Ethnicity & Health

ISSN: 1355-7858 (Print) 1465-3419 (Online) Journal homepage: http://www.tandfonline.com/loi/ceth20

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To cite this article: Alvar Loria, Pedro Arroyo, Victoria Fernandez, Jeanette Pardio & Hugo Laviada (2018): Prevalence of obesity and diabetes in the socioeconomic transition of rural Mayas of Yucatan from 1962 to 2000, Ethnicity & Health

To link to this article: https://doi.org/10.1080/13557858.2018.1442560

Published online: 20 Feb 2018.

ETHNICITY & HEALTH, 2018
https://doi.org/10.1080/13557858.2018.1442560

Taylor & Francis
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Prevalence of obesity and diabetes in the socioeconomic transition of rural Mayas of Yucatan from 1962 to 2000

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ABSTRACT

Background: The Mayas of the State of Yucatan in Mexico are the only aboriginal group with obesity and diabetes data before 1997.
Objective: To analyze socioeconomic trends associated with the increase in obesity and diabetes seen in rural Yucatan from 1962 to 2000.
Methods: Body weight, height and venous Fasting Blood Glucose (FBG) were measured in 263 rural Maya adults participating in a 2000 nutrition survey.
Results: Diabetes (FBG > 125 mg/dL) and obesity (BMI $\geq$ 30 kg/m^2) were 10.6% and 35.7%, respectively. These results contrast with those of a 1962 survey where diabetic prevalence was 2.3% and 0% in women and men respectively, with widespread adult pellagra and malnutrition. An important socioeconomic transition that took place in Yucatan during this lapse appeared to be associated to the obesity and diabetes increase.
Conclusions: Rural Yucatan evolved from malnutrition conditions to high prevalence of obesity and diabetes in less than 40 years. This change was associated with the transition from an agroindustry-based economy, characterized by high-energy expenditure and low protein intake, to lower energy requirements of a Government-subsidized economy with larger food supply.

ARTICLE HISTORY
Received 8 March 2017
Accepted 13 February 2018

KEYWORDS
Epidemiology of diabetes; obesity; ethnicity; socio-economic; diet

Introduction

The prevalence of obesity and type 2 diabetes mellitus in Mexico has greatly increased in México in recent years (Olaiz-Fernández et al. 2007; Villalpando et al. 2010; Gutiérrez et al. 2012). Obesity is a risk factor for several non-communicable chronic diseases including type 2 diabetes (Pi-Sunyer 2002, 97S). There is little information about the underlying causes that brought about this epidemiologic profile. The interactions between social, economic, and environmental determinants of lifestyle play a vital role in obesity development (Egger and Dixon 2014). The case of the State of Yucatan in the Mexican Republic

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provides an example of how changes in determinants of lifestyle may have participated in modulating the prevalence of obesity and diabetes.

Methods

The Mayas of Yucatan are an ethnic group living in the Peninsula of Yucatan in Southeastern Mexico. They share several cultural markers such as common history, language, culinary culture and physical activity patterns (Dressler, Oths, and Gravlee 2005, 231). A survey was carried out in August and September, 2000 in two communities, Uci and San Rafael, each with less than 1200 inhabitants. Uci and San Rafael belong to the municipality (county) of Motul and Maxcanu, repectively. The distance of Uci and San Rafael to their municipal headquarters is 5 and 28 km, and 30 and 120 km to Merida, the State capital city, respectively. A total of 263 adult individuals (153 women and 110 men) from 18 to 81 years of age from both communities were sampled. 146 of them were from Uci which represented 23% of its adult population while 117 were from San Rafael representing 30% of its inhabitants. Participation in the study was promoted by the Federal Government Program of IMSS-Oportunidades through which a total of 289 individuals were invited. However, 26 of them (9%) refused blood extraction and were excluded from the study.

Anthropometry

Weight was measured with a SECA brand portable scale with a precision of ± 0.1 kg and variability of near zero. Determination of height was done using a wooden portable stadiometer consisting of a 2 m long flexible metal metric tape and a 90° mobile angle measuring ruler. Subjects were measured standing on a flat surface on bare feet with only light clothes. The measurements were made by two independent observers who were certified by the National Institute of Anthropological Research of the Universidad Nacional de México (UNAM).

On appointment, blood samples were taken after at least 10 h of fasting in a vacuum tube containing potassium oxalate and sodium fluoride to prevent glycolysis. The samples were stored in an ice container and then transported to the Clinical Laboratory of Hospital O'Horan, Faculty of Medicine, University of Yucatan, Merida. Upon arrival, the blood samples were centrifuged to separate the plasma which was assayed the following day. The time between bloodletting and plasma obtention ranged from three to six hours. Glucose was measured using glucose-oxidase method (Boehringer Mannheim) and a 4010 photometer (Boehringer Mannheim). The laboratory had an internal quality assay program using controls with assigned values and an accuracy of ± 2% with glucose CV precision below 4% at the time of the assays. To determine the plasma concentrations of cholesterol and triglycerides, enzymatic-spectrophotometric conventional method was employed using oxidase-peroxydase enzyme for cholesterol and glycerol-phosphate oxidase-peroxydase enzyme for triglycerides (Concepta-Abbot).

Dietary survey

Households visits were made from Monday through Sunday and a 24h-dietary recall questionnaire was applied with equal quotas for each week-day. Information on foods

consumed in the three main meals within the household or outside as well as foods eaten in-between, including ingredients, were investigated. When foods were home-consumed, name of dishes, plus drinks and accompanying foods (tortilla, wheat bread, crackers) were registered.

The survey was approved by the Ethics Committee of the Hospital O'Horan, Merida, Yucatan. An oral consent was obtained from the participants, and a written consent was signed by community representatives in Uci and San Rafael.

Statistical analysis

We used mean and standard deviation (SD) in the descriptive analysis, a Student t test in the evaluation of intercommunity differences, and a chi square test for distribution homogeneity.

Results

Table 1 is the laboratory and demographic data of our study showing the descriptive values and community mean differences. The participants were mostly middle-aged with high BMI (Body Mass Index) and a small majority were women. The data of the results depict similarity in the levels of glucose and triglycerides in the two communities. In the case of cholesterol, it was lower in San Rafael which is more distant to the capital city, Merida, than Uci.

There was no significant community difference in the proportion of diabetics and pre-diabetics in the two communities (Table 2). Globally, nearly 11% of the 263 participants were diabetic. None had been previously diagnosed.

Table 3 shows the frequency of the main ingredients of 645 dishes according to the culinary technique used in their preparation. Globally, the main ingredients were more frequently fried than cooked and the two ingredients with the highest consumption (67% of all ingredients) showed Fried/Cooked Ratio of 2.02 and 1.50 which contributed to the larger proportion (58%) of fried versus cooked ingredients in the 645 dishes.

Table 1. Laboratory, demographic and anthropometric data of the two communities.

Variable	Global $N = 263$ Mean ± SD	San Rafael $N = 117$ Mean ± SD	Uci $N = 146$ Mean ± SD	Community differences P
Glucose (mg/dL)	104.4 ± 34.2	105.3 ± 33.9	103.7 ± 33.0	NS 0.71
Triglycerides (mg/dL)	190.2 ± 132.2	182.6 ± 124.0	196.3 ± 138.5	NS 0.40
Cholesterol (mg/dL)	174.7 ± 50.0	150.6 ± 39.1	194.0 ± 49.5	<0.01
Gender score[a]	0.42 ± 0.49	0.44 ± 0.50	0.40 ± 0.49	NS 0.44
Age (yrs)	45.4 ± 12.7	43.9 ± 12.6	46.6 ± 12.8	NS 0.09
Height (cm)	151.5 ± 7.8	152.1 ± 7.7	151.0 ± 7.8	NS 0.25
Weight (kg)	66.1 ± 11.4	66.4 ± 10.5	66.0 ± 12.1	NS 0.79
BMI (kg/m^2)	28.8 ± 4.6	28.7 ± 4.4	28.9 ± 4.8	NS 0.76
Hip (cm)	99.1 ± 9.0	99.1 ± 8.7	99.2 ± 9.3	NS 0.98
Waist (cm)	94.9 ± 12.5	95.0 ± 11.8	94.7 ± 13.0	NS 0.87
WTH ratio	0.96 ± 0.08	0.96 ± 0.07	0.95 ± 0.09	NS 0.74

Note: Community differences evaluated with Student t test. NS = non-significant difference. BMI = Body Mass Index. WTH = Waist to Hip ratio.

[a]Gender scores were Females = 0 and Males = 1. Mean score <0.50 indicates majority of women.

Table 2. Distribution of subjects according to the levels of fasting glucose.

Diagnosis	Glucose (mg/dL)	San Rafael % (*N*)	Uci % (*N*)	Global % (*N*)
Diabetic	>125	8.5% [10]	12.3% [18]	10.6% [28]
Prediabetic	110–125	8.5% [10]	7.5% [11]	8.0% [32]
Normal	<110	82.9% [97]	80.1% [117]	81.4% [214]
Global		100% [117]	100% [146]	100% [263]

Chi square test ($p = 0.60$) indicated that distribution of cases was similar in the communities.

Discussion

In the present study, the rural Mayas of Yucatan were found to have a high BMI average and a 10.6% diabetes prevalence. The latter places them among the highest in Mexican aboriginal groups (Castro-Sánchez and Escobedo-de-la Peña 1997, 527; Guerrero-Romero, Rodríguez-Morán and Sandoval-Herrera, 1997a, 286; Guerrero-Romero, Rodríguez-Morán and Sandoval-Herrera 1997b, 137; Alvarado-Osuna, Milian-Suazo, and Valles-Sánchez 2001, 459; Rodríguez-Morán et al. 2008, 352). There are no data before 1997 for any aboriginal group with the exception of the report of Chávez, Balam, and Zubirán (1963, 333) performed in rural Yucatan in 1962. At that time, the diagnosis of diabetes was made by a blood glucose assay using the Folin-Wu method, measured 1.5 h after a 100 g load of glucose in subjects with trace positivity in at least one of the following two screening tests for glycosuria: glucose oxidase tape method (Jablokow, Hutchins, and Knights 1957, 425) and Benedict test (Stanley and Benedict 1909, 485). In spite of the low sensitivity of the 1962 screening tests, we believe that it did not play a major role in the absence of diabetes in males and the low rate of 2.3% in females reported by Chávez, Balam, and Zubirán (1963, 333). This possibility is supported by data on weight and height from the 1962 survey (Chávez A, unpublished data), i.e. body weight was measured at that time using a mechanical scale with a precision of ± 0.5 kg, and body height with a metallic metric tape fixed to a wall, with subjects without shoes, wearing light clothing and standing on a flat surface. Females ($N = 139$) had higher BMI than the 141 males (25.3 vs 22.0 kg/m^2). The 1962 BMIs were clearly lower than our 2000 BMI > 28 kg/m^2 in males and females (Table 1). Also, in agreement with low diabetes and low BMI in 1962, is the report by Chávez and Pimentel (1963, 398) of widespread adult pellagra and malnutrition, associated to the consumption of a low-energy and low-protein diet, in this same Yucatan population. On the basis of these

Table 3. Main ingredient, alone or combined, according to the culinary technique (fried vs cooked) in the 645 dishes reported by 263 adults of San Rafael and Uci in 2000.

Ingredient	Culinary technique			Fried/Cooked Ratio
	Fried	Cooked	Fried + Cooked	
GLOBAL	376 (58%)	269 (42%)	645 (100%)	1.40
Meat[a]	184 (29%)	91 (14%)	275 (43%)	2.02
Cereal[b]	93 (14%)	62 (10%)	155 (24%)	1.50
Egg	52 (8%)	62 (10%)	114 (18%)	0.84
Legume	27 (4%)	37 (6%)	64 (10%)	0.73
F&SF[c]	10 (2%)	12 (2%)	22 (3%)	0.83
Vegetable	10 (2%)	5 (1%)	15 (2%)	2.00

[a]Pork/chicken/beef/turkey.
[b]Corn/Rice/wheat/pasta.
[c]Fish & Seafood.

observations, we concluded that the low prevalence of diabetes in rural Yucatan in the 1962 study had not been greatly affected by the low sensitivity of the glycosuria screening tests used. The contrasts between 1962 and 2000 show a drastic change in the prevalence of obesity and diabetes in the rural Mayas of Yucatan during the 38-year period. The speed of change in obesity and diabetes may have been influenced by the low prevalences in 1962 due to the chronic undernutrition suffered during five centuries of external and internal colonization of Yucatan and other regions of Mexico (Bracamonte 2007). Hemp planting had been the main crop of the Yucatan Peninsula since the middle of the nineteenth century (Villanueva-Mukul 1990). However, since the early 1960s, the lifestyle in this region has been influenced by at least four macroeconomic changes.

(1) Decline of hemp production. Due to the introduction of synthetic fiber in the hard-fiber market in 1960, there has been a steady decline in hemp production. In the early 1970s the Federal Government took direct control of the whole industrialization process leading to a subsidized economy of the rural sector through the capital inflow provided by the Federal Government to the henequen industry (Escalante 1988, 4). The Government subsidies to the rural hemp growers led to increased food availability and to less strenuous physical activity.
(2) Tourist development in the Eastern Coast of Yucatan. Since the mid-1970s, large investments transformed Cancun from a small village of a few hundred people to a city of more than 400 thousand (Pérez and Carrascal 2000, 145). The urban and touristic development attracted labor force for the construction and services industries, with permanent or temporal patterns of residence which have changed the economy of the rural communities into a predominantly cash economy (INEGI 2000). This internal migration has resulted in a cash flow to the families that have remained in their communities (Iglesias 2011, 69).
(3) Urban concentration and expansion of the 'maquila' industry. New activities have also contributed to the transition of Yucatan from a predominantly rural society, dependent on agriculture, into an increasingly urban population concentrated in the State capital, laboring in sweat shops ('maquila industry') and services (INEGI 2000); Iglesias 2011, 69). Similar changes were experienced by the two counties where San Rafael and Uci are located, which experienced a decrease in primary activities from above 60% to below 20% in the lapse 1970–2000.
(4) NAFTA implementation. A fourth more recent macroeconomic factor may be the full implementation of NAFTA (North American Free Trade Agreement) (Arroyo and Loria 2012, 348). However, it is expected that Yucatan will be less affected by NAFTA, since it is in the Southeastern tip of the country farthest than any other Mexican State from the U.S. border.

Changes in dietary and physical activity appear to be the main transformations linked to the high prevalence of obesity and diabetes in rural Yucatan. The adult population of San Rafael and Uci consumed calorie-dense diets in 2000 (Table 3). Our findings agree with the dietary studies performed by Daltabuit and Leatherman (1998, 317) and Leatherman and Goodman (2005, 833) in the community of Yalcobá, located in the corn-producing area of the Yucatan Peninsula and in relative proximity to Cancun. These authors reported a transformation from self-production to a market economy in the area. We

believe these changes took place earlier in the hemp-producing areas in the Central and Western parts of the Peninsula since subsidies from the state-owned hemp industries antedated the Cancun tourist development.

The socioeconomic transition initiated in the 1960s appears to have changed the diet of rural Yucatan to a more varied and energy-dense diet with more fried than cooked ingredients (Table 3) when compared with other Mexican groups, including the corn producing area of rural Yucatan described by Leatherman and Goodman (2005, 833).

Conclusions

The near absence of diabetes and the high prevalence of nutritional deficiencies of the rural Maya population in the early sixties in comparison with the high prevalence of obesity and diabetes in 2000 were related to social, economic and cultural determinants of lifestyle changes that occurred in rural Yucatan during the period.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Fondo Nestlé para la Nutrición de la Fundación Mexicana para la Salud.

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