



## Nutritional status and socioeconomic change among Toba and Wichí populations of the Argentinean Chaco

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### ABSTRACT

The prevalence of overweight and obesity is growing at an accelerated pace in disadvantaged populations. Indigenous populations all over the world, whose lifestyle is changing rapidly and drastically, seem to be particularly prone to show an increased prevalence of overweight and its co-morbidities among adults. The aim of this study was to evaluate the association between socioeconomic and nutritional statuses in adults of two indigenous populations of the Argentine Gran Chaco: the Toba and Wichí of the province of Formosa. Originally hunter-gatherers, they are now more settled and engage in temporary wage labor and local political positions.

A total of 541 adults (>20 years old) participated in the study. Almost 50% of the adult Toba and 34% of the adult Wichí were overweight and 10% of adults in both populations were obese. Socioeconomic status was positively associated with body mass index in both populations. Furthermore, political connectedness with the non-indigenous sector, as in the case of community leaders, was highly correlated with obesity. Differences within and between groups can be explained by biocultural factors that include gender, diet (foraged vs store-bought), lifestyle (sedentary vs more active), and history of political power.

Our study highlights the interactions among social, cultural, and political economic variables, such as political hierarchies within the group or degree of social connectedness with community leaders. By making these variables an integral part of our analysis and interpretation, we hope to improve our understanding of the situation of indigenous populations in transition.

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### 1. Introduction

Although historically a condition of the affluent, overweight and obesity are now becoming endemic to low income communities as well (Monteiro et al., 2004; Popkin, 2003). As a result, there is growing concern that the increased prevalence of nutrition-related diseases, along

with the decreased quality of life associated with these conditions, will have long-term economic and social consequences for these communities. Many studies demonstrate a relationship between socioeconomic status (SES) and nutritional status; however, the sign of the relationship differs depending on the level of development of the population being considered. There is generally a negative relationship between SES and obesity in developed nations, but a positive one in developing countries (Godoy et al., 2005a, 2006; Komlos and Baur, 2004; Monteiro et al., 2002; Popkin, 2001, 2002; Stunkard and Sorensen, 1993; Uljaszek, 2003).

A biocultural approach can be used to analyze and interpret the relationship between nutritional status and

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SES (Godoy et al., 2005b; Goodman and Leatherman, 1998). This approach highlights the complex two-way interaction between human biology and the social, cultural, political environment. Humans are influenced by the control, production, and distribution of material resources, ideology, and power. Simultaneously, people affect the pattern and timing of those factors (Goodman and Leatherman, 1998). Because of their focus on the interactive and synergistic effects of biology and society, biocultural perspectives are particularly fruitful for studying the effect of rapid socioeconomic and demographic transitions on variables such as nutritional and health status (Ulijaszek and Koziel, 2007). Many Latin American indigenous groups are undergoing such transitions and are showing dramatic changes in the prevalence of overweight, obesity, and chronic disease (Candib, 2007; Frisancho, 2003; Lourenco et al., 2008; Orden and Oyhenart, 2006; Tavares et al., 2003; Tavares and Anjos, 1999).

Most indigenous populations in Latin America have experienced, at various degrees and paces, a process of *westernization*. This process is characterized by a shift in subsistence practices (from agriculture or foraging to wage labor and market economy) and an escalation of urbanization and secularization (Caldwell, 1976; Caldwell et al., 2006; Kirk, 1996; Popkin, 2002). For some native Latin American populations, particularly Mesoamerican groups, the westernization processes started with the arrival of Spanish and other European colonizers and continue in the present. For other indigenous populations, either because of their geographical isolation (Amazonian groups) or their purposeful resistance to colonization (Chacoan groups), the experience of westernized influences is more recent. We concentrate here on Chacoan groups that began a demographic, epidemiological and nutritional transition during the last century.

Changes towards a westernized lifestyle include a shift from diets usually low in saturated fats and high in protein and fibers, to diets rich in saturated fats and simple sugars (Peña and Bacallao, 1997; Uauy et al., 2001). For example, in Chacoan groups, diets based on fresh water fish, game (deer, wild rabbit, rheas, armadillos) and wild fruits (*algarroba*<sup>1</sup> seeds, legumes, *chañar*<sup>2</sup>) are changing to staple diets of white bread, fried dough, noodles, and polenta (Valeggia et al., 2005). In addition, nutritional transitions are usually accompanied by paramount changes in the way food resources are acquired. Quite frequently a labor- and time-intensive subsistence based on agriculture/horticulture practices is followed by the purchase of food items in cash markets (Eaton and Cordain, 1997; Eaton et al., 1997). A change in mode of subsistence triggers corresponding modifications in diet composition and physical activity patterns.

Diet composition and levels of physical activity are two proximate mechanisms that have been the focus of several biological anthropology studies in transitional populations in Latin America (Benefice et al., 2007; Brabec et al., 2007;

Fernandez et al., 2003; Godoy et al., 2005a; Hernandez et al., 2003; Lourenco et al., 2008; Reyes-Garcia et al., 2008; Tavares et al., 2003; Valeggia and Ellison, 2003). Nutritional household surveys, interviews, and direct observational studies provide detailed qualitative information on the degree of change experienced by these populations. However, qualitative methods have not been sufficiently utilized to explore causal relationships beyond the almost obvious culprits (diet and exercise) of overweight and obesity. There are several themes that deserve attention because of their potential impact on the embodiment of lifestyle changes in different sectors of the population. For example, westernization processes may alter the meaning of *work* in historically hunter–gatherer groups. Where is the subsistence currently coming from, if it is not from the bush? Was foraging regarded as “work”? Gender differentials might also play a crucial role in how resources are distributed and converted into metabolic energy. Men receive wages (cash) in most cases of employment. How are those earnings distributed within the family, if distributed at all? Working for a wage outside home also increases the worker’s connections to the non-indigenous section. But not all men work for a wage, so that creates potential power differentials within the community. Is this reflected in access to quality resources? Although we are not able to address all these questions in this work, we would like to point these multifaceted interactions as important forces that shape the response of each individual to the impact of lifestyle changes and, as an extension, also direct the collective response at a population level.

Our study examines the complex relationships among social, economic, and nutritional statuses among adults (>20 years old) from two indigenous populations of the Argentine Gran Chaco: the Toba and Wichí of the province of Formosa (Fig. 1). These populations offer an opportunity to explore how intra-community variation in market economy participation and in non-indigenous sociopolitical life in general is related to nutrition and health.

## 2. Methods

### 2.1. Study populations

The Toba and the Wichí are two of several indigenous groups that currently live in the Gran Chaco region in northern Argentina (Braunstein and Miller, 1999). The Toba belong to the Guaycurú linguistic family, while the Wichí are in the Mataco-Mataguayo group (Braunstein and Miller, 1999). Traditionally, Chacoan groups were nomadic or semi-nomadic hunter–gatherers with rudimentary agriculture (Arenas, 2003; Braunstein and Miller, 1999; Mendoza and Wright, 1989). Ethnographic studies described these groups as egalitarian with an immediate-return economy (Woodburn, 1982), i.e. food was collected for immediate consumption with tools made when required until well into the 20th century. There was no surplus of food or material goods, and no storage of accumulated resources. Socioeconomic stratification was almost non-existent and, at least among the Toba, their egalitarian concept of leadership persisted until the late 1980s (Mendoza, 2002).

<sup>1</sup> *Prosopis* sp.

<sup>2</sup> *Geofroea decorticans*



Fig. 1. Approximate location (indicated with black solid star), within the Gran Chaco of South America, of the Toba and Wichí communities in this study. Modified, with permission, from Miller (1999).

However, major changes in their traditional lifestyle have occurred since the arrival of European settlers in the late 1800s. The restrictions on access to large tracts of land, their partial integration into the labor market, and the arrival of missionaries from various Christian groups have determined the settlement process of these communities (Braunstein and Miller, 1999; Gordillo, 1994, 2002; Mendoza, 2002; Mendoza and Wright, 1989). As a result, Toba and Wichí settlements vary over an array of environments and show considerable variation in lifestyles. These range from a rural, traditional lifestyle that is quite dependent on hunting and gathering, to an urban, sedentary lifestyle that depends on wage labor and store-bought goods for sustenance. The lifestyle changes more relevant to our analyses began between 50 and 100 years ago.

## 2.2. Study area and participants

The study presented here is part of a long-term project (Chaco Area Reproductive Ecology Project), which is aimed

at characterizing the reproductive ecology of indigenous groups in the province of Formosa, Argentina. We studied one Toba<sup>3</sup> and one Wichí community, both located in the western Argentine Chaco (61–62°W and 23–24°S, Fig. 1) in adjacent sections of land. These Toba and Wichí communities share the same ecological environment and broad cultural practices. Although they belong to different linguistic families, they have been interacting for as long as their oral tradition can recall (Braunstein and Miller, 1999). At present day, relationships are amicable, but intermarriage has been negligible. The Toba community of Sombrero Negro (SN) consists of approximately 1600 people distributed in three main villages and seven minor ones. The Toba live in a collectively owned 35,000-ha property where some members still practice traditional forms of subsistence and others rely, to varying degrees, on a market economy. The Wichí community of Pozo de Maza (PM) consists of approximately 600 people distributed in one main village and four minor ones. They live on government-owned land, which is relatively close (0.5–12 km) to the non-indigenous town of Pozo de Maza. Although they still hunt and gather, those activities are being partially supplemented or replaced by low-paying, unskilled jobs in the market economy.

We discussed our research plans with community leaders and explained the purpose and design of the study to everyone during community meetings. As the meetings developed, local health workers translated discussions and agreements to the Toba and Wichí local languages as necessary. Participation in the study followed the informed consent process as reviewed and approved by the Harvard University Standing Committee on the Use of Human Subjects in Research (2004).

A total of 541 adults (>20 years old) participated in the study (Toba: 201 women, 130 men; Wichí: 136 women, 74 men) between September 2004 and November 2005. Our best estimates of the number of indigenous people living in rural areas of the Gran Chaco, which is based on information from political censuses (for voting purposes), would suggest that there are about 10,000 Toba and 7000 Wichí. With these estimates in mind, the sample used in this study is representative of the communities that lie in the rural/foraging end of the spectrum. The data analyzed here reflect household heads and their spouses; we did not include dependent elderly parents or unmarried adult children living in the household.

## 2.3. Anthropometrics and nutritional status

Height was measured to the nearest 0.1 cm using a portable stadiometer (C.A.M., Argentina). Body mass and percentage body fat (% BF) were estimated using a portable digital scale (TANITA® TBF 301), accurate to 100 g and 0.1%, respectively. All participants were measured bare-

<sup>3</sup> Also known as Western Toba (Mendoza, 2002); Toba-Pilagá (Métraux, 1937) or Bolivian Toba (Karsten, 1932). Based on linguistic and some ethnographic differences, some authors consider them to be different from the Eastern Toba of the Gran Chaco (Miller, 1999). For simplicity's sake, we will refer to them as Toba throughout the article.

footed, wearing light clothing, and following established anthropometric protocols (Frisancho, 1990). Pregnant women were excluded from the anthropometric analysis. The body mass index (BMI) was calculated as body mass (kg)/height (m<sup>2</sup>) and the nutritional status of each participant was classified as underweight (<18.5 kg/m<sup>2</sup>), normal weight (18.5–24.9 kg/m<sup>2</sup>), overweight (25–29.9 kg/m<sup>2</sup>), or obese (>30.0 kg/m<sup>2</sup>) following the World Health Organization criteria (WHO, 2000).

All individuals had their height, body mass, and body fat measured on three occasions in January, May, and October of 2005 by Valeggia and one field assistant. Intra- and inter-observer reliabilities were assessed at the beginning of each sampling month. No seasonal variation was found for any of the anthropometric measures; therefore, an average BMI and average % BF were calculated using the three monthly measurements for each individual.

#### 2.4. Socioeconomic status

It is difficult to apply standard measures of socioeconomic status to the Toba and Wichí populations. In these populations, cash income is sporadic and unpredictable, and formal education levels are uniformly low. Usually, it is each person's connections to the non-indigenous, market economy that influence the socioeconomic status of a particular family (Gordillo, 1994). Ethnographic data collected before the study were used to develop a socioeconomic status (SES) index that separated well the more affluent participants from the less affluent ones. This ad hoc SES index considered cash income from wages and federal unemployment subsidies (per year), cash income and/or material goods received in exchange for political favors, possession of modern electrical appliances (e.g. television, radios, tape recorders), type of housing (traditional adobe and straw huts, improved dwellings constructed with traditional and non-traditional materials, or brick houses provided by the provincial government), and social and political networking (within and/or outside the community). This last variable was considered crucial for determining socioeconomic status, but it was the most difficult to measure. For establishing a ranking of social and political networking we relied on field notes and data from 24-h recalls. We used our field notes collected during past field seasons to identify references to exchanges between the focal individual and people within and outside the community. For example, if one person was observed coming back from town in a truck driven by a

non-indigenous political leader, the person was assigned one "point" towards political connectedness with non-indigenous people. Second, we used data from 24-h recalls in which we recorded all activities the interviewees recalled being engaged during the previous day. These recalls included social activities and trips to nearby towns. Using these two sources of networking data we estimated a ranking that was used in the calculation of the SES index.

Men were assigned to low, medium or high SES categories based on the following criteria: (1) low SES: no cash or material goods income, no modern appliances, traditional adobe hut, no or weak social/kinship connections to community political leaders, and little connections with the non-indigenous culture and state agencies; (2) medium SES: some cash or material goods income, one or two modern appliances, improved traditional hut; some connections with kinship and reciprocity networks within the community, and some connections to the non-indigenous culture and state agencies; and (3) high SES: stable cash or material goods income, more than two modern appliances, brick house, being a political leader or strong social/kinship connections with one, and well-developed connections with the non-indigenous culture and state agencies (e.g., employment by provincial or municipal government, political positions in town parties). Because women do not work outside their home they were assigned the same SES rank of their husband. Single women and widows were assigned the SES rank of their closest male relative (father, brother, or son). Valeggia and an experienced local researcher independently ranked each man and woman into the three SES categories. There were only two disagreements in the categorization of the study participants: two Wichí men were categorized as low SES by one of the rankers and as medium SES by the other. These disagreements were settled by consensus. Table 1 shows the number of participants in each of the three socioeconomic index categories.

The men in the high SES category showed some differences among them. In both ethnic groups, there was a subset of high SES men (Toba:  $n = 6$ , Wichí:  $n = 10$ ) who had considerably more social connections to non-indigenous parties and more western material goods than the rest of the men in the category. Ethnographic data, collected using participant observation (Valeggia, unpublished data), indicated that these men were community leaders. These high SES men are the cultural brokers between their communities and the non-indigenous parties (government, political parties, non-governmental

**Table 1**

Number of participants (and percentage of the population) classified in each of the three socioeconomic index (SES) categories in the Toba and Wichí communities.

SES	Toba				Wichí			
	Women		Men		Women		Men	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Low	45	22	49	38	31	23	12	16
Medium	122	61	56	43	80	59	51	69
High	34	17	25	19	25	18	11	15
Total	201		130		136		74	

agencies, researchers, merchants, and neighbors). When community-wide decisions are taken, these are the men who gather and discuss the issue at hand. For example, as part of the informed consent process, our research team met several times with a council formed by these sixteen leaders. Given these special attributes, we have performed additional analyses on this subset of men (and their spouses and close female kin) to explore whether the associations predicted for the community as a whole applied to them as well.

### 2.5. Diet composition

Data on diet composition were obtained using 24-recalls in the Toba community and direct observations among the Wichí. Each Toba participant responded to a validated, closed questionnaire about food items consumed during the previous 24 h (Buzzard, 1998). A total of  $n = 102$  Toba men and  $n = 99$  women participated in the recalls. The sampling was done at random within each village and all villages are represented. None of the prospective participants refused to be interviewed when invited. Recalls were recorded by a trained field assistant and validated with direct observation of food consumed in 16 Toba families (Valeggia, in preparation). For analysis, recalled food items were categorized as *foraged* if they were the direct product of fishing, hunting, or collecting by community members, or as *marketed*, if they were processed food items purchased or received through a donation from governmental or non-governmental agencies. Most marketed products are sold by non-indigenous people in non-indigenous towns. There is one store, run by a non-indigenous man, just a few meters from the entrance to the Toba community where basic food items (noodles, rice, wheat flour, candy, sodas, meat and eggs) can be purchased.

Each Toba participant contributed three 24-h recalls, one in each of the three sampling periods (January, May, and October 2005). For each individual we computed whether he or she reported having eaten foraged or marketed items. Each individual was assigned a 1 if he/she reported having had one or more of the food items in a category, or a 0 if he/she did not report any consumption in this category. For each sampling period, we calculated the proportion of positive entries for each of the groups being considered (e.g. for high-SES Toba men, for medium-SES Toba men, for low-SES Toba men, etc.). An overall average proportion was estimated across sampling periods to account for seasonal variation in diet composition (Valeggia et al., 2005). Thus, the number obtained for each group represents the percentage of individuals who reported having eaten at least one *foraged* and *marketed* items during the previous 24 h.

Twelve Wichí families participated in an observational study of daily activities that provided the diet composition information presented here. This was part of a separate pilot study that did not include dietary and activity recalls. Three field assistants visited each family at their house once in each sampling period and recorded all foraged and marketed foods consumed by family members from dawn to dusk. All villages were represented by at least one family

being observed. Families were chosen at random within each village and none of them refused to participate. Socioeconomic status was relatively balanced across the sample: three families were classified as high SES, five families as medium SES, and four families as low SES. Given the recording methods used, it was not possible to determine differences in the dietary composition among male and female participants. Thus, for the Wichí adults we report combined information.

### 2.6. Statistical analyses

The correlation between BMI and % BF was analyzed using Pearson's correlation test and BMI differences between sexes and between ethnic groups were evaluated using *t*-tests for independent samples. We used standard multiple regression analysis to evaluate the contributions of SES, sex, and age in predicting BMI (Tabachnick and Fidell, 2007). We used SPSS Explore to evaluate assumptions which led to the inverse transformation of BMI and age to reduce skewness and improve the normality, linearity and homoscedacity of residuals.

Differences in the percentage of marketed and foraged food items consumed were analyzed using Chi-square tests. Statistical significance was set at  $p < 0.05$ . Statistical analyses were performed using SPSS 16.0.

## 3. Results

### 3.1. Anthropometrics and nutritional status

Both populations showed good overall nutritional status as indicated by their body mass indices and percentage of body fat (Table 2). Adults (30 years old and older) had BMIs above 25 kg/m<sup>2</sup>, the upper cut-off for normal weight for WHO standards (WHO, 2000). Younger adults (20–29 years old) had, on average, BMI values within the normal range, except for young Toba women, who as a group had a mean BMI slightly over the 25 kg/m<sup>2</sup> cut-off. BMI values tended to increase with age, but showed a slight reduction in the oldest age category. This trend was consistent in both sexes and in both populations. Body fat percentage values were highly correlated with BMI values (see Section 2.6) and showed the expected sex differences: in both populations, women had significantly higher body fat percentages than men (Toba:  $t_{(266)} = 15.6$ ,  $p < 0.001$ ; Wichí:  $t_{(161)} = 6.4$ ,  $p < 0.001$ ). Toba women had significantly higher body fat percentages than Wichí women ( $t_{(208)} = -4.5$ ,  $p < 0.001$ ); while there were no significant differences between Toba and Wichí men ( $t_{(147)} = 1.5$ ,  $p = 0.26$ ). Only a small percentage of men (Toba: 1%; Wichí: 1%) and women (Toba: 3%; Wichí: 2%) were classified as underweight, whereas approximately half of the participants were either overweight or obese (Table 3).

Women tended to have higher BMIs than men among the Toba ( $t_{(309)} = 3.4$ ,  $p < 0.001$ ), but not among the Wichí ( $t_{(201)} = 0.3$ ,  $p = 0.78$ ) (Table 2 and Fig. 2). Toba women tended to have slightly higher BMI than Wichí women ( $t_{(315)} = 2.0$ ,  $p = 0.04$ ); while the opposite was true for men ( $t_{(170)} = -0.93$ ,  $p = 0.35$ ).

Table 2

(a) Average ( $\pm$ standard deviation) body mass index (BMI) and (b) body fat percentage (% BF) of Toba and Wichí women and men by age category.

Age category (years)	Toba				Wichí			
	Women		Men		Women		Men	
	n	BMI (SD)	n	BMI (SD)	n	BMI (SD)	n	BMI (SD)
(a)								
20–29	90	25.2 (4.1)	42	23.2 (2.6)	56	24.3 (3.2)	33	23.6 (2.6)
30–39	40	26.8 (4.0)	33	25.2 (3.3)	25	25.6 (4.5)	11	26.4 (6.0)
40–49	28	29.4 (4.6)	19	25.7 (4.1)	21	27.5 (4.7)	10	28.1 (3.6)
50–59	19	28.7 (5.5)	22	27.3 (4.0)	19	27.6 (4.7)	9	28.1 (3.6)
60+	24	26.9 (5.4)	14	25.8 (5.8)	15	26.0 (4.7)	11	26.2 (2.6)
Totals	201	26.6 (4.7)	130	25 (3.9)	136	25.7 (4.1)	74	25.5 (3.4)
(b)								
Age category (years)	Toba		Wichí		Wichí		Wichí	
	Women		Men		Women		Men	
	n	% BF (SD)	n	% BF (SD)	n	% BF (SD)	n	% BF (SD)
20–29	90	31.4 (7.2)	42	17.3 (5.4)	56	26.7 (7.5)	33	17.8 (4.6)
30–39	40	34.8 (5.7)	33	21.0 (5.2)	25	31.8 (6.4)	11	24 (8.8)
40–49	28	39.1 (6.1)	19	23.4 (8.1)	21	34.1 (7.7)	10	24.6 (7.2)
50–59	19	40.4 (6.1)	22	24.2 (6.0)	19	37.8 (5.5)	9	27.7 (5.9)
60+	24	41.5 (6.5)	14	19.8 (7.7)	15	31.6 (10.8)	11	22.6 (5.6)
Totals	201	34.9 (7.4)	130	20.7 (6.6)	136	30.6 (8.3)	74	22 (6.8)

Table 3

Prevalence of underweight, normal weight, overweight and obesity and range of percentage body fat (% BF) among Toba and Wichí men and women.

BMI	Toba				Wichí			
	Women		Men		Women		Men	
	% (n)	BF range	% (n)	BF range	% (n)	BF range	% (n)	BF range
UW	3 (5)	19–32	1 (1)	6	2 (3)	11–28	1 (1)	6
NORM	39 (78)	14–43	62 (80)	11–24	48 (65)	10–36	50 (37)	9–30
OW	35 (71)	27–50	25 (33)	17–38	35 (47)	22–45	34 (25)	11–38
OB	23 (47)	37–50	12 (16)	24–38	15 (21)	33–45	15 (11)	26–36

UW: underweight (BMI < 18.5 kg/m<sup>2</sup>), NORM: normal weight (BMI = 18.5–24.9 kg/m<sup>2</sup>), OW: overweight (BMI = 25.0–29.9 kg/m<sup>2</sup>), and OB: obese (BMI > 30 kg/m<sup>2</sup>).

### 3.2. Socioeconomic status

BMI was consistently higher among participants of high socioeconomic status. This was true for both men and women of both ethnic groups (Fig. 3). We present in Table 4 a summary of the results obtained from the standard multiple regression of SES, sex, age and ethnicity on BMI. The analysis of variance indicated that the standardized regression coefficient  $\beta$  was significantly different from zero ( $F_{(4,522)} = 45.08, p = 0.000$ ). The adjusted  $R^2$  shows that a fourth of the total variation in BMI ( $R^2 = 0.25$ ) was explained by socioeconomic status, sex, age and ethnicity.

An examination of the squared semipartial correlations<sup>4</sup> ( $sr^2$ ), shows that SES made the most significant individual contribution (13%), whereas the other three dependent variables combined explained only 5% of the variation. Consequently, the four variables combined explained an additional 7% of the variability in BMI.

<sup>4</sup> Squared semipartial correlation values indicate the amount by which  $R^2$  would be reduced if that variable were omitted from the equation. That is,  $sr^2$  represents the unique contribution of the independent variable to the total variance of the dependent variable (Tabachnick and Fidell, 2007).

Strong political connections and leadership were strongly associated with nutritional status. Among the Toba, five of the six main community leaders were obese (outliers in Fig. 2), and the remaining one was overweight.

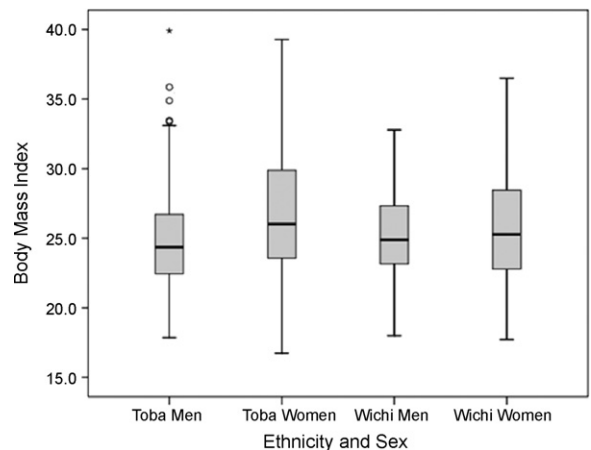


Fig. 2. Box plot of body mass index (BMI) values for Toba and Wichí adult men and women. Open circles and stars indicate outliers, which in this case, correspond to the BMI values of five Toba leaders.

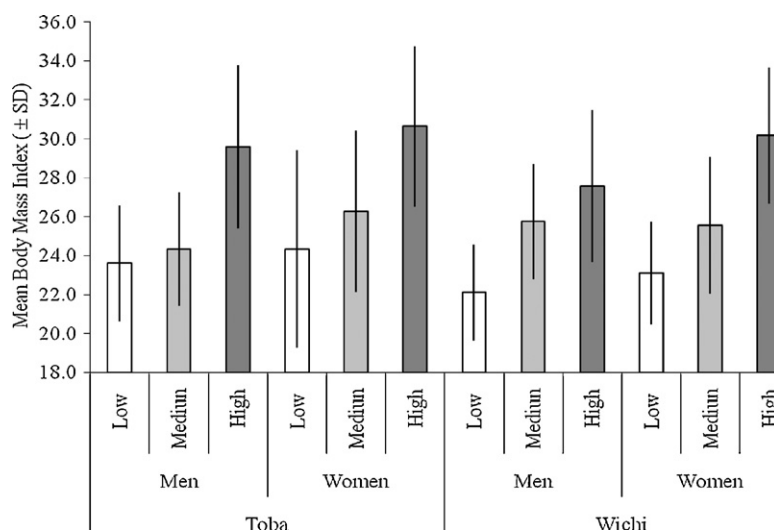


Fig. 3. Mean BMI ( $\pm$ SD) of Toba and Wichí adult men and women according to their socioeconomic index classification (low, medium, or high).

Although their wives were also either overweight or obese, they did not represent outliers within the Toba women sample. Four of the ten Wichí leaders were obese, another four were overweight, and the remaining two were of normal weight, but none of them were outliers within their sample. Four of the Wichí leaders' wives were obese, two were overweight, and two were within normal range (two of the leaders were widowers).

### 3.3. Diet composition

Wichí and Toba adults ate a mixed diet that included items of various origins. Hunted items included game (armadillo, deer, wild rabbit, fowl, capybara, vizcacha), fish (shad, carps, catfish), wild honey, fruits (algarroba, mistol, legumes), and the products of the low maintenance horticulture that have characterized these groups for centuries (e.g. melon, squash, watermelon; see Arenas, 2003 for a comprehensive listing of traditional foraged items in these populations). Marketed items included processed carbohydrates such as rice, polenta, white flour tortas, noodles, store-bought meats (e.g. beef, goat, and pork), vegetable oil, and vegetables (e.g. potatoes, onions, squash). Soft drink consumption was rare; Wichí families living close to the center of town were the only ones observed drinking carbonated beverages. None of the

interviewed men consumed eggs or dairy products of any kind. Only the wives of the community leaders reported eating store-bought eggs and, infrequently, some cheese.

Socioeconomic status was strongly associated with diet composition in both ethnic groups. Participants in the higher socioeconomic categories reported higher consumption of marketed foods than those in lower SES categories (Table 5). Among the Toba, 70% of men in the high SES category consumed marketed food items, whereas only 48% of men in the low SES category did so. Among the Toba women, the difference in the consumption of marketed items was less pronounced (high: 48%, low: 42%, Table 5). The inverse pattern was found for the consumption of foraged items, but the differences were not as pronounced. Among the Toba, we also found an effect of gender on diet composition. In all SES categories, women tended to eat more foraged and less marketed food than men did. Wichí families showed similar diet composition variation across socioeconomic status. Families in the high SES category were observed eating marketed items more than twice as frequently as families in the low SES categories (82% vs 35%, Table 5). Fewer high SES families ate foraged food items than the other lower SES groups, but the differences in this category of foods were not as pronounced as in the marketed food category.

Table 4

OLS regression analysis: dependent variable BMI.

Variables	BMI (inverse)	SES	Age (inverse)	Sex	Ethnicity	B	$\beta$	sr <sup>2</sup>
SES	-0.46	1				-0.004	-0.39	0.13
Age (inverse)	0.32	-0.3	1			0.115	0.213	0.04
Sex	-0.12	0.12	0.08	1		-0.001	-0.09	0.01
Ethnicity	0.03	0.01	0.02	0	1	0	0.03	0.0009
								0.18
						R <sup>2</sup>	0.26	
						Adjusted R <sup>2</sup>	0.25	

SES = socioeconomic status, B = unstandardized coefficients,  $\beta$  = standardized coefficients, sr<sup>2</sup> = squared semi-partial correlations (i.e. the amount by which R<sup>2</sup> would be reduced if that variable were omitted from the equation).

Table 5

Percentage of participants who reported consumption of marketed and foraged items in each of the three SES categories.

	Marketed			Foraged		
	Low	Medium	High	Low	Medium	High
Toba Men	48	68	70	48	40	36
Toba Women	42	41	48	52	53	40
Wichí Men and Women	35	60	82	50	50	42

#### 4. Discussion

Both populations showed considerably high levels of overweight and of obesity. This pattern is quite different from what has been described for pre-industrial or early-industrial western societies for which BMI values were never that high (Komlos et al., 2009). A third of the adult women and Wichí men and a quarter of Toba men were classified as overweight. The overall prevalence of obesity was found to be around 16%, a notably high value. These findings are in good agreement with previous studies conducted in Namqom, a peri-urban population of the province of Formosa, Argentina (Valeggia and Lanza, 2005). Namqom is further along in the transculturation gradient than the populations studied here. They are completely settled, their subsistence relies on temporary labor, government subsidies, selling of basketry, and, for a few of them, political posts. They are fully immersed in the local market economy. The prevalence of obesity among women reaches 30% and among men is 18% (Valeggia et al., 2005). In women, the effect of age on BMI may reflect the association between parity and weight retention that has been reported for another Toba population (Valeggia and Ellison, 2003). Although not as pronounced, high overweight rates have been reported for other South American indigenous communities experiencing drastic lifestyle changes (Benefice et al., 2007; Coimbra and Santos, 2004; Godoy et al., 2005b; Lourenco et al., 2008; Orden and Oyhenart, 2006; Santos and Coimbra, 1998; Ulijaszek, 2003; Valeggia and Lanza, 2005).

Women had higher average BMI values than men. Body fat percentage values suggest that the higher BMI values in women indeed signal larger fat deposits, reflecting a basic characteristic of mammalian biology (Bronson, 1989). Female mammals face metabolically expensive reproductive processes such as pregnancy and lactation, and have developed presumably adaptive mechanisms to store energy in the form of fat deposits to serve that purpose. Thus, all things being equal, females will exhibit higher fat mass than men. However, it is worth noting that the rates of obesity are similar between men and women in the Wichí population (about 15%), but not among the Toba (23% for women and 12% for men). Qualitative data suggest that, in general, Wichí men spend much more time in contact with non-indigenous agents in town and away from the family compound than Wichí women or than Toba men. Thus, Wichí men seem to have more opportunities to be exposed to and to consume calorie-dense market foods and drinks, which are not necessarily shared with their families. In addition, a preliminary analysis of daily activities (24-h activity recalls) in both ethnic groups indicates that Wichí men do not participate in high-to-

moderate level of physical activities such as bicycle riding, long treks to the wetlands, and sports (Valeggia and Lanza, in preparation). Finally, alcohol consumption may be contributing some extra calorie intake. We found higher prevalence of alcoholism among Wichí men than among Toba men (unpublished data).

Many important social and cultural patterns are altered in populations experiencing rapid transitions. In our study, the observed high rates of overweight are most likely a consequence of a change in diet composition from a high protein-low fat diet and an active lifestyle to a highly caloric diet and a more sedentary lifestyle. Long-term ethnographic studies of the Toba and Wichí of western Formosa indicate that their traditional diet had been rich in animal protein from a great variety of game and fish, and in fibers and starch from wild fruits and tubers and the produce of an incipient horticulture (Arenas, 2003). The data presented here and elsewhere (Valeggia and Lanza, 2005) show that the current diet of these rural populations contains a substantial proportion of processed foods, with a high prevalence of starchy products, such as white bread, crackers, noodles, and rice. Nowadays, purchased food probably acts as a buffer during times of scarcity when these people used to lose weight. The winter months are traditionally the lean times in the annual cycle of the Gran Chaco (Arenas, 2003; Mendoza, 2002). An analysis of seasonal variation in diet composition among the Toba and the Wichí showed that both populations report higher consumption of marketed foods during the winter than during months when foraging yields higher returns (Valeggia et al., 2005).

Changes in the nutritional status of populations in transition cannot be properly understood without studying the interrelationships among historical, sociocultural, and biological variables. When we describe the high prevalence of overweight and obesity in Toba and Wichí populations, we may rightly point to changes in diet composition and physical activity levels as its immediate proximate causes. However, these changes are accompanied by and respond to profound shifts in social and cultural values that affect the way indigenous populations interact with the hegemonic forces surrounding them (Coimbra and Santos, 2004; Valeggia and Lanza, 2005; Valeggia et al., 2005). In the last few decades, participation in the market economy and in wage labor has rapidly accelerated in these populations. The Toba began participating in labor migrations to sugar plantations in the early 1900s and started receiving governmental subsidies in the 1950s, but it was not until the late 1980s that their attention shifted towards a search for jobs, resources, and political positions in the local municipality. As Gordillo (2002) argues, a crucial force in this turning point has been



the internalization of hegemonic discourses about the importance of *trabajo* (work), particularly in the public sector employment. Influenced by state and religious agents (mainly Anglican and Evangelical), who place high value in cash-labor, Chacoan people are incorporating and reproducing non-indigenous values and changing their very notion of subsistence. At the core of this shift is the ambivalence that the “bush” now generates as a symbol of *passé* “old ways”, yet a place that brings life (De la Cruz, 1995; Gordillo, 2002). These changes in their perception of subsistence and adaptation to a new lifestyle are sometimes explicitly conveyed in their discourse. “We have not eaten yet”, was the answer to our 24-h diet recall question. However, upon further conversation, we learned this man had had some fish and *doca* (*Morrenia odorata*, a fruit) in the morning. When inquired about this omission in the diet recall, he explained that foraged items were not “*comida*” (food), only store-bought food is to be considered real food, perhaps a reflection of what is now more valued.<sup>5</sup> We obtained similar responses from several participants, prompting us to change the way we phrased the recall question. In clear contrast, and illustrating how the transition affects people in the same community differently, a second man pensively expressed: “as long as we have fish and honey, we will survive”.

One more layer of complexity is added when we consider how the incipient accumulation of wealth that results from the market economy affects social hierarchies. Traditionally, the indigenous societies of the Gran Chaco have been relatively egalitarian, with political authority following kinship lines and strict social and religious rules enforcing redistribution of resources within the community (Miller, 1999). The daily needs were mostly covered by reciprocal exchange of goods. Empty-handed foragers could trust that they would receive food and other resources from more successful ones following lines of kinship (Mendoza and Wright, 1989). Although our ethnographic research suggests that these reciprocity rules are still present and regularly enforced, the access to cash and non-indigenous commodities is sharply unequal within the community. This unequal distribution of resources, coupled with changes in their conception of work and foraging, is triggering, or at least exacerbating, a clear social stratification process. Some individuals stand out as community leaders and, although it is difficult to characterize how leaders emerge, it is apparent that most of them have kinship ties to historical traditional leaders as well as a good command of Spanish and intercultural issues. These qualities grant them some prestige among non-indigenous agents (e.g. government officials), and allow them to obtain jobs at the provincial or municipal administration or posts at the local political parties. This, in turn, increases further their intra-community prestige since they can now distribute valued resources and goods. In our study, the consequences of these changes are more clearly reflected in the proportion of store-bought and

foraged food items consumed by low, medium and high ranked individuals. Among high ranked individuals, marketed food has replaced foraged food during most of the year. For medium and low ranked families, store-bought food is still a supplement.

The development of social and economic differences in relatively egalitarian hunter-gatherer societies and their subsequent effect on health and well being have received recent attention from anthropologists and public health researchers (Brabec et al., 2007; Godoy et al., 2005a, 2006; Reyes-García et al., 2008). In agreement with those studies, our results show that although overweight and obesity rates are relatively high, at least some of the variation in nutritional status in the populations was accounted for by socioeconomic stratification. Most Toba and Wichí community leaders (16/18) were overweight or obese. Furthermore, among the Toba, the BMI of the leaders were statistical outliers in the sample. A similar pattern was observed among the spouses or close female relatives of these men. It is quite clear that access to commodities and cash economy facilitates the accumulation of both material and metabolic resources. Interestingly, we found that among both Toba and Wichí men there was a positive, if not statistically significant, association between SES and height (Valeggia, in preparation) This would suggest that there may be long-term differences in stunting, with higher status men being better nourished than lower status ones from early childhood. This association could also reflect that leaders might have been selected on the basis of their height. Stature was not correlated with SES among women.

The relationship between changes in lifestyle and nutritional status has profound implications for the epidemiology of populations in transition. During the early stages of the epidemiological transition, the prevalence of infectious diseases is usually high, but following improvements in health care, this load eventually becomes relaxed in later stages. Increasingly, the epidemiological composition of Latin American indigenous groups is shifting towards diseases associated with obesity, including diabetes, cardiovascular disease, and high cholesterol (Monteiro et al., 2002; Peña and Bacallao, 1997; Popkin, 1998a,b). For example, an epidemiological surveillance study in a neighboring rural Wichí population showed high prevalence of hypertension, which was higher than in non-indigenous populations in the same region (Coughlan et al., 2005). This disturbing tendency extends to indigenous people living in urban environments. More than half of the Toba adults living in an urban settlement in the outskirts of the city of Resistencia were classified as overweight and a quarter of them showed symptoms of hypertension and proteinuria (Bianchi et al., 2006).

Although most studies that discuss the health implications of over-nutrition consider overweight and obesity as a single category, it is becoming clear that they should be analyzed separately. It has been extensively demonstrated that a body-mass index above 30 kg/m<sup>2</sup>, the criteria for classifying someone as obese, is associated with a higher risk for cardiovascular disease and other co-morbidities (Adams et al., 2006; McGee, 2005). Furthermore, the risk of death among obese people is two to three (or more) times higher than that of people within the normal BMI range

<sup>5</sup> However, given that all interviewees were non-indigenous, it could also be taken as the man's interpretation of what the interviewer might have thought was real food.

(BMI between 18.5 and 24.9 kg/m<sup>2</sup>) (Adams et al., 2006; Whitlock et al., 2009). However, the relationship between BMI in the overweight range (BMI between 25 and 29.9 kg/m<sup>2</sup>) and mortality risk is controversial (Lewis et al., 2009). While some studies indicate an adverse relationship, others found a slight or no association (McGee, 2005; Whitlock et al., 2009). The debate surrounding this issue is still current, but in the meantime, treating overweight and obese people as groups with different morbidity and mortality risks seems warranted. In our sample, the approximate 30% of overweight adults could be the result of increased food security and a decreased seasonal fluctuation in food resources. Further research is needed to evaluate whether these changes in nutritional status, in the absence of other morbidity and mortality risks such as smoking, are predictors of increased health problems.

## 5. Conclusions

The Toba and Wichí populations described here show a high prevalence of obesity among adults. Even in the absence of other cardiovascular disease risk factors, it is reasonable to predict that the high obesity values are, or will soon be, associated with high incidence of hypertension, diabetes, and other chronic metabolic disorders as it is the case in numerous Native American groups throughout the continent. Our results suggest that changes in lifestyle, particularly in diet composition, may be the prime proximate mechanisms responsible for this epidemiological situation. However, our study also highlights the importance of incorporating social, cultural, and political economic variables, such as political hierarchies within the group or degree of social connectedness with community leaders. By making these variables an integral part of our analysis and interpretation, we will significantly improve the explanatory power of our models and, thus, contribute to improving our understanding of the situation of indigenous populations in transition both from a theoretical and from an applied perspective.

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