared and processed foods. On Fridays, Sundays, and Tuesdays, the streets surrounding the indoor market close and transform into a large outdoor market, where more vendors sell their produce.

Additionally, the number of meals eaten per day is hypothesized to influence BMI. Based on exploratory research and unstructured interviews, it was determined that some Atitecos skip breakfast or lunch whereas others eat three meals per day. Those who ate fewer than three meals per day were hypothesized to have a lower BMI and lower SES.

Finally, the source of drinking water may influence BMI. Those who drink untreated tap water or water directly from Lake Atitlán may have a higher incidence of diarrheal diseases and therefore absorb less food and nutrients. The ability to pay for purified bottled water may be another indicator of SES. Those who can afford to purchase bottled water are hypothesized to have higher BMIs because they have the money to buy more food. Overall, this study aims at confirming a hypothesized positive association between BMI and SES and determining which behavioral practices are most associated with BMI in Santiago Atitlán, Guatemala.

Methods

Research methods for this study included participant observation, unstructured interviews, and 56 semi-structured interviews in Santiago Atitlán between March and July 2007. BMI, SES, and behavioral data were obtained from semi-structured interviews, while exploratory and qualitative data were obtained from participant observation and unstructured interviews. Semi-structured interview respondents were selected based on *canton* (regional) location. A representative sample of the population from all seven *cantones* was interviewed in proportion to Santiago Atitlán as a whole to eliminate regional bias to responses. Interviews were conducted on all days of the week, excluding holidays.

Body mass index

The heights and weights of respondents were measured using a wooden Shorr Height measuring board and Tanita electronic scale, respectively. BMI was calculated using weight in kilograms divided by the sum of height in meters squared.

Socio-economic status

Schooling

Educational attainment has been shown to be related to both health outcomes (MacIntyre, McKay, Der, & Hiscock, 2003) and obesity (Zhang and Wang a, 2004). Schooling was measured through self-reported years of schooling.

Literacy

Literacy, another measure of educational attainment, was obtained by self-reported literacy.

Income

Household income and obesity have been found to be positively associated (Zhang and Wang b, 2004). Income was calculated using self-reported Quetzales earned per week by the respondent.

Behavioral Practices

Marriage

Marriage has been shown to be positively correlated with BMI (Tavani et al. 1994 and Azadbakht & Esmailzadeh, 2007). Marriage was coded as 1 and all other responses (including single, committed, and widowed) were coded as 0.

Number of children

The number of children, which has been shown to be positively correlated with BMI (Tavani et al. 1994), was self-reported by the respondent.

Market visits

The number of market visits was the respondent's self-reported frequency of market visits per week.

Meals

The number of meals was the respondent's self-reported frequency of meals per day.

Water

The source of drinking water for most Atiteco residents is either bottled water, called *agua pura*, or tap water from Lake Atitlán. The municipal water pump provides slightly chlorinated tap water from Lake Atitlán to residents. Bottled water was coded as 1 and all other sources of water (including untreated tap water, treated tap water, and water directly from the lake) were coded as 0.

Data Analysis and Statistical Methods

SPSS 12.0 for Windows (SPSS Inc., Chicago, IL) was used to conduct statistical analyses. The initial sample for analysis was 56, which was reduced to 54 respondents with complete data on BMI, SES, and behavioral variables. Descriptive statistics were generated for continuous and numerical variables while frequencies were generated for categorical variables.

To determine the association between BMI and various SES and behavioral variables, two types of tests were utilized. For associations between BMI and continuous or numerical variables, simple linear regression was performed. Simple linear regression was performed with BMI as the dependent variable and the following independent variables: (1) income; (2) schooling; (3) number of children; (4) market visits; (5) meals. An independent-samples t test for comparison of means was used for BMI as the dependent variable and the following independent variables grouped into only two

discrete levels: (1) income: high or low; (2) literacy: illiterate or literate; (3) married: married or not married; (4) water: bottled water or other source. Finally, a multivariate regression using income, schooling, married, market visits, and bottled water consumption was created to predict BMI. A reduced multiple linear regression was created using only two variables, income and marriage, which were the two strongest single indicators of BMI.

Ethical Considerations

This study was approved by the Social and Behavioral Sciences Institutional Review Board of the University of Pennsylvania.

Results

The average BMI was 25.88 among the Santiago Atitlán sample (Figure 2). 22.2% of the population was classified as obese, 25.9% as overweight, 48.1% as normal weight, and 3.7% as underweight. A larger proportion of women were interviewed, as would be expected, because males were more likely to be working away from their homes during the day. Most respondents (87.3%) were Tzu'utujil Maya and a minority (7.3%) was Ladino in ethnicity. The SES data reflect high poverty levels in Santiago Atitlán. Over two-thirds of respondents had no schooling (0 years) resulting in 1.56 years of schooling on average for the respondents. A vast majority of respondents earned 0-200 Quetzales per week, none earned between 250 and 500 Quetzales per week, and a few earned over 500 Quetzales. This natural division (under 250 Q and over 500 Q) led to the creating of lower class and upper class variable.

Table 1
Selected socio-demographic, health and behavioral characteristics of study participants

	n	Mean	SD	
Weight status				
Body mass index (BMI)	54	25.88	4.72	*
Weight classification (%)				
Underweight (BMI<18.5)	2	3.7%		
Normal weight (18.5<BMI<25)	26	48.1%		***
Overweight (25<BMI<30)	14	25.9%		
Obese (BMI<30)	12	54.0%		***
Demographic characteristics				
Age (yr)	55	33.87	13.24	***
Gender				
Female	51	92.7%		
Male	4	7.3%		
Ethnicity				
Tz'utujil	48	87.3%		
Maya (non-Tz'utujil)	1	1.8%		
Ladino	4	7.3%		
Other	2	3.6%		
Marital Status				
Married	31	56.4%		
Single	20	36.4%		
Widowed	4	7.3%		
Number of Children	55	3.44	2.65	
Socio-economic status				
Income (Q per week)	48	113.98	128.65	
Schooling (years)	54	1.56	3.00	
Literacy				
Literate	20	36.4%		**
Illiterate	35	63.6%		***
Behavioral Practices				
Market Visits per week	54	3.50	2.45	***
Meals per day	53	2.74	0.46	***
Water Source				***
Agua Pura (purified bottled water)	16	29.1%		***
Other (Tap, Lake)	39	70.9%		***

All three measures of SES were positively associated with BMI (Tables 2 and 3). A simple linear regression model of BMI and income demonstrated that for every 1 Quetzal increase in income per week, BMI also increased by 0.011, yielding a significant model (p=0.048). When income was divided into two natural categories of high (≥400 Quetzales) and low (<400 Quetzales) incomes, there was a significant difference in mean BMI (p=0.018). The average BMI for high income respondents was 32.18 whereas the average BMI for low income respondents was 25.49. The linear regression with BMI and schooling yielded another significant positively associated model (p=0.046). For every one year addition of schooling, BMI increased by 0.431. Although the mean BMI for literate respondents was higher than the mean BMI for illiterate respondents, the difference was not significant (p=0.086).

Five behavioral practices also produced interesting associations with BMI using simple linear regression and t-tests for comparisons of mean (Tables 3 and 4). The mean BMI for married respondents was significantly higher than the mean BMI for non-married respondents (p=0.002). A simple linear regression indicated that BMI and number of children were negatively correlated; however, the model was not significant (p=0.692). A simple linear regression model of BMI and market visits per week demonstrated that for every additional market visit, BMI increased by 0.640, yielding a significant model (p=0.015). A linear regression of BMI and meals per day also indicated positive correlation, although the model was not significant (p=0.813). Finally, respondents who drank bottled water (*agua pura*) had significantly higher BMI than respondents who drank water from other sources, including tap water and directly from Lake Atitlán.

Table 2
Results from simple linear regression with body mass index (BMI) as the dependent variable and measures of socio-economic status and behavioral practices as independent variables

	n	Intercept	B	Standard Error	R^2	t	Sig.
Socio-economic status							
Income	48	24.687	0.011	0.005	0.082	2.028	0.048*
Schooling	53	25.129	0.431	0.211	0.076	2.041	0.046*
Behavioral Practices							
Number of children	54	26.221	-0.098	0.245	0.003	-0.399	0.692
Market visits per week	53	23.617	0.64	0.255	0.11	2.513	0.015*
Meals per day	53	24.931	0.36	1.51	0.001	0.238	0.813

* p<0.05

Table 3
Results from simple linear regression and t-tests for equality of means for behavioral practices and body mass index (BMI)

	n	Mean	Standard Deviation	Standard Error Mean	t-statistic	Sig. (2-tailed)
Socio-economic status						
Income					-2.449	0.018*
Low Income (Income<400 Q)	45	25.492	4.662	0.695		
High Income (Income>400 Q)	3	32.1872	2.294	1.324		
Literacy					-1.751	0.086+
Illiterate	34	25.036	4.209	0.722		
Literate	20	27.322	5.294	1.184		
Behavioral Practices						
Marital Status					-3.337	0.002**
Not married	24	23.684	4.067	0.83		
Married	30	27.641	4.525	0.826		
Drinking Water					2.043	0.046*
Bottled water (agua pura)	16	27.849	4.811	1.203		
Other water (tap, lake, etc)	38	25.054	4.496	0.729		

+ p<0.10
* p<0.05
** p<0.01

Multiple linear regression was used to construct a model using each of the variables that were significant either with simple linear regression or an independent samples t-test (Table 4). A reduced multiple linear regression model was constructed using BMI as the dependent variable and only the strongest single variables for socio-economic status and behavioral practices as independent variables (Model 1). The dichotomous variable of high vs. low income was selected to represent SES and the dichotomous variable of married was selected as the most significant behavioral practice. The dichotomous variable of high vs. low income was used instead of income as a continuous variable. Overall, the model with these two independent variables was significant ($p=0.000$) and had an R^2 of 0.303.

A second model using the five strongest SES and behavioral variables of income, schooling, marriage, market visits, and water, was constructed (Model 2). All five independent variables used in the multivariate model were positively associated with the dependent variable of BMI. The overall model has a significance of $p=0.005$ and an R^2 of 0.329. The independent variable of marriage is the most significant in the multivariate model ($p=0.006$).

Finally, a full model using BMI as the dependent variable and all measures of SES and behavior that were individually significant was constructed (Model 3). This model accounts for age and gender as well as income, schooling, literacy, marriage, market visits and water. This full model has an overall significance of $p=0.010$ and an R^2 of 0.388.

Table 4
Results from multiple linear regression with body mass index (BMI) as the dependent variable and socio-economic and behavioral variables as the dependent variables

	Model 1 n=48	Model 2 n=47	Model 3 n=47
Gender			-4.147 (4.351)
Age			-0.058 (057)
Socio-economic status			
Income (Low vs High)	4.609 (2.526)+	2.568 (4.098)	-2.528 (2.975)
Schooling		0.322 (0.301)	0.834 (0.386)*
Literacy			-2.845 (1.914)
Behavioral Practices			
Married	4.267 (1.227)***	3.881 (1.329)**	4.465 (1.369)**
Market per week		0.075 (0.280)	0.091 (0.281)
Water		0.691 (1.543)	0.608 (1.533)
Intercept	23.312	22.772	24.963
R^2	0.303	0.329	0.388
Overall Significance	0.000***	0.005**	0.010**

+ $p<0.10$
* $p<0.05$
** $p<0.01$
*** $p<0.001$

Discussion

In Santiago Atitlán, BMI and all indicators of SES were positively associated, including income, years of schooling, and literacy. Two-thirds of the high-income respondents were obese, whereas slightly over half of low-income respondents had either normal or under weight BMI. In simple linear regression models, both schooling and income had significant associations with BMI.

The positive association of BMI and SES in Santiago Atitlán but not in developed parts of the world can be explained because of Santiago Atitlán's relative poverty. The

poorest families in Santiago Atitlán often face malnutrition, especially for children, and may not have the resources to become overweight or obese. However, the wealthier families in the town might still be considered relatively poor compared to families in more developed regions of Latin America. The maximum weekly income in this sample was 600 Quetzales, which is currently approximately $80 per week. A similar positive correlation between BMI and SES has been established among Mexico's poorest quintile (Fernald, 2007). Santiago Atitlán does not yet have the wealthiest classes of the more developed world, who generally have lower BMIs because of education, healthy eating practices, and exercise. This negative correlation between SES and overweight or obesity has been established in Mexico overall (Rivera and Sepulveda-Amor, 2003). Santiago Atitlán's "wealthy" class is considered relatively wealthy because they can afford to feed themselves completely and are not affected by malnutrition.

Overweight and obesity prevalence in Latin America among women in particular are increasing throughout Latin America (Filozof et al., 2001). In Mexico, women from high SES backgrounds consume greater quantities of total energy, cholesterol, saturated, and total fat than other women (Barquera et al., 2003). Previous studies have shown a positive correlation between obesity and education in Guatemala, controlling for other SES variables (Martorell et al., 1998). This study confirms these trends in Santiago Atitlán, finding significant positive associations among women between BMI and measures of SES. A large majority of respondents in this study were women, because women were more likely to be at home during interview times.

A second objective of the study was to determine which behavioral practices were associated with BMI. Marriage, market visits per week, and drinking bottled water were

all positively correlated with BMI. Marriage, the variable with the strongest association, was significant not only in the simple linear regression but also in both multiple regression models. The behavioral practices that were significant were interestingly also significantly associated with income. This indicates that these practices may be intervening mechanisms that help to explain the relationship between SES and BMI.

Marriage was strongly positively associated with both income and BMI. Women who are married are more likely to receive money from their husbands, whereas single mothers may not receive monetary support from anyone else. Also, a married woman may not have to work if her husband supports her, and therefore may have a more sedentary lifestyle than a woman who must do daily work and labor. This study supports the positive correlation found between marriage and obesity in Tehran and between marriage and BMI in Northern Italy (Azadbakht & Esmailzadeh, 2007; Tavani et al. 1994). However, this study does not find the significant association between BMI and number of children that was reported in Northern Italy (Tavani et al. 1994).

Respondents who earned more tended to visit the market more frequently and had a higher BMI. This indicates that the amount of market visits may lead to the consumption of more food and therefore higher BMI. Although wealthier families are more likely to be able to afford refrigeration and therefore store food for longer without spoilage, this luxury does not seem to prevent wealthier families from visiting the market more often.

Drinking purified bottled water was positively associated with income and BMI. Atitecos who get their drinking water from the tap or directly from Lake Atitlan may be more likely to get diarrheal diseases and therefore absorb less food and nutrients.

However, the drinking of bottled water may be another indicator of SES (especially income and education) and may not be a direct mediating variable.

The strengths of this study include the stratified sampling methods. A representative sample from each *canton* of Santiago Atitlán was interviewed, which should account for any regional differences in the town. In addition, the collection of both quantitative data (such as heights and weights for BMI) and qualitative data through semi-structured interviews allows for both statistical testing and thorough written explanation. On average, each interview lasted between 30 minutes and an hour, allowing for detailed explanation of socio-economic issues and behavioral practices. Finally, this study focused only on the town of Santiago Atitlán, rather than a large region of Guatemala or even the entire nation. Because the study was restricted to a specific town in Guatemala, the behavioral practices such as market visits per week and water source could be controlled for since these variables are unique to Santiago Atitlán. The town only has one central market and the tap water of the town comes directly from Lake Atitlán, which are scenarios not found in every other town in the Guatemalan highlands.

Despite these strengths, the biggest limitation of the study is the relatively small sample size. Because each interview lasted from 30 minutes to an hour on average, only 56 semi-structured interviews were completed with all BMI, SES, and behavioral practice data. In order to get quality responses, the quantity of the sample was not very large. In addition, the sample mainly consisted of women, because men were more likely to be out of the house or at work during the day, when most interviews occurred. Finally, the setup of the study is such that causality cannot be proven; only associations can be determined.

As the association between SES and BMI has been established not only in Guatemala as a whole (Martorell et al., 1998) but also in the particular town of Santiago Atitlán, future research could explore in more depth the mechanisms that link SES and BMI. While market visits, marriage, and drinking water are all viable mechanisms, more could be determined that might be useful in public health interventions regarding obesity in Santiago Atitlán in particular, or in the Guatemalan highlands in general.

Obesity is particularly a challenging problem in Santiago Atitlán because of the simultaneous existence of malnutrition. The development of the coexistence of malnutrition and obesity was first published in South Africa (Steyn et al., 1998), and is now studied in many developing countries (Caballero, 2005). In Latin America, studies have demonstrated that between 2.2% and 13.4% of households have both an overweight mother and a stunted child, depending on the country (Garrett and Ruel, 2005). This phenomenon similarly affects Santiago Atitlán. Many believe that addressing malnutrition should remain a priority in Latin America, despite the emerging increases of obesity and overweight (Martorell et al., 1998). Because of the lack of consensus on how to address obesity in developed countries like the United States (Blackburn and Kanders, 1994), obesity interventions are especially challenging in the developing world. Nonetheless, some effective programs and studies integrating obesity and malnutrition have been developed in Chile (Uauy & Kain, 2002).

This study suggests that public health interventions for obesity should target married Atitecos who visit the market frequently. Additional mediating variables that link SES to BMI should be further explored. Future research and public health

interventions should work to better understand how malnutrition among children and obesity or overweight among adults can occur in Santiago Atitlán and Latin America.

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