



Body mass index, socio-economic status and socio-behavioral practices among Tz'utujil Maya women

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ABSTRACT

This study investigates the associations between body mass index (BMI), socio-economic status (SES) and related socio-behavioral practices including marriage and market visits in a population of adult Tz'utujil Maya women in Santiago Atitlán, Guatemala, aged 18–82. Mixed qualitative and quantitative methods include cross-sectional anthropometric measurements and semi-structured interviews gathered in 2007, as well as participant observation and purposive interviews conducted in 2007–2008. The regional quota sample of 53 semi-structured interviews was designed to be representative of the *cantones* (municipal divisions) of Santiago Atitlán. BMI was positively associated with years of schooling, income and literacy, all measures of SES. A statistical analysis of our data indicates that increased income, increased market visits and being married are significantly positively associated with BMI. Qualitative analysis based on the grounded theory method reveals relevant themes including a preoccupation with hunger and undernutrition rather than obesity, a preference for food quantity over dietary diversity, the economic and social influence of a husband, the effects of market distance and the increasing consumption of food from *tiendas*. These themes help to explain how SES, socio-behavioral practices and BMI are positively associated and can inform future public health interventions related to obesity and undernutrition.

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1. Introduction

Obesity and overweight are rising problems in Latin America, especially as subsistence economies transition to market-based economies (Popkin, 2001). Although the prevalence of obesity and overweight has historically been higher in developed countries than in developing ones, several epidemiological studies have demonstrated that obesity and overweight prevalence in many developing countries has reached or exceeded levels in developed nations, particularly in Latin America (Filozof et al., 2001;

Popkin, 2001; Peña and Bacallao, 1997). In low income regions of Mexico, for instance, more than 50% of men and 60% of women are overweight or obese (Fernald et al., 2004). In Guatemala, the prevalence of obesity and overweight increased from 34.1% in 1995 to 44.9% in 2002 (Garnier et al., 2005). Obesity and overweight are major risk factors for several chronic conditions, including cardiovascular diseases, type II diabetes mellitus, sleep apnea and selected cancers (World Health Organization, 2000; Eckel and Krauss, 1998).

In addition to obesity and overnutrition, child undernutrition still plagues many Latin American countries. The prevalence of chronic child undernutrition in Guatemala was 44% in 2000 (Marini and Gragnolati, 2003). The simultaneous combination of obesity and chronic child undernutrition, sometimes in the same household,

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presents unique challenges to the communities affected by them (Jehn and Brewis, *in press*).

The transition from a subsistence-based diet, rich in proteins and fibers and low in fats and processed foods, to a more industrialized diet which contains calorie-dense yet nutrient-poor processed foods may help to explain rising obesity trends in Latin America (Garrett and Ruel, 2005; Leatherman and Goodman, 2005; Baer, 1998). In addition, lifestyle changes in transitional societies usually involve a decrease in physical activity levels (Garrett and Ruel, 2005). Sedentarism combined with hypercaloric diets eventually results in an increase in body mass and fat storage, beyond the necessary amount for a healthy state. Indigenous communities in Latin America, including Andean, Mesoamerican and Amazonian populations, are particularly susceptible to the effects of these nutritional transitions (Valeggia and Lanza, 2005).

Body mass index (BMI), a statistical measure of a person's weight scaled according to height, is used to classify people into the categories of obese ($BMI \geq 30$), overweight ($25 \leq BMI < 30$), normal range ($18.5 \leq BMI < 25$) and underweight ($BMI < 18.5$) (World Health Organization, 2000). The relationship between body mass index and socio-economic status (SES) has been studied in both developed and developing nations, including in Latin America. In developed countries, a landmark review by Sobal and Stunkard (1989) established a negative association between BMI and SES, a finding which has been reaffirmed (McLaren, 2007). For example, BMI and SES are inversely associated in Mexico, a relatively wealthy Latin American nation, according to a national survey in 1999 (Barquera et al., 2003). In developing countries, however, a positive relationship between BMI and SES is observed (Sobal and Stunkard, 1989). A positive association between BMI and SES has been established in all Latin American countries other than in Mexico. In Guatemala, for instance, better education is positively associated with obesity (Martorell et al., 1998). In the Bolivian Amazon, wealth is positively associated with nutritional status (Godoy et al., 2005).

However, as developing countries experience economic transitions and per capita gross national product (GNP) increases, this positive association between BMI and SES becomes less clear. Monteiro et al.'s (2004) review of obesity and SES in developing countries found differences in association due to gender and a country's per capita GNP. Although a positive relationship between obesity and SES remained among men, many studies pointed to an inverse relationship among women in the same populations. Of fourteen studies on women reviewed, ten reported a statistically significant negative association, two indicated no association and two demonstrated a statistically significant positive association (Monteiro et al., 2004). In addition, this study identified the general trend that the burden of obesity shifts towards lower SES populations within a country as per capita GNP increases. It is also worth noting that although associations among BMI and SES have been established at the national level, smaller populations within these nations can differ from national trends. In Mexico, for instance, low-income subpopulations demonstrate a positive association between BMI and SES, which differs from national Mexican trends (Fernald, 2007).

In addition to SES, socio-behavioral practices including marital status and market visits have been studied in relation to BMI or obesity status. In developed countries, several studies point to a positive association among women between marriage and BMI (Averett et al., 2008; Jeffery and Rick, 2002; Lipowicz et al., 2002; Tavani et al., 1994), weight (Hanson et al., 2007), or weight gain (Sobal et al., 2003). For instance, in the US, becoming married is significantly associated with a 0.70 unit BMI increase in women (Jeffery and Rick, 2002). In Northern Italy, BMI has been found to be positively associated with marriage and number of children (Tavani et al., 1994). However, one US study reported a significant positive association between marriage and obesity in men but not women (Sobal et al., 1992).

In developing countries, some studies have also pointed to positive associations between marriage and obesity in Brazil (Velasquez-Melendez et al., 2004; Kac and Struchiner, 2005), Jamaica (Jackson et al., 2003), South Africa (Malhotra et al., 2008), Morocco (Batnitzky, 2008), Bahrain (Al-Mannai et al., 1996), Iran (Janghorbani et al., 2008; Azadbakht and Esmailzadeh, 2007), Syria (Fouad et al., 2006) and Uzbekistan (Mishra et al., 2006). In Brazil, married women have a higher risk of developing maternal obesity as a consequence of postpartum weight retention (Kac and Struchiner, 2005). In South Africa, being married is significantly positively associated with BMI and waist circumference (Malhotra et al., 2008). In Tanzania, divorced females had a lower prevalence of obesity than married women, although widowed women had a higher risk for obesity than married and single women (Mosha, 2003). However, one Brazilian study found no significant association between obesity and marriage after adjusting for confounding variables (Gigante et al., 1997).

The influence of markets on nutritional status has also been studied in developed and developing countries. In developed countries, there is increasing evidence that the availability and location of markets influence people's diets, BMI and health (Inagami et al., 2006; Brown et al., 2008). Frank et al. (2009) demonstrate that in females, BMI decreased with visits to grocery stores and increased with visits to fast food outlets. Some studies also demonstrate that the availability of supermarkets or grocery stores in a neighborhood is associated with a lower BMI (Morland and Evenson, 2009; Powell et al., 2007; Stafford et al., 2007; Morland et al., 2006). Distance seems to play a role in this association. For instance, in Los Angeles, individuals who travel the farthest from home to reach a grocery store are more likely to be obese (Inagami et al., 2006). Furthermore, cross-sectional studies have demonstrated a positive association between access to food stores and improved dietary choices (Black and Macinko, 2008; Laraia et al., 2004; Morland et al., 2002).

In developing countries, some studies also point to the influence of village markets on nutritional status and health. In Indonesia, the distance to the nearest market was found to be one of the most useful predictors for the ranking of communities by nutritional status (Kusumayati and Gross, 1998). In a multivariate model including indicators of food availability and food production, a greater travel distance to the market predicted an increased prevalence of under-nutrition (Kusumayati and Gross, 1998). In rural areas of

Zimbabwe, excessive time and energy resources, as measured by time cost of distance and energy cost of distance, respectively, can be spent on trips to local and regional markets (Mehretu and Mutambirwa, 1992).

In addition, visits to the market might increase exposure to and consumption of processed foods and street foods, which may influence BMI. One study using nationally representative data from Guatemala found that supermarket purchases increased the percentage share of highly and partially processed foods and were significantly positively associated with individual body mass index (Asfaw, 2008). Furthermore, availability of street foods at village markets may also affect women's diets and nutritional status. Street foods, often inexpensive, convenient and fried, were found to comprise 63% of the total weight of food consumed among Nigerian market women (Afolabi et al., 2004; Oguntona and Tella, 1999).

The Tz'utujil Maya community of Santiago Atitlán in the Western Highlands of Guatemala has maintained a distinct culture separate from *Ladino* (*Mestizo*, or of mixed European and indigenous descent) populations of Guatemala. *Ladino* populations in Guatemala comprise around 55–60% of the overall Guatemalan population, whereas indigenous populations make up approximately 40–45% (Central Intelligence Agency, 2008; Encyclopedia Britannica, 2008; República de Guatemala, 1996). Indices of poverty and child and maternal mortality in Santiago Atitlán reflect the area's status as a developing region. For instance, a majority of the population of Santiago Atitlán earns less than the legal Guatemalan minimum wage of 1274 Quetzales (US\$ 165.81) per month (Censo de Santiago Atitlán, 2006).

The objective of this study was to investigate the association between BMI and SES among non-pregnant Tz'utujil Maya adult women of Santiago Atitlán aged 18 or over. This study focused on adult women because of their central role in household food resource allocation (Barquera et al., 2003; Goody, 2002), the impact of nutrition and energetics on their fertility status (Ellison, 2001) and the well-documented increases in maternal obesity in Latin America over the last few decades (Filozof et al., 2001; Martorell et al., 1998). Guatemalan national trends demonstrate positive associations between BMI and SES (Martorell et al., 1998). Predicting that this national trend would extend to indigenous populations in the highlands, we hypothesized that BMI would be positively associated with SES among the Tz'utujil Maya in Santiago Atitlán.

After reviewing the literature on obesity, marriage and markets, we were interested in exploring socio-behavioral practices that might mediate the association between BMI and SES. First, we hypothesized that marriage would be associated with an increase in BMI, based on findings from several studies in both developed and developing countries. Second, we hypothesized that women who shopped at the market more often would have higher BMIs, as higher visit frequency may reflect shorter travel distance, greater economic resources and larger consumption capacity of the family. While studies in developed countries find a negative association among BMI and market visit frequency and availability, some studies from developing countries indicate that proximity to village

markets decreases the risk for undernutrition and increases exposure to processed and street foods.

Although a mixed-methods approach is ideally suited for examining the biocultural underpinnings of the relationship between obesity and SES (Griffiths and Bentley, 2005), previous investigations in Latin America rely primarily on quantitative methods alone. This current study of the Tz'utujil Maya uniquely uses mixed qualitative and quantitative analysis to establish an association between SES and BMI and to explore independent socio-behavioral variables associated with BMI.

2. Materials and methods

2.1. Study population

The Tz'utujil Maya have inhabited the Lake Atitlán region since the 13th century. Spanish conquistador Pedro de Alvarado conquered the Tz'utujil Maya in 1524 and Franciscan missionaries intending to evangelize the Tz'utujil Maya organized them into the current town structure around 1545 (Early, 1970). Santiago Atitlán gained international attention during the Guatemalan Civil War in December 1990 when a massacre of 14 unarmed Tz'utujil Maya by the Guatemalan Army resulted in a government resolution calling for the permanent departure of the military from the town (Loucky and Carlsen, 1991; Carlsen, 1996).

Located between the southwest shore of Lake Atitlán and the base of the volcano Tolimán, Santiago Atitlán lies at an altitude of 5000 feet and has a population of 32,254 (Schram and Etzel, 2005; XI Censo Nacional de Población, 2002). Santiago Atitlán is divided into nine municipal divisions, or *cantones*. The primary language for 94% of the residents is Tz'utujil, one of the 21 Mayan languages spoken in Guatemala; however, 54% of the villagers speak Spanish fluently (Schram and Etzel, 2005).

Farming of maize, beans, coffee, tomatoes, carrots and avocados are staples of the Tz'utujil economy and many of these products are exported. Traditionally, corn, black beans and sugar have provided the major energy needs in the Tz'utujil diet (Goody, 2002). Corn is often consumed in the form of tortillas or *tamalitos* (steamed corn dough) and may be eaten with black beans, *chirmol* (homemade salsa), cheese, eggs or meat. An indoor market located near the village central plaza opens daily and provides much of the food for Tz'utujil residents.

2.2. Data collection methods

We used a parallel mixed methods design for this study (Creswell et al., 2003). All cross-sectional quantitative data were collected from June to July 2007. Qualitative data collection including participant observation and semi-structured interviews began in March to July 2007 and continued in July to August 2008 with follow-up interviews to verify and augment initial findings. Since 2005, our research team has worked with the community, municipality and health care providers in Santiago Atitlán to address health through relevant community-based participatory research.

2.3. Qualitative research methods: interviewing and participant observation

Initial exploratory data were obtained from participant observation and 50 unstructured interviews from March 2007 to July 2007. All ethnographic, interview and quantitative data were gathered by the first author (J.N.), although each of the co-authors was present in the field both in 2007 and 2008 during the data collection period. Participant observation included the first author participating in the daily life of a host family and observing all aspects of food shopping, preparation, cooking, presentation and cleanup. Although the first author resided with the same upper-middle class host family during the duration of both field research periods, participant observation of meals with 11 other families from various *cantones* and socio-economic strata also occurred.

Qualitative data from unstructured and semi-structured interviews were recorded during the interviews on paper-based field notes. For each of the semi-structured interviews, one of two women field assistants was present to facilitate translation between Spanish and Tz'utujil if necessary, although approximately half of the respondents spoke Spanish. After each semi-structured interview, the first author and the field assistant reviewed the interview notes, summarized and clarified any specific points. Field notes and narrative comments were then recorded into a word processing document.

A grounded theory approach was utilized to identify salient themes and possible mediators regarding obesity and socio-economic status. Grounded theory, an analytic strategy in qualitative research, is used to inductively generate theories and explain processes that are derived from a systematic analysis of data (Lingard et al., 2008; Charmaz, 2000; Strauss and Corbin, 1998). The first author coded the initial interviews (35 total) conducted in March 2007 to identify general concepts related to food consumption and nutrition, which informed the questions for a semi-structured questionnaire that contained fixed-choice and open-ended responses.

In total, 53 semi-structured interviews were conducted from June to July 2007. Qualitative data from these semi-structured interviews were coded and combined with analytic memos to discern major themes. After several themes emerged from the interviews conducted in 2007, the first author conducted 15 follow-up interviews in July to August 2008 using theoretical sampling, the process of going back to the field, sampling specific issues that illuminate the emerging theory and filling gaps and holes in the data (Charmaz, 2000).

2.4. Quantitative research methods: questionnaire and statistical analysis

A semi-structured questionnaire included both closed and open-ended questions that primarily focused on nutrition, SES and socio-behavioral practices. Semi-structured interview respondents were selected using regional quota sampling methods based on *canton* location of residence. A sample from each of the *cantones* was

interviewed in proportion to the population of Santiago Atitlán as a whole, based on a 2004 Census, to capture regional and socio-economic variation in responses (Schram and Etzel, 2005). Because of the lack of a household level map and an inability to enumerate the population, samples were not able to be randomly collected, although an effort was made to select participants across the entire region of each *canton*.

The first author and a field assistant chose a position near the geographic center of each *canton* to begin interviewing. Approximately every tenth house was visited from this position until the regional quota was reached. The female head of household was interviewed if present; however, another adult woman was selected if the head of household was unavailable. Interviews were conducted between 09:00 and 18:00 h on all days of the week, excluding holidays, and typically lasted between 30 and 60 min. At the end of each interview, BMI was calculated from direct measurement of height and weight. This regional quota sampling process led to visits to 54 houses in Santiago Atitlán. Of these, one declined to interview and in two houses there was no response upon a subsequent visit. In two households two adult women were interviewed. Fifty-three semi-structured interviews were conducted, but four of these women declined to participate in height and weight measurements. Therefore, response rate for the semi-structured interviews was 94.6% and response rate for the BMI calculations was 87.5%.

2.4.1. Body mass index

The heights and weights of respondents were measured using a wooden Shorr Height measuring board (Olney, MD) and a Tanita electronic scale (Model BC-548, Arlington Heights, IL), respectively. Women were measured wearing light clothes and no shoes or hats. BMI was calculated using weight in kilograms divided by the square of height in meters (kg/m^2).

2.4.2. Measures of socio-economic status

Schooling: Schooling was measured through self-reported years of schooling.

Literacy: Literacy, another measure of educational attainment, was obtained by self-reported literacy in Spanish, since Tz'utujil Maya is not a written language. This variable was dichotomized to illiterate (coded 0) and literate (coded 1).

Income: Income was calculated using self-reported Quetzales (the Guatemalan currency) earned per week by the immediate family.¹ If respondents only knew their daily or monthly family income, a calculation was made to convert the number to a weekly income.

2.4.3. Socio-behavioral practices

Marital status: Respondents were asked to identify with one of the following categories: married, committed, single, divorced or widowed. Marital status was then

¹ The 2007 exchange rate used to convert Guatemalan Quetzales to US\$ in this study was 7.6833 (Central Intelligence Agency, 2009).

dichotomized to formally married or committed (coded 1) and single, divorced or widowed (coded 0).

Market visits: Respondents were asked how many times in the last week they visited the market. If they were unsure of the number, respondents were asked to estimate.

Age: Respondents were asked how old they were in years. Whenever available, respondents were asked to show their vaccination cards (provided by the *Centro de Salud*) which often provided a date of birth. If unsure of their age and if vaccination cards were unavailable, respondents were asked to estimate their age to the nearest year. Dates of birth were converted and age was entered as a whole number year.

Quantitative data were recorded on field notes and then entered into a spreadsheet. SPSS 12.0 for Windows (SPSS Inc., Chicago, IL) was used to conduct statistical analyses of coded and quantitative data.

Associations were calculated between BMI, socio-economic and socio-behavioral variables. 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) literacy: illiterate or literate and (2) marital status: married or not married. For associations among BMI and SES or socio-behavioral 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) literacy, (4) marital status and (5) market visits. Single associations were measured followed by multivariate modeling. A backwards stepwise regression was utilized to discern which variables were most significant in a multiple linear regression model.

2.5. Ethical considerations

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

3. Results

3.1. Quantitative results

The average BMI among adult women in Santiago Atitlán was 26.01 (Table 1). Twenty-four and a half percent of the women were classified as obese, 22.4% as overweight, 51.0% as normal weight and 2.0% as underweight. The average height of respondents was 1.44 meters, the average age of respondents was 33.43 years and the average number of children each respondent had was 3.47. The SES data reflect high poverty levels in Santiago Atitlán. Over two-thirds of respondents had no formal schooling, resulting in an average of 1.59 years of schooling and a range of 0–12 years among Atiteco respondents. Over two thirds of respondents earned 0–100 Quetzales (US\$ 0–13.02) per week and the average income was 99.58 Quetzales (US\$ 12.96) per week. Over 95% of the respondents earned less than the legal Guatemalan

Table 1

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

	<i>n</i>	Mean	SD	Range
<i>Weight status</i>				
Body mass index (BMI)	49	26.01	4.75	17.83–34.25
<i>Weight classification (%)</i>				
Underweight (BMI < 18.5)	1	2.0%		
Normal range (18.5 ≤ BMI < 25)	25	51.0%		
Overweight (25 ≤ BMI < 30)	11	22.4%		
Obese (BMI ≥ 30)	12	24.5%		
Height (meters)	49	1.44	0.06	1.31–1.63
<i>Demographic characteristics</i>				
Age (years)	49	33.43	13.21	18–82
Number of Children	49	3.47	2.71	0–10
<i>Socio-economic status</i>				
Income (Quetzales per week)	45	99.58	108.20	0–600.00
Income (US\$ per week)	45	12.96	14.08	0–78.09
Schooling (years)	49	1.59	3.05	0–12
<i>Literacy (%)</i>				
Literate	18	36.7%		
Illiterate	31	63.3%		
<i>Socio-behavioral practices</i>				
<i>Marital status (%)</i>				
Married	26	53.1%		
Single	16	32.7%		
Widowed	4	8.2%		
Committed	1	2.0%		
Market visits per week	49	3.51	2.50	1–7

minimum wage of 318 Quetzales (US\$ 41.39) per week (Censo de Santiago Atitlán, 2006). Literacy was reported by 36.7% of respondents while illiteracy was reported by 63.3%. In terms of marital status, 53.1% of respondents were married, 32.7% were single, 8.2% were widowed and 2.0% were committed. On average, respondents visited the market 3.51 times per week.

All three measures of SES were positively associated with BMI (Tables 2 and 3). A bivariate linear regression model of BMI and income demonstrated that for a ten Quetzal increase in income per week, BMI also increased by 0.15, yielding a significant model ($p = 0.02$) (Table 3, Model 1). The bivariate linear regression with BMI and schooling yielded a positive association ($p = 0.07$), although not significant (Table 3, Model 2). For every

Table 2

Results from *t*-tests for equality of means for body mass index (BMI) and socio-economic and socio-behavioral practices.

	<i>n</i>	Mean	SD	<i>t</i> -statistic	Significance (2-tailed)
<i>Socio-economic status (SES)</i>					
<i>Literacy</i>					
Illiterate	31	25.32	4.15	−1.35	0.185
Literate	18	27.20	5.57		
<i>Socio-behavioral practices</i>					
<i>Marital Status</i>					
Not married	22	24.18	3.86	−2.58	0.013*
Married	27	27.51	4.95		

* $p < 0.05$.

Table 3

Results from simple and multiple linear regressions with body mass index (BMI) as the dependent variable, and various measures of socio-economic status and socio-behavioral practices as independent variables.

	Model 1 n = 45	Model 2 n = 49	Model 3 n = 49	Model 4 n = 49	Model 5 n = 49	Model 6 n = 49	Model 7 n = 45	Model 8 n = 45
<i>Socio-economic status</i>								
Income	0.02 (0.00) ⁺							0.01 (0.01)
Schooling		0.40 (0.22) ⁺					0.48 (0.23) [†]	
Literacy			1.68 (1.54)					
<i>Socio-behavioral practices</i>								
Married				3.33 (1.29) ⁺			3.56 (1.28) ^{**}	3.17 (1.39) [†]
Market per week					0.58 (0.26) ⁺			0.18 (0.27)
<i>Demographic</i>								
Age						-0.06 (0.05)		
Intercept	24.55	25.37	25.57	24.18	23.97	27.96	23.41	22.74
R ²	0.12	0.07	0.03	0.12	0.09	0.03	0.26	0.24
Overall Significance	0.02 ⁺	0.07 ⁺	0.28	0.01 ⁺	0.03 ⁺	0.27	0.00 ^{**}	0.01 ^{**}

B (SE) presented for each model.

⁺ $p < 0.10$.

[†] $p < 0.05$.

^{**} $p < 0.01$.

additional year of schooling, BMI increased by 0.40. Although the mean BMI of 27.20 for literate respondents was higher than the mean BMI of 25.32 for illiterate respondents using a *t*-test for equality of means, the difference was not significant ($p = 0.19$) (Table 2). Finally, age was not found to be significantly associated with BMI, possibly due to random measurement error in the age variable. Therefore, age was not controlled for in multiple linear regression models.

Two socio-behavioral practices also generated associations with BMI using bivariate linear regression and *t*-tests for comparisons of mean (Tables 2 and 3). The mean BMI for married respondents was 27.51, which was significantly higher than the mean BMI of 24.18 for non-married respondents ($p = 0.01$). A bivariate linear regression model of BMI and market visits per week demonstrated that for every additional market visit, BMI increased by 0.58, yielding a significant model ($p = 0.03$).

Multiple linear regression was used to construct models using the variables that were significant either with simple linear regression or an independent samples *t*-test. A backwards stepwise linear regression was performed to search for the best combinations of variables that predict BMI (Table 3, Model 7). Marital status and years of schooling remained significant after the backwards stepwise regression. Holding schooling constant, marriage is associated with an increase in BMI of 3.56. Holding marital status constant, a one-year increase in schooling is associated with a 0.48 increase in BMI. Overall, the model with these two independent variables was significant ($p = 0.00$) and had an R^2 of 0.26. A final model using all non-multicollinear variables, including income, marital status and market visits was significant ($p = 0.01$) and had an R^2 of 0.24 (Table 3, Model 8). Schooling and literacy were not included in the model because they were each highly correlated with income ($p < 0.01$). Holding income and market visits constant, marriage is associated with an increase in BMI of 3.17 ($p = 0.03$).

3.2. Qualitative results

Analysis of unstructured and semi-structured interviews using grounded theory revealed several salient themes, including a preoccupation with undernutrition and hunger rather than obesity, a preference for food quantity over dietary diversity, the economic and social influence of a husband, the effects of market distance and the increasing consumption of food from *tiendas* (Table 4). These themes may help to explain the positive relationship found between BMI and SES.

3.2.1. Preoccupation with undernutrition rather than obesity

Although the high prevalence of obesity and overweight among Tz'utujil women may indicate that obesity is a significant health issue in the town, a vast majority of respondents demonstrated concern about undernutrition exclusively, especially for their families and children. Of the semi-structured interviews ($n = 49$), 92% of women mentioned concerns of suffering from hunger or of not being able to afford sufficient foods they believed to be healthy. For instance, one Tz'utujil woman, classified as overweight, said,

My children do not get enough to eat. My eldest daughter is nine-years old but she is smaller than many five-year olds. I feed her as much as I can, but some days she becomes so hungry she eats dirt off of the ground.

Another woman, with a normal range BMI, said,

I do not have enough money to eat three meals a day. I usually skip breakfast, but sometimes I will skip lunch. I can't afford many foods.

Even among women classified as obese ($n = 12$), a majority of respondents were exclusively concerned with not getting enough food to eat. Nine obese respondents mentioned concerns about not getting sufficient food. One of these women said,

Table 4

Number of women who identified socio-economic, marital and market related themes.

	<i>n</i>	Identified	Disagreed	Not addressed
<i>Socio-economic status</i>				
Preoccupation with undernutrition rather than obesity				
Overall	49	45 (92%)	2 (4%)	2 (4%)
Among obese women	12	9 (75%)	1 (8%)	2 (17%)
Food quantity important in food purchasing decisions	49	31 (63%)	1 (2%)	17 (35%)
<i>Difficult to afford meats</i>				
Overall	49	27 (55%)	5 (10%)	17 (35%)
Among women with income ≥ 100 Q per week	25	10 (40%)	4 (16%)	11 (44%)
Among obese women	12	6 (50%)	2 (17%)	4 (33%)
<i>Marital status</i>				
Among married women with children				
Reported receiving money from husband	26	18 (69%)	2 (8%)	6 (23%)
Stopped formal work after marriage	26	6 (23%)	1 (4%)	19 (73%)
Among single women with children				
Reported receiving money from partner or father of children	11	2 (18%)	6 (55%)	3 (27%)
Reported receiving money from another family member	11	2 (18%)	5 (45%)	4 (36%)
<i>Market visits</i>				
Travel distance affects visits	49	28 (57%)	2 (4%)	19 (39%)
Shop at <i>tiendas</i>	49	41 (84%)	0 (0%)	8 (16%)

Food is very expensive. There is no money. The amount I make every day is not sufficient. I see that we don't get enough food, but there is nothing I can do. I can't even afford soup.

Of the remaining women classified as obese, two did not mention any concerns about their diets and only one woman mentioned concerns of eating too much.

3.2.2. Food quantity versus dietary diversity

From semi-structured interviews, 63% of Atiteco women reported that food quantity was an important factor in food purchasing decisions. Women often reported being more concerned with getting a sufficient amount of food for everyone in their family than with being able to buy diverse foods, including meats, dairy, fruits and vegetables. During hard economic times, some women reported exclusively purchasing corn tortillas because of their affordability. One woman, classified as overweight, said,

On days that I don't have enough money for many foods, I will just buy tortillas. Our family will then eat tortillas with salt. We don't have other options. It's difficult.

Another woman, with a normal range BMI, said,

I always buy tortillas because they are so cheap. I can get five or six for a Quetzal. That is enough for a meal. It's the same food every day, but I feel full after eating tortillas. With just a few Quetzales to spend, I can't get enough of any other food that will satisfy me.

Dietary diversity was particularly restricted in relation to meats, such as chicken, beef or fish. In Santiago Atitlán, meats are viewed as relatively expensive foods; they can cost over 20 times as much as corn or some vegetables by weight. Among semi-structured interview respondents, 55% referred to not being able to purchase sufficient meat

because of its high price. One woman, classified as overweight, said,

I like to cook my children fish, but I can rarely afford more than tortillas and vegetables. Fish is expensive. Meat is expensive. I cannot buy as much food for us as I would like, but I try. We just can't afford meats.

Among women who reported an income of 100 or more Quetzales per week ($n = 25$; approximately the top half of the sample by SES), 40% referred to not being able to purchase sufficient meat. Among women who were obese ($n = 12$), six reported not being able to purchase sufficient meat. Although upper-SES and obese Tz'utujil women reported being able to afford meats at a slightly higher rate than the overall sample, approximately half of these women nonetheless felt unable to purchase meats.

Some women (6 respondents) reported that they were not accustomed to eating meats after being unable to afford them for long periods of time, which might partially explain why some women no longer purchased meats even if they sometimes had sufficient money. One overweight woman said,

We aren't accustomed to eating meat. It is too expensive, so I never bought it. It has been many years since I last ate meat. Now my children won't eat meat because they aren't used to it.

3.2.3. Economic and social role of a husband

Tz'utujil women highlighted the importance of the economic and social role of a husband during interviews. Women who were married often reported receiving money from their husbands, whereas single mothers were less likely to receive monetary support from their children's fathers. All married women had children ($n = 26$) and 16 of them reported receiving money from their husbands. There appeared to be a relationship among the presence or

absence of a husband, his financial viability and the ability to purchase adequate nutrition.

Married women complained of their husbands drinking habits (9 respondents) and low incomes (7 respondents), but nonetheless reported receiving money from them. One woman, classified as overweight, said,

My husband eats with the family for dinner but will go out and drink a lot. Then he will not have as much money to give us. When this happens, we sometimes will only eat tortillas and salt. We're still together.

Some married women, particularly those whose husbands had respected and high-paying professions reported giving up an occupation after marriage to raise children ($n = 6$). For example, Chonita² worked in her parents' *tienda* until she got married. Chonita's husband is a teacher, a respected and well-paying profession in Santiago Atitlán, so Chonita stopped working after giving birth to the first of two children. Chonita commented,

I gained weight during each of my pregnancies. Now I have lots of fat. I never lost the weight.

Chonita's BMI of 33.07 classifies her as obese, and Chonita was one of only two respondents in the sample to mention concerns of obesity and a desire to lose weight.

In some cases, marriage and the cessation of work might lead to a more sedentary lifestyle. For instance, one married woman said,

I used to go to people's houses and do chores for a Quetzal. I would hand wash laundry, clean dishes, scrub floors and do other chores. Before it was very hard work. I suffered when I was younger. But I don't do that anymore. I can hire someone to do this in our house now.

In contrast to married women, single mothers often lost contact with the fathers of their children, and therefore did not receive financial support from them. Among single mothers ($n = 11$), only two reported receiving financial support from the fathers of their children. One single mother said,

Their father left for the city and said he would come back. He never did and we never got married. Fathers are irresponsible.

In addition, among single mothers ($n = 11$), two reported receiving some sort of financial support from their parents or siblings. One single mother said,

I live with my parents and brother. My father and brother both work and help with my children, but they also drink too much.

Another single mother said,

I live with my sister's family and all of our children – all seven of them – are more like brothers and sisters than

cousins. But I still have to pay for my childrens' food and school on my own.

3.2.4. Travel distance to market and importance of *tiendas*

The travel distance to the market emerged as an important theme in 57% of the semi-structured interviews. Because Santiago Atitlán has only one market located in the center of town, residents nearer to the center have better access to it. Poorer families often live in the rural outskirts of Santiago Atitlán and must travel longer distances to the market. For instance, one woman of normal range BMI from a rural *canton* said,

I can only afford to buy food one time per week, but the market is too far. So I ask a neighbor to shop for me.

Because poorer Atitecos often live farther away from the center of town, they frequent the market less often and have less access to fresh foods.

Although market visits are an important source of local foods, including tortillas, corn, beans, meats, fruits and vegetables, 84% of respondents described an increasing reliance on *tiendas* (small variety stores) for everyday food supply. Rather than selling local foods, *tiendas* often supply mass-produced processed foods including soft drinks, chips, candies and other snacks. While there is only one central market in Santiago with local foods and fresh produce, there are 581 *tiendas* throughout the town, which are more accessible to Atitecos who live on the outskirts of town (*Censo de Santiago Atitlán, 2006*). One rural woman, classified as overweight, said,

The market is too far away so I often buy food and snacks from *tiendas*. *Tienda* food is inexpensive and tasty, so my children are happy.

3.2.5. Summary of qualitative results

In summary, qualitative analysis based on grounded theory clarifies the relationship between economics and food purchasing, the economic influence of a husband after marriage and the effects of market distance. Tz'utujil women of all BMI classifications reported overwhelming concern for hunger and undernutrition in their families. Obesity and overweight among high SES women might be partially explained because these women often worry about hunger and aim to get large quantities of food, particularly through tortillas, when they visit the market.

A majority of married women reported receiving economic support from husbands, whereas single mothers less often reported receiving money from their children's fathers. The economic role of a husband might help to explain the positive association between marriage and SES.

Travel distance to the market emerged as an important childrens' theme in interviews. Low SES women, often living in the rural outskirts of Santiago Atitlán, might visit the market less and therefore consume less because of both money and travel distance. Many Tz'utujil women mentioned *tiendas* as increasingly important sources of food distribution.

² A pseudonym.

4. Discussion

The elevated prevalence of obesity and overweight is a salient problem among Tz'utujil Maya women, despite high levels of poverty in Santiago Atitlán and concerns with child undernutrition. Nearly half of the Tz'utujil Maya women in this sample (46.9%) were classified as obese or overweight, consistent with the Guatemalan national rate of 44.9% (Garnier et al., 2005). Furthermore, Guatemala maintains the highest prevalence of households containing both an overweight mother and a stunted child in Latin America, estimated at 13.4% (Garrett and Ruel, 2005) and 23.0% (Jehn and Brewis, in press). Because of transitioning economies and changing dietary patterns and lifestyles, obesity and related chronic diseases are becoming increasingly important health concerns among the Tz'utujil Maya and in the developing world.

The positive association of BMI and SES among Tz'utujil Maya women but not in developed parts of the world can be explained by Santiago Atitlán's relative poverty and location in a developing region. The poorest families in Santiago Atitlán often face undernutrition, especially among children, and may not have the resources to become overweight or obese.

The families of higher SES in Santiago Atitlán might still be considered relatively poor compared to families in more developed regions of Latin America. The maximum weekly income reported in this sample was 600 Quetzales, which is US\$ 78.09 per week. Santiago Atitlán does not yet have the wealthiest classes of the more developed world, who generally have lower BMIs because of education, attitudes toward obesity, dietary restraint and physical activity (Monteiro et al., 2004; Sobal and Stunkard, 1989). This study confirms the overall Guatemalan and developing world trend of a significant positive association between BMI and measures of SES among Tz'utujil Maya women (Martorell et al., 1998; Sobal and Stunkard, 1989). These results become especially important as overweight and obesity prevalence increases throughout Latin America, particularly among women (Filozof et al., 2001).

A second objective of the study was to determine which socio-behavioral practices were associated with BMI. The socio-behavioral practices that were significantly associated with BMI, such as marriage and market visits, were 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. BMI and marriage associations among the Tz'utujil Maya follow trends found in developed countries (Averett et al., 2008; Jeffery and Rick, 2002; Tavani et al., 1994) as well as developing countries (Velasquez-Mendez et al., 2004; Kac and Struchiner, 2005; Jackson et al., 2003; Malhotra et al., 2008).

High SES respondents tended to visit the market more frequently and had higher BMIs. One explanation for this association might be that wealthier women live near the center of town and therefore have better access to the market. Just as markets influence people's nutritional status (Kusumayati and Gross, 1998), diets (Afolabi et al., 2004; Oguntona and Tella, 1999) and BMI (Asfaw, 2008) in

developing countries, the same holds true among Tz'utujil Maya women.

The strengths of this study include mixed qualitative and quantitative methods. The collection of both quantitative data (such as heights and weights for BMI) and qualitative data through unstructured and semi-structured interviews allows for statistical testing supported by qualitative analysis. In addition, a regional quota sample representative of each *canton* of Santiago Atitlán was interviewed, which should account for any regional and SES differences in the town.

This study's relatively small sample size limits any definitive conclusions. However, much of the qualitative ethnographic and interview data supported the quantitative findings. In addition, the use of BMI as the sole measure of adiposity among the Maya includes some documented limitations. Although useful for international comparison, BMI contains limitations in measuring body fat percentage, visceral adipose tissue and central obesity, particularly among non-European populations (Deurenberg-Yap et al., 2000; Lear et al., 2007; Rothman, 2008). Exposure to undernutrition, infection, poverty and war may lead to stunting and short stature (Bogin et al., 2007). Because of their short stature, particularly in the legs, BMI measurements might overestimate obesity among the Guatemalan Maya (Smith et al., 2003). The measurement of waist circumference may be a viable alternative in determining central obesity (McCarthy, 2006; Groenvelde et al., 2007). This preliminary study points to possible relevant associations that can direct future studies which might utilize measures other than BMI to measure adiposity.

As the association between SES and BMI has been established not only in Guatemala as a whole (Martorell et al., 1998) but also among Tz'utujil Maya women, future research could explore in more depth the mechanisms that link SES and BMI. While market visits and marriage are viable mechanisms, others could be determined that might be useful in public health interventions regarding obesity in Santiago Atitlán in particular, or in Latin America in general.

Obesity is a particularly challenging problem among the Tz'utujil Maya because of the simultaneous existence of child undernutrition. The coexistence of child undernutrition and maternal overweight has now been established throughout the developing world (Garrett and Ruel, 2005; Caballero, 2005; Fernald and Neufeld, 2007). In developing countries, overweight and obesity is associated with a short or stunted stature (Varela-Silva et al., 2007). The child phenotype of overweight and obesity with short stature is a risk factor for coronary heart disease, diabetes and other metabolic diseases later in life (Barker, 1995; Gluckman and Hanson, 2004).

The influence of infant and child undernutrition on adult obesity may be explained by Barker's (1997) developmental programming hypothesis, which proposed that a fetus experiencing undernutrition may develop a metabolism that would be geared towards insulin resistance and higher efficiency later in life, potentially leading to adult obesity (Gluckman et al., 2005; Bogin et al., 2007). Several additional factors may cumulatively contribute to these risks, including metabolic pathways for reduced fat oxidation and increased metabolism of

carbohydrate, urbanization of rural communities, nutrition transition from subsistence-based to globalized foods, changes in physical activity patterns with a decrease of energy expenditure and intergenerational consequences of malnutrition and poor health of mothers leading to impaired phenotypes in offspring (Varela-Silva et al., 2007; Frisancho, 2003).

While addressing undernutrition remains a priority among Latin American children, public health initiatives now must simultaneously combat obesity and overweight among adults (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.

This study suggests that public health interventions for obesity should target married Tz'utujil women who visit the market frequently. Additional mediating variables that link SES to BMI, such as *tienda* visits and processed food consumption should be further explored. Future research and public health interventions should work to better understand how undernutrition among children and obesity or overweight among adults can occur among the Tz'utujil Maya in Santiago Atitlán and in Latin America generally.

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