

## Type 2 Diabetes and Dietary Patterns 1961 to 2009: Some Social Determinants in Mexico

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### Abstract

*In order to analyze whether the increase in mortality from diabetes in Mexico is related to changes in eating patterns over the period 1961 to 2009, and if they in turn could be explained in the Mexican socioeconomic context, we conducted an ecological study with information from the Food Balance Sheets FAO. A cluster analysis was performed to shape eating patterns (three) and some socioeconomic variables were analyzed. It was observed that the energy derived from cereals and legumes (beans) was significantly reduced, and simultaneously, energy from sugars, animal foods, and vegetable fats had a significant increase. Various socioeconomic conditions may have favored changes in diet and increased mortality from diabetes. These conditions are: trade liberalization, low growth, rising inequality and informal work, declining agriculture, falling real wages in relation to the value of what is called the "basic food and non-food baskets"; increasing prices of healthy food, low cost of processed foods and beverages, and the lack of control in the food market. (Gac Med Mex. 2015;151:330-43)*

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### Introduction

Type 2 diabetes shows a continued increase in all nations of the world. World statistics allow to conclude that this is not only affecting the most socially disadvantaged population in countries of middle and low income, but this is also observed in countries with high income. According to the World Federation of Diabetes, in 2013 there were 382 million people with diabetes in the world (8.3% of adults) and by 2030, 592 million will be likely to be affected. Eighty percent of the cases belong to middle and low income countries, and 175 million people with diabetes are undiagnosed. It is

becoming increasingly common in young individuals. Most people with diabetes are between 40 and 59 years of age. World-wide, diabetes caused over 5 million deaths in 2013<sup>1</sup>. Type 2 diabetes has been widely documented to be one of the main causes of disease, disability and death in Mexico and it has turned into a public health problem in the world, with the resulting challenges for its prevention, detection and control. Since this is a chronic-degenerative disease, it requires permanent care<sup>2</sup>. Short- and long-term complications require medical attention and specialized treatments, which implies for its attention to entail considerably high costs. The burden of diabetes is huge in terms both human and financial<sup>1</sup>. Losses of 264 thousand

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healthy years of life and 171 thousand due to disability have been documented in people with diabetes older than 45 years. It has represented approximately 548,000 million dollars in health expenditure (10.8% of total expenditure in the entire world) in 2013<sup>1</sup>. In Mexico, direct costs for attention of this disease in all institutions of the health sector and private insurance companies were reported to add up to \$ 343,226,541.00 Mexican pesos in 2011<sup>3</sup>.

Repeatedly, it has been pointed out that in the increased frequency of diabetes, in addition to the genetic component, lifestyle changes have mainly influenced, since westernization of customs has brought along modifications in environmental, cultural, behavioral, economic and social factors, such as dietary patterns and sedentarism which, together with population aging and increased obesity, might explain its epidemic behavior<sup>4-7</sup>. Populations dietary patterns, understood as a component of social determinants of health<sup>1,4-7</sup>, are driven, among other aspects, by socio-economic conditions resulting from public policies implemented in Mexico in the past decades, which have followed indications of the so-called Washington Consensus<sup>8,9</sup>, which have been put into practice in Mexico since 1983, promoting economic globalization. Therefore, focusing on social determinants of health, this work pretends to analyze if the diabetes-associated mortality increase in Mexico in the period from 1900 to 2012<sup>5,10</sup> is related to changes in dietary patterns and whether these, in turn, could be explained by economic growth (rate of per capita GDP), GDP composition by sectors, income distribution evolution, rates of informal employment, level of poverty, behavior of real and nominal minimum wage and relative prices of some foods.

## Material and methods

As part of a line of investigation on dietary patterns<sup>11</sup>, an ecological time trend study was carried out using data of the food balance sheets (FBS) published by the FAO<sup>12</sup>. In order to group the years whose apparent consumption of foods would have been homogeneous over the period from 1961 to 2009, dietary patterns were established by means of hierarchical clusters analyses based on the energy provided by each food, with regard to kcal/person/day. Then, the Kruskal-Wallis test was used to determine if differences in the consumption of kcal/person/day between patterns were statistically significant. In addition, kcal/person/day means were calculated, as well as the proportion

of energy intake with each established dietary pattern. Then, dietary patterns were organized according to the groups of foods comprising them<sup>11</sup>.

FBSs allow for availability of foods in one country (also known as apparent consumption or mean apparent food consumption) to be estimated. They show estimates on the amounts and groups of the main foods for human consumption in different countries and per year. Consequently, in this text, the expressions "food consumption" or "dietary intake" should be understood as foods available for consumption. The reported values are a ratio constructed based on the difference between the production of a certain food plus importations minus exportations, together with its use as animal food, and the result is divided by the population. Therefore, food availability does not provide information on access and effective consumption of food, especially in terms of differences by population groups: age, sex, and locality. However, since FBSs are produced each year, they allow for comparisons between different countries to be established or else to describe food consumption trends in a country over the course of time<sup>13</sup>.

Diabetes-associated mortality rates were obtained from mortality statistics by the INEGI<sup>14</sup> for the years 1990, 2000 and 2012, using the database generated by interactive consultation, where mortality data are expressed by year of registration, age and sex, among other variables. Rates were calculated per each 100,000 inhabitants according to the reported age-group, with the population projections of the CONAPO (1990-2050). From 1990 to 1997, the rates were obtained based on all diabetes-associated deaths, which included: 2,500, diabetes mellitus with no complications mentioned; 2,501, diabetes with ketoacidosis; 2,501, diabetic coma; 2,502, diabetes with renal manifestations; 2,504, diabetes with ophthalmic manifestations; 2,505, diabetes with neurological manifestations; 2,506, diabetes with peripheral circulatory disorders, and 2,507, diabetes with other specified manifestations. For 2000 and 2012 rates, only type 2 diabetes-associated deaths were considered (E110 to E119). This difference, where two periods are compared – one from 1990 to 1997 and the other from 2000 on – is because there were changes in the classification of diabetes from 1998 on. In the first period (1990-1997), type 1 diabetes-associated deaths cannot be separated from those associated with type 2 diabetes (ICD-9); however, after the adoption of the new international classification of disease (CIE-10), this division is possible without any problem.

The reviewed socioeconomic variables were:

- GDP composition by sector from 1970 to 2012 (World Bank World Development Indicators)<sup>15</sup>.
- Economic growth; per capita GDP growth rate from 1950 to 2012<sup>16</sup>.
- Income distribution evolution in Mexico from 1984 to 2010<sup>17</sup>.
- Labor informality evolution in Mexico from 1992 to 2010; the percentage of workers serving in establishments with 5 or less employees (economic informality) and the percentage of workers with no right to a pension when they retire (informal employment) were analyzed<sup>18</sup>.
- Evolution of poverty<sup>19</sup>.
- Based on information by the INEGI<sup>20</sup>, the real minimum wage was calculated with respect to the Consumer Price Index, which was obtained based on the nominal minimum wage (SMN – *Salario Mínimo Nominal*) deflated by the national consumer price index (INPC – *Índice Nacional de Precios al Consumidor*) (SMN/INPC) and the real minimum wage (SMR – *Salario Mínimo Real*) with respect to the food, beverages and tobacco (ABT – *Alimentos Bebidas y Tabaco*) component of the INPC (ABT-INPC) (SMN/ABT-INPC).

Even though the above described indicators are illustrative, they exhibit an important weakness, since both the basket of products considered in the INPC and the basket of food, beverages and tobacco include products that are not part of the satisfactors acquired by the poorest population. Accurate measurements of both types of basic basket as defined by the CONEVAL were used<sup>21</sup>: the CBA (Food Basic Basket) and the CBNA (Non-Food Basic Basket). The first is comprised exclusively by food and non-alcoholic beverages. The food basket plus the non-food basket include a minimum series of products and services. This is also because these baskets serve as a basis to determine if a person is poor or not by comparing his income with the cost of the basic basket. According to CONEVAL, when a person's income is compared with the cost of the food basket, if the former is lower (or higher), the person is defined as suffering (or not suffering) alimentary poverty. When a person's income is compared with the cost of the food basket plus the health and education expenses contemplated in the CBNA, the person is determined as being poor or not in his capabilities and, finally, when total cost of the CBNA is compared with a person's income, the person is determined as suffering patrimonial poverty or not. With this information, the nominal minimum wage deflated by the

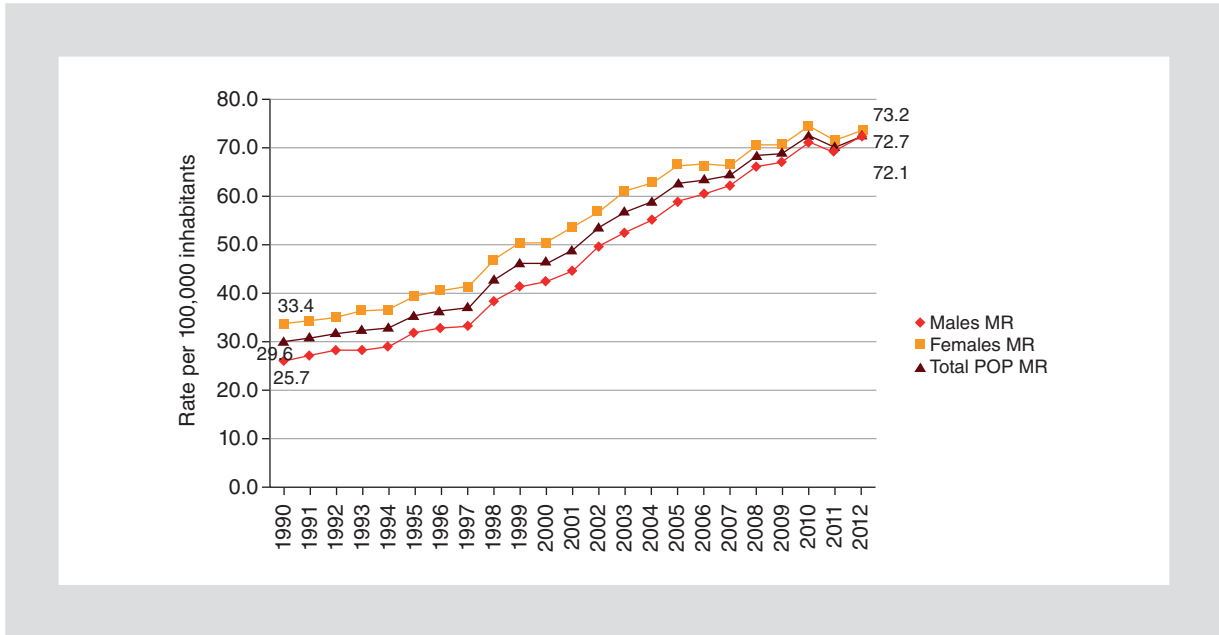
cost of the CBA was calculated: PCBA (SMN/PCBA), as well as the nominal minimum wage deflated by the cost of the CBNA: PCBNA (SMN/PCBNA) from 2004 to 2013. The variable was constructed to show how many CBA and CBNA can be bought per nominal minimum wage per month. In addition, the relative price of a food with regard to another was calculated by dividing the price of food A by the price of food B and, this way, the relative price of corn tortillas, beans and fresh fruit with regard to the price of sodas and potato chips was obtained. For this, on one hand, average prices of 2000 and 2001 were calculated and compared with average prices of 2012, and on the other, the quadratic trend of the corresponding series (polynomial) was analyzed.

## Results

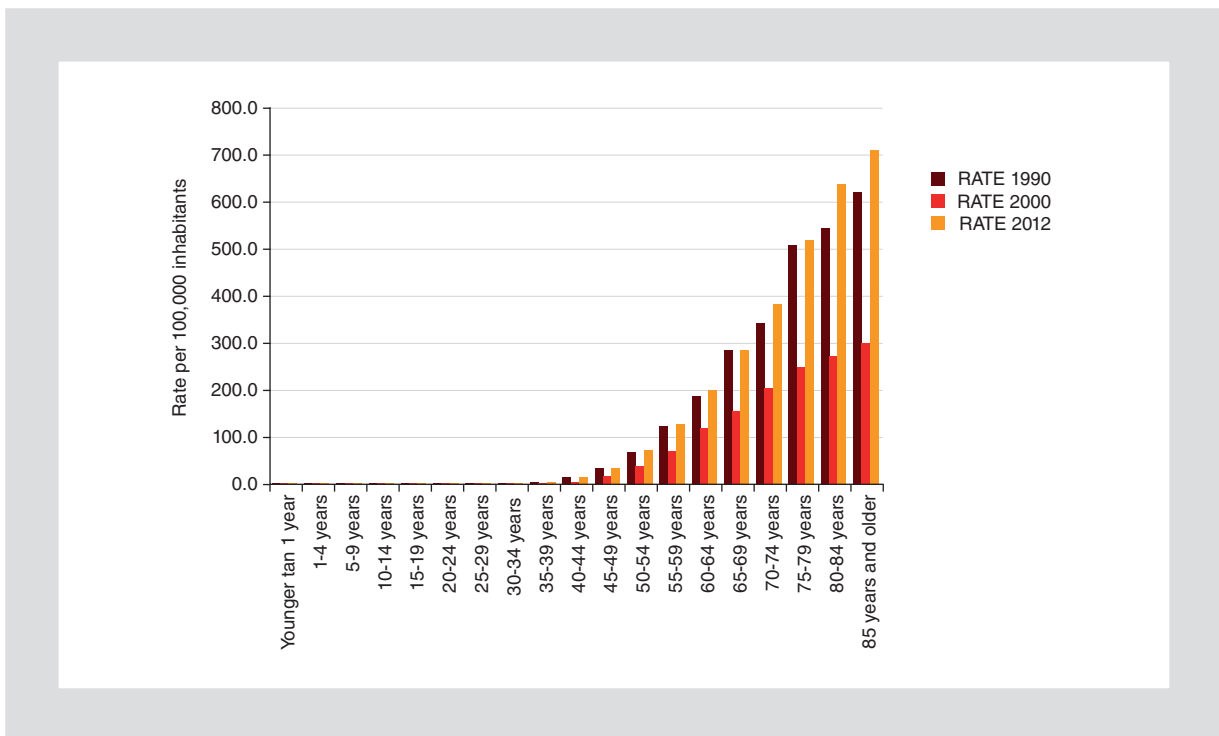
The evolution of type 2 diabetes-associated mortality in Mexico has followed an ascending curve over the past 20 years; it has passed from a mortality rate of nearly 30 per 100,000 inhabitants in 1990 to a rate of more than 70 per 100,000 inhabitants in 2012. It is slightly higher in females, although the difference in rates by sex has shortened: in 1990, the mortality rate was 33.4 and 25.7 in females and males, respectively, and by 2012, a 73.2 rate was observed for females and 72.1 for males (Fig. 1). For the above data, total of diabetes-associated deaths was used since, as previously mentioned, before 1998, separating the rates by type of diabetes was not possible. With regard to age, in 2012, in the group under 35 years, diabetes accounted for a bit more than 1% of deaths. Among people aged from 35 to 44 years, it accounted for 3.3% of total. In the group of 45 to 64 years of age, it was the leading cause of death, and a third part of deaths from this cause were concentrated in this group. The population of 65 years and older showed a little over 15% of total deaths, and practically 3 out of every 5 deaths from the disease (52,367) in the entire national population were recorded in this age group. That is, deaths were observed to occur in younger people from 2012 on. In 2012, 74.3% of type 2 diabetes-associated deaths occurred in people of 60 years or older and people aged 50 years or more contributed with 92% of total deaths recorded that year for type 2 diabetes (Fig. 2).

## Dietary patterns

By means of hierarchical clusters analysis, the diet of Mexicans over the last 5 decades was defined in



**Figure 1.** Diabetes-associated mortality rate, overall and by sex, in Mexico, 1990-2012 (INEGI mortality statistics 1990-2012. Rates were calculated based on Projections of CONAPO, 2010-2050. Mexico, 2014).



**Figure 2.** Diabetes-associated mortality rate, overall and by sex, Mexico, 1990, 2000 and 2012 (INEGI, mortality statistics, 1990, 2000 and 2012. Rates were calculated with population projections of CONAPO (1990-2050) and were calculated for each 100,000 inhabitants according to the reported age group).

3 alimentary patterns (Table 1). The Kruskal-Wallis test was used to determine that there were statistically significant differences ( $p < 0.001$ ) in mean kcal/person/day consumption between the three obtained patterns. Apparent kcal/person/day consumption

increased over the studied period and within each pattern: in pattern I (from 1961 to 1974), kcal/person/day increased from 2,316 to 2,703, representing an increase of 387 kcal/person/day. In pattern II (from 1975 to 1988) kcal/person/day increased from 2,782 to 3,073, denoting

**Table 1. Alimentary patterns: Measurements of alimentary energy input (kcal/person/day) per period and proportion of each food in the alimentary patterns**

Pattern	I		II		III	
	1961-1974		1975-1987		1988-2009	
kcal/person/day	2495.6	%	3014.8	%	3132.8	%
Food						
Corn	1078.7	43.2	1093.0	36.2	1066.4	34.0
Sugar	315.9	12.6	438.4	16.0	483.5	15.4
Wheat	246.0	9.8	315.2	10.4	280.0	8.9
Beans	146.9	5.8	135.5	4.5	107.8	3.4
Vegetable oils	140.1	5.6	224.1	7.3	257.0	8.2
Milk	110.3	4.4	161.8	5.3	155.0	4.9
Pork	90.5	3.6	149.7	4.9	105.3	3.5
Fruit	80.9	3.2	99.9	3.3	107.2	3.4
Rice	44.3	1.7	51.2	1.6	54.3	1.7
Alcohol	36.6	1.4	50.5	1.6	59.5	1.8
Beef	30.6	1.4	39.5	1.3	54.9	1.7
Animal fat	28.5	1.1	51.4	1.7	69.7	2.2
Nuts	24.9	0.99	23.5	0.77	23.6	0.75
Green vegetables	17.1	0.68	25.9	0.85	39.2	1.2
Eggs	17.1	0.68	29.7	0.98	51.1	1.6
Poultry	16.2	0.64	26.9	0.89	75.9	2.4
Potatoes	13.5	0.54	19.4	0.64	24.5	0.78
Butter	7.2	0.28	12.0	0.39	13.0	0.41
Fish	5.9	0.23	15.2	0.50	20.5	0.65

Prepared by the authors based on the FAO's Food Balance Sheets. Food and Agriculture Organization of the United Nations. Statistical Databases, URL:<http://faostat.fao.org> 1961 to 2009.

an increase of 291 kcal/person/day), and in pattern III (from 1989 to 2009), kcal/person/day increased from 3,038 to 3,146, with an increase of 108 kcal/person/day.

When the composition of dietary patterns of Mexicans was organized by groups of food, it was clearly observed that while grains, root/tubular/bulb vegetables and legumes (beans) decreased, sugars, foods of animal origin and fats and oils were increased and fruits and green vegetables showed a slight increase (Table 2).

Alimentary pattern I was comprised on average by 2,495.6 kcal/person/day and was composed according to the following proportions: 57.7% grains (46.19% corn, 9.8% wheat and 1.7% rice), sugars (12.6%), 11% foods of animal origin (4.4% milk, 3.6% pork meat, 1.4% beef, 0.68% egg, 0.64% poultry and 0.23% fish), fat and oils

(5.6% vegetable oils, 1.1% animal fat, 0.28% butter), legumes (5.8% beans), 3.2% fruit, 0.68% green vegetables and 0.54% root/tubular/bulb vegetables (Tables 1 and 2).

Alimentary pattern II was comprised on average by 3,014.8 kcal/person/day, representing a more than 500 kcal/person/day increase with respect to the previous pattern and showed substantial modifications in the proportion of energy contribution provided by food: within the grains, corn remained as the most important source of energy; however, its apparent consumption decreased by 8%, whereas the consumption of wheat showed a slight increase. An important increase was observed in apparent consumption of sugars (16%), foods of animal origin (13.9%) and fats and oils (9.4%); particularly vegetable oils showed an important increase

**Table 2. Alimentary patterns according to the percentage of Kcal/person/day provided by groups of food**

Food	I %	II %	III %
Grains	57.7	48.1	44.6
Sugars	12.6	16.0	15.5
Animal products	11.0	13.9	14.8
Fats and oils (animal and vegetable)	7.0	9.4	10.8
Legumes	5.8	4.5	3.4
Fruit and green vegetables	3.9	4.2	4.6
Root/tubular/bulb vegetables	0.54	0.71	0.81

Prepared by the authors with study data. 2014.

(7.3%). Legumes (beans) were reduced together with root/tubular/bulb vegetables, while fruits and green vegetables showed a slight increase (Tables 1 and 2).

Alimentary pattern III was comprised on average by 3,132.8 kcal/person/day. Similarly, grains were the food group that provided more energy in the alimentary pattern (44.6%); however, corn continued to decrease (10% less than in the first pattern); although the consumption of wheat remained in third place, it showed a slight decrease with regard to the previous period, and rice showed a similar caloric contribution in all three patterns. Sugars remained in second place, but its contribution in kcal/person/year was doubled: from 247 kcal/person/day, it was observed to increase to 497 in the third pattern. Foods of animal origin were also increased with regard to pattern I from 11 to 14.8%: although milk has maintained a similar energy contribution in all three alimentary patterns, it has constituted the highest source among products of animal origin, and in the second and third pattern, it replaced beans. In the group of meats, pork has been the product with the highest caloric contribution in all three alimentary patterns. Both fish and poultry showed a 4-fold availability increase with regard to kcal/person/day contribution, with consumption of poultry showing an increase from 0.64 to 2.4% between the first and third period. Consumption of beef had a slight increase over time; however, the proportion of daily caloric input has been considerably low and egg contribution showed a more than 2-fold increase between the first and the third period. Fats and oils showed a considerable increase in their input; animal fat consumption, including butter, was increased to the double between the first and third pattern and especially vegetable oils were increased from 5.6% in the first pattern to 8.2% in the third, where they were almost matched with

wheat and were above pork meat, milk, fruit and beans. The latter showed a marked decrease in caloric input, reducing their contribution by almost 50% over the course of the studied period and even, as previously mentioned, in addition to being replaced by vegetable oils, they were also replaced by pork meat and milk. Fruit preserved its apparent consumption in a similar level in all three periods. Caloric input by root/tubular/bulb vegetables increased with regard to the first pattern. Along the studied period, the consumption of nuts was decreased and their availability was very low<sup>11</sup> (Tables 1 and 2).

### Socioeconomic context

Exponential per capita GDP growth rate in the 1950-1980 period was 3.25%<sup>22</sup>, whereas from 1981 to 2011 this indicator was reduced to 0.9% (Fig. 3). On this regard, table 3 shows the evolution of the Mexican economical structure over the last 40 years; it is important highlighting that, on one hand, a loss of participation of the agricultural sector in Mexican production is observed, which was reflected by an increased participation of the industrial and services sectors. On the other hand, it's important underscoring that the trade opening of Mexican economy went from 17.5% in the early 1970's to 65.3% in the 2010-2012 period. Therefore, the foreign trade ratio (imports plus exports as a proportion of the GDP) was increased 3.7 times.

In this sense, table 4 shows that income in the richest households systematically increased between 1984 and 1994; then, it decreased during the decade of 2000. In 2010, more than 56% of the income was concentrated in 20% of the richest households, whereas 20% of the poorest households concentrated barely 4.9% of the income. Gini's coefficient grew after 1984, was maintained at elevated levels, and decreased between 2000 and 2010.

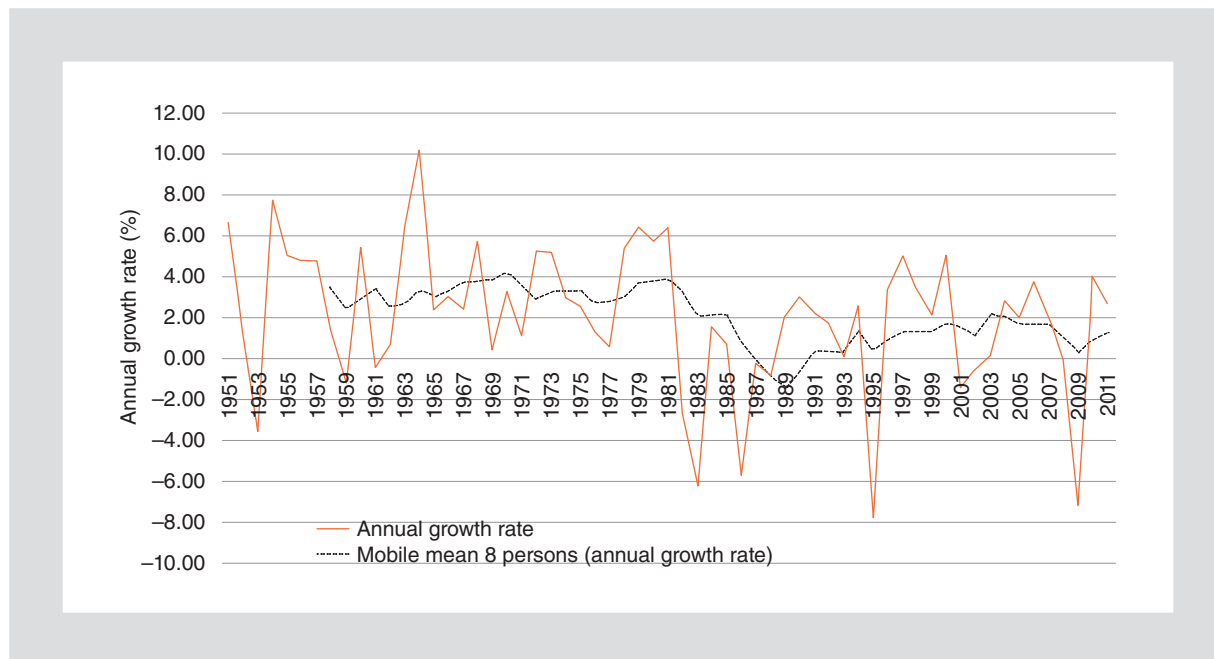


Figure 3. Economic growth (per capita GDP growth rate, 1950-2011) (World Bank [POVCALNet]).

Table 3. Production composition and trade opening (as a percentage of the GDP 1970-2012)

Year	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04	2005-09	2010-12
Agriculture	11.0	9.9	7.4	8.0	6.6	5.3	4.0	3.4	3.5
Industry	31.0	33.8	41.3	41.5	34.1	34.6	34.0	35.3	35.3
Servces	58.0	56.3	51.3	50.6	59.3	60.1	62.0	61.3	61.2
Foreign trade	17.5	20.1	25.6	33.2	36.5	61.5	56.8	57.1	65.3

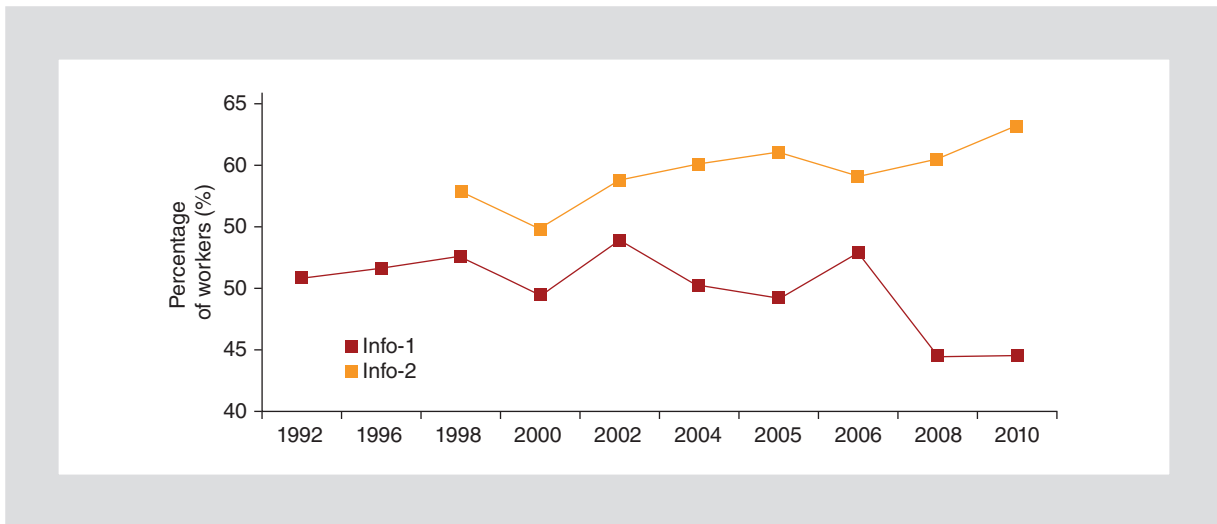
United Nations and WB-WDI (World Bank World Development Indicators). References: Industry includes the construction, mining and manufacturing sectors.

Table 4. Evolution of income distribution in Mexico (1984-2010)

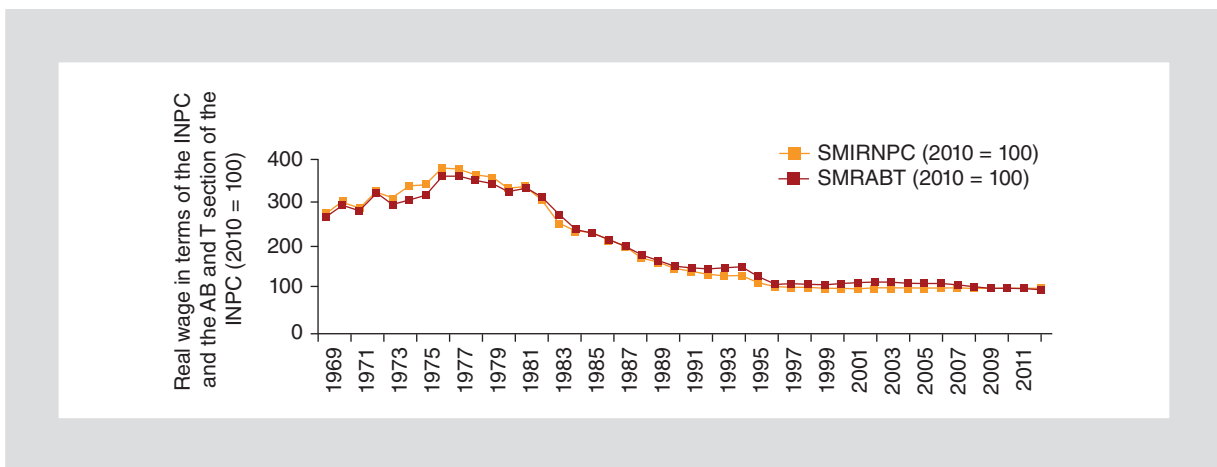
	1984	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010
I	1.9	1.6	1.7	1.7	1.6	1.6	1.8	1.7	2.0	1.8	2.0
II	2.8	2.5	2.5	2.7	2.5	2.4	2.6	2.9	2.8	2.9	2.9
III	3.8	3.4	3.3	3.7	3.6	3.4	3.6	4.0	3.8	3.8	3.9
IV	4.9	4.4	4.3	4.7	4.7	4.4	4.6	5.2	4.8	4.8	4.9
V	6.1	5.5	5.4	5.9	5.9	5.5	5.7	6.4	5.9	5.9	6.0
VI	7.5	6.9	6.7	7.2	7.3	6.8	7.0	7.7	7.2	7.2	7.3
VII	9.4	8.6	8.4	9.0	9.1	8.5	8.7	9.4	8.8	8.8	9.0
VIII	12.0	11.2	10.9	11.4	11.6	10.9	11.2	11.7	11.2	11.1	11.3
IX	16.6	15.8	15.4	15.7	16.1	15.2	15.5	15.5	15.4	15.0	15.2
X	35.1	40.3	41.5	38.0	37.7	41.4	39.4	35.6	38.3	38.7	37.5
Gini coeff.	46.3	51.1	51.9	48.5	49.0	51.9	49.7	46.1	48.1	48.3	47.2

World Bank (POVCALNet).





**Figure 4.** Evolution of labor informality in Mexico (1992-2010) (CEDLAS and World Bank. References: Info-1: percentage of workers serving in establishments with 5 and less employees; Inf-2: percentage of workers with no right to a pension when they retire).



**Figure 5.** Real minimum wage evolution (prepared by the authors based on the INEGI).

With regard to labor conditions, figure 4 shows the evolution of labor informality and economic informality (workers employed in small units characterized by low level of productivity and high instability). Clearly, economic informality was decreased, whereas labor informality was increased in the period.

From the above, it can be inferred, as shown in figure 5, that the real minimum wage has dropped from the early 1980's until the present day, *i.e.*, this indicator peaked in the late 1970's. In addition, it shows that when the economy was stabilized after the 1994-1995 crisis, the real minimum wage with regard to the general products basket as measured by the INPC did not recover. The same can be observed with regard to the wage measured in relation to the food, beverages and tobacco component of the INPC (SMRABT).

As to the evolution of nominal minimum wage in relation to the cost of the CBA and the CBNA, figure 6 indicates that the minimum wage had its purchasing power decreased by 16.4% between January 2004 and August 2013, which implies that the minimum wage could purchase 2 CBAs in 2004, whereas in 2013 was only enough to purchase 1.66 CBA. With regard to the CBNA, the purchasing power drop was lower; in this case, it lost only 4.4%. Poverty decreased after the peso crisis (1994-1996): between 1996 and 2005, the economy had a brief period of growth, as shown by figure 7. However, from 2006 on, poverty measured in its three dimensions was increased and in 2012 reached values similar to those in 1992-94. The evolution of the relative price of corn tortillas, beans and fresh fruit with regard to the price of sodas was analyzed in



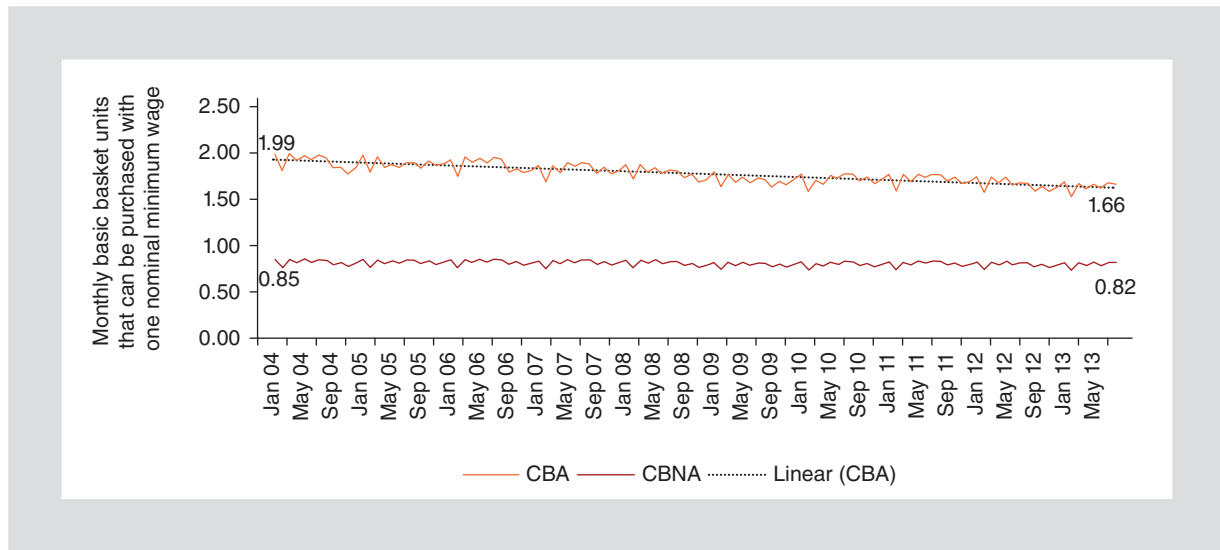


Figure 6. Nominal minimum wage evolution with regard to the cost of CBA and CBNA (prepared by the authors based on INEGI, CONEVAL).

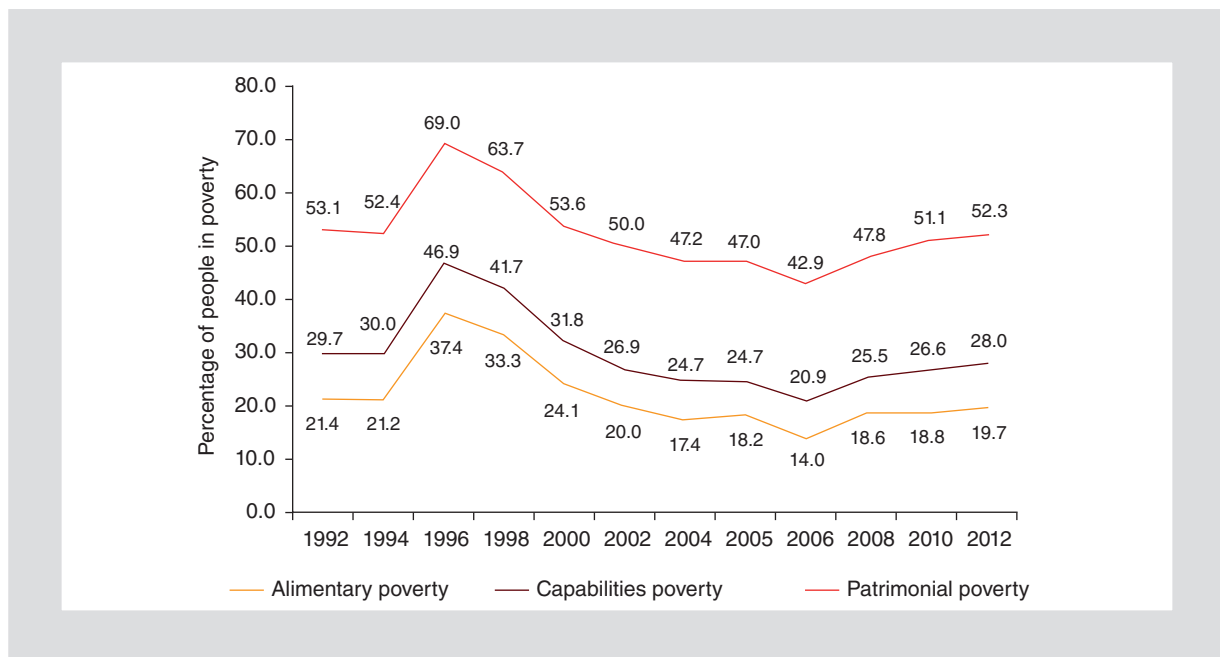


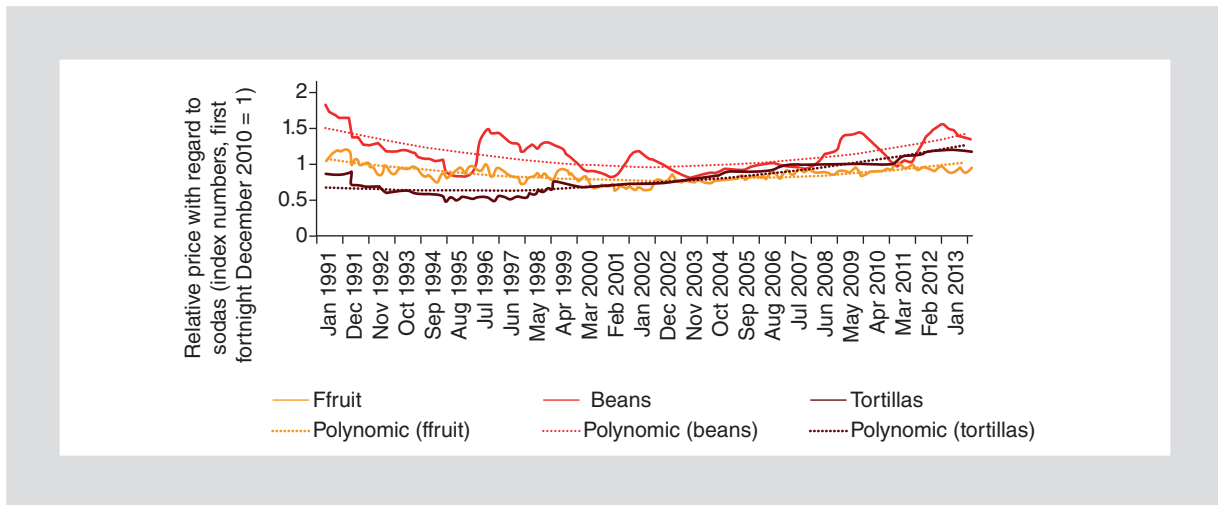
Figure 7. Percentage of people in poverty by income dimension 1992-2012 (CONEVAL).

this context. From 1991 to the early 2000's, the trend of relative prices was decreasing in all three cases. From 2002 to the present day, the prices of corn tortillas, beans and fresh fruit have increased with regard to sodas, i.e., the price of sodas has decreased in relation to corn tortillas, beans and fresh fruit (Fig. 8). Taking the same comparison years, and although with less acute variations, the prices of fresh fruit, beans and corn tortillas were observed to also increase with regard to potato chips (Fig. 9). Table 5 shows 2000 and 2001 average prices compared to average of prices in

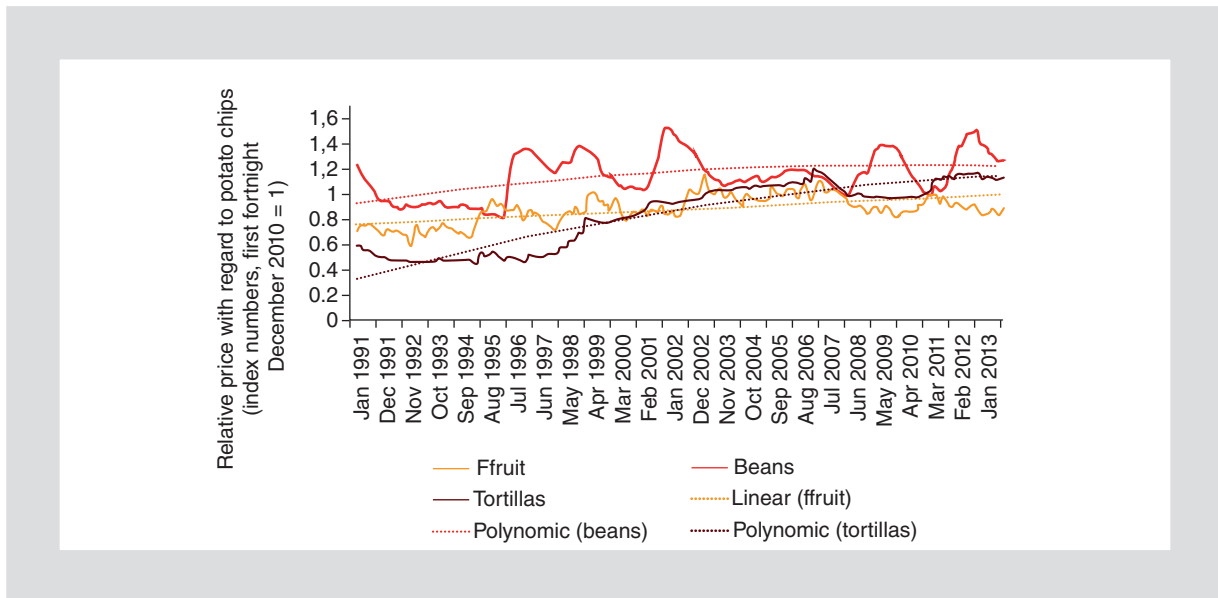
2012; with regard to sodas, the relative price increase of tortillas was 71.8% and that of beans, 60.1%, whereas the price of fresh fruit increased by 33.4%. In the case of potato chips, the increase was lower: 2.9% vs. fresh fruit, 23.1% vs. beans and 32.2% vs. corn tortillas.

## Discussion

Diabetes in Mexico has shown a considerable increase; in 1990, diabetes-associated deaths accounted for 6.1% of total deaths and by 2012 they increased



**Figure 8.** Relative price of fresh fruit, beans and tortillas with regard to sodas (prepared by the authors based on the Income and Expenditure on Food Survey 1991-2102. Instituto Nacional de Estadísticas, Geografía en Informática. [Polynomic refers to the quadratic trend of the corresponding series]).



**Figure 9.** Relative price of fresh fruit, beans and tortillas with regard to potato chips (prepared by the authors based on the Income and Expenditure on Food Survey 1991-2102. Instituto Nacional de Estadísticas, Geografía en Informática. [Poly. refers to the quadratic trend of the corresponding series]).

**Table 5.** Fresh fruit, corn tortillas and beans relative prices evolution with regard to sodas and potato chips

Average Prices	Sodas			Potato chips		
	Ffruit(S)	Beans(S)	Tortillas(S)	Ffruit(PC)	Beans(PC)	Tortillas(PC)
2000-2001	0.67	0.91	0.68	0.84	1.10	0.85
2012	0.90	1.45	1.16	0.86	1.40	1.12
var. %	33.4%	60.1%	71.8%	2.9%	23.1%	32.2%

Ffruit: fresh fruit; R: indicates that it is the price of this product relative to sodas; PC: relative price of this product with regard to potato chips. Relative prices are index numbers with the first fortnight of December 2012 equal to 1. Prepared by the authors based on data issued by INEGI.

to 14.1%. Since the year 2003, around 400,000 new cases have been recorded every year<sup>4</sup>. Since 1997, an important progression of the disease has been observed, to the extent that since the year 2000, type 2 diabetes has been the leading cause of death<sup>4</sup>. World statistics allow concluding that the frequency or magnitude of type 2 diabetes keeps growing and will continue to increase if adequate measures are not taken. In Mexico, the increase in obesity and overweight will add more risk conditions for the adult population.

In this study, some socioeconomic conditions of Mexico that preceeded the era when type 2 diabetes was declared a rapidly rising epidemic (1997) and that could have favored transformations in Mexicans' diet could be identified. The changes in dietary patterns that have been observed are due to many causes; following with the focus on social determinants, it is possible to demonstrate that most of them run in parallel with the evolution of the Mexican economic structure, which has been marked over the past 30 years by a capital account liberalization, trade opening and retreat of the State from economic activity<sup>8,9</sup>. By middle of the 1980's, Mexican economy started a process of intense economic opening that reached its highest point with the signing of the North American Free Trade Agreement (NAFTA)<sup>23</sup>. This model was born with the purpose of achieving sustained economic growth, stability of prices (prices of foods was increased by 87% world wide; in particular, international price of corn was increased by 181%) and to promote the highest levels of wellbeing for the population. However, it has not yielded the projected results, since there has been no economic growth (Fig. 3), general life conditions of the population have not improved and neither is income distribution more equitable. From 1982 to the present date, not only has equity not been promoted, but it went backwards and inequality was increased (Table 4). As previously mentioned, agriculture has been poorly subsidized, which has promoted farmers' migration and abandonment of this activity (Table 3); only informal and uncertain jobs have been created (Fig. 4) and real and nominal minimum wages have been reduced (Figs. 5 and 6)<sup>24</sup>. This has represented elevated social costs for the country, with a resulting increase in poverty (Fig. 7), larger social gap and consolidation of small economic groups (Table 4).

As a result of these conditions, intermediate determinants have been strongly modified, i.e., those of cultural and behavioral nature, such as changes observed in ways of life typical of modernity: industrialization, urbanization and globalization<sup>4,5,25-28</sup>. Thus, an

increasingly sedentary existence, shaped by automatized ways life and with fewer opportunities for physical activity, either in daily life, working life or in leisure time, has been established. This, added to proximal determinants such as genetic factors, aging, body fat distribution and ethnicity, allow for the increase of diabetes and other chronic conditions to be explained.

With regard to the diet, in Mexico and other countries of the world, consumption habits have been modified to such an extent that, as observed in this study, traditional diet has been abandoned, since the availability of grains, root/tubular/bulb vegetables and legumes (beans) has decreased (Table 2). And on the other hand, another diet, based on the consumption of simple carbohydrates or refined sugars, saturated fats and vegetable oils, has been adopted (Tables 1 and 2)<sup>11,30-33</sup>. The FAO has reported that between 1990 and 2010, the world saw an increase of approximately 210 kcal/person/day in dietary energy intake. The increase was higher in developing countries (275 kcal/person/day) than in developed countries (86 kcal/person/day). In developing countries, the highest increases in absolute figures were from 260 to 270 kcal/person/day and were observed in Asia, where the rhythm of economic growth was accelerated, and in Latin America and the Caribbean, whereas in Oceania and Sub-saharian Africa, where economic growth was slow, the increase was lower than 130 kcal/person/day<sup>32</sup>. With this regard, in this period (1988-2008), average increase in Mexico was only 108 kcal/person/day, which could be explained by the increase of poverty from 1994 to 1996 caused by the peso crisis (1994-1995). Although the economy had a brief boom from 2000 to 2005, since 2006, poverty measured in its three dimensions was increased in Mexico (Fig. 7). According to the economic growth of the country, in previous periods there was a higher increase in kcal/person/day; from the year 1961 to 1974, this increase was 387 kcal/person/day, and from 1975 to 1987, 291 kcal/person/year. Hence, this correspondence is consistent with the per capita GDP rate exponential growth in the 1950-1980 period, which was 3.25%, whereas in the 1981-2012 period, Mexican economy experienced a strong deceleration and the GDP was reduced to 0.9% (Fig. 3). It is important to highlight that, since the late 80's, Mexican population showed an apparent consumption of kcal/person/year higher than those recommended (on average, 2,000 for females and 2,200 for men) and than those projected for the years 2015 and 2030 in the world: 2,940 and 3,050 kcal/person/day, respectively, and for Latin America and the Caribbean in the same years: 2,980

and 3,140 kcal/person/year<sup>34</sup>. However, this doesn't reflect the large differences existing in the country in terms of expenditure on food by levels of income<sup>11</sup>. In addition, as previously mentioned, this high kcal/person/day apparent consumption was mainly driven by the increase in products of animal origin and especially in sugars, with the later providing approximately 14% of total calories in the studied period, much higher than the values recommended by the WHO (10% or less), which allows for the substantial increase in obesity and diabetes some years later (1997) to be understood. Thus, due to the velocity dietary patterns and traditional ways of life are changing in many middle and low income countries, it is not surprising that chronic diseases (heart diseases, hypertension, stroke and diabetes) are penetrating as serious epidemics and, as Drewnowsky and Popkin point out, the world epidemics of diabetes and of the diseases it carries, is not a problem that is limited to industrialized countries<sup>35</sup>. It is worth mentioning that the diet is considered in diabetes as a contributor for its onset, on one hand favoring the development of obesity and, on the other, through its composition. It cannot be affirmed that there are diabetogenous foods; however, there is evidence, emerging from laboratory and epidemiological studies in different populations, that a high energetic-density diet, rich in fats (especially saturated), high in refined and simple sugars and poor in complex carbohydrates (fiber) entails a decrease in glucose tolerance and insulin sensitivity, and in addition, it presumably unmasks some genetic predisposing factor<sup>6,7</sup>. Moreover, dietary patterns based on high consumption of fruit and vegetables have been documented to reduce the risk of developing diabetes<sup>34</sup>. In addition, the consumption of abundant amounts of sugar generates serious homeostatic problems in the organism, disrupts the hunger-satiety mechanisms and causes addiction<sup>36</sup>, obesity, hypertension and diabetes<sup>37-39</sup>. In Mexico, the expenditure in sugar has been observed to be considerably higher in the group of people with lower income; furthermore, this group of persons spends more in sodas (non-alcoholic beverages) than in milk. Poverty and diabetes can be clearly regarded as being associated with lower expenditure on healthy food and low consumption of fruit, lean meat, fish, etc. Low income groups consume foods of lower quality, low cost and high caloric content<sup>11</sup>.

According to the above, the real wages drop with regard to the CBA and CBNA allows understanding why, in the poorest tables, fresh fruit, beans and corn tortillas, whose price has disproportionately increased,

have been replaced by low-cost processed and ultraprocessed foods and beverages with elevated contents of saturated fats, rich in salt (sodium chloride and glutamate) and sugars (Figs. 8 and 9 and Table 5), little or no nutritious and that considerably contribute to overweight and obesity and, consequently, to diabetes and other chronic diseases<sup>40,41</sup>.

According to Mintz, it is important pointing out that the increase in sugar consumption is associated with the amount of processed foods that have invaded the market in the last decades, since due to its versatility, sugar is used to make sodas "thicker", make baked bread smooth, stabilize chemical contents of salt, reduce acidity of food, delay bread hardening and inhibit bacterial growth and, therefore, it is used as a preservative<sup>42</sup>. This reflects, on one hand, the lack of control of the market, which, with its policies, promotes the consumption of processed foods that are deleterious for health (Figs. 8 and 9 and Table 5)<sup>43,44</sup>. Nevertheless, access to these products is differentiated: while processed foods have an extensive and uncontrolled distribution in vast and heterogeneous social settings, access to the market and to the consumption of nutritious foods is every day more excluding<sup>45,46</sup>. On the other hand, the importance of consuming a diet based on fruit, vegetables, legumes and local food is little diffused, which has promoted for the traditional diet to be abandoned, as shown in tables 1 and 2. This may be directly related to Mexico's economic structure: loss of participation of the agricultural sector in production, trade opening and reduction of subsidies to the prices of food. In the same sense, it should be observed that the real minimum wage peaked in the late 1970's and started to drop after the implementation of adjustment policies carried out by the Mexican government due to the external debt crisis that initiated in August 1981. Figure 5 shows that the poorest workers were most affected by the adjustment policies implemented in the 1980's, which is known as the lost decade<sup>47</sup>. The same could be observed with regard to the minimum wage measured in relation to the food and beverages component of the INPC. On the other hand, the minimum wage saw its purchase power be reduced by 16.4% between January 2004 and August 2013, thus implying that, in 2004, the minimum wage could purchase 2 CBA, whereas in 2013, it was only sufficient to purchase 1.66 CBA (Fig. 6). Furthermore, according to information from the INEGI, 60% of Mexican workers have been documented to work in informality conditions and, between 2010 and 2013, this indicator has remained constant.

With regard to income distribution, it can be said that it increased; however, the Gini coefficient remains elevated, indicating a regressive income distribution. It grew after 1984, remained at elevated levels and decreased between 2000 and 2010 (Table 4). The literature has pointed out two main causes for the decrease in the Gini coefficient: first, social programs such as the Program for Human Development-Opportunities (PDH-O – *Programa de Desarrollo Humano-Oportunidades*), and second, a decrease in the wage premium for qualified work<sup>48</sup>. In this sense, it should be highlighted that with regard to economic policies implemented by the Mexican government over the past 20 years, the most important social protection programs are PDHO, senior citizens, scholarships and PROCAMPO<sup>49</sup>. Of these, the PDHO program has the reduction of poverty as its primary goal, and was implemented in 1997. Levy highlights that PDHO was an innovative program when it first started, since: “It proposed to substitute income transfers by means of generalized or directed alimentary subsidies (through price discounts, price controls, distribution of food in kind and other similar mechanisms) by income monetary transfers, thus granting beneficiary families total freedom in their expenditure decisions”. It made the delivery of monetary transfers conditional to the adoption of certain behavioral patterns by beneficiary households. In one package, it combined benefits related to nutrition, health and education in order to exploit their complementarities. It adopted a long-term approach to social care. It included assessments of operations and impacts of the program as part of its design. It applied strict standards for the selection of beneficiaries. It delivered the benefits directly to the beneficiaries, without the participation of “intermediaries”<sup>50</sup>. By the end of 2005, the PDHO covered 24% of the country’s population; by 2013, its coverage reached 24.35 million people<sup>50,51</sup>. In spite of advances in social programs, alimentary poverty remains as a structural problem of complex resolution, as shown by figure 7. The explanation for the prevalence of poverty in Mexico during 2006-2012 is multiple, and clear inefficiency in the application of social programs should also be added. In this sense, the CONEVAL has pointed out that the PDHO was not a good instrument to deal with the recent crisis because it is a program of structural, not circumstantial, nature<sup>49</sup>.

Thus, it can be concluded that in the Mexican population, the problem of diabetes and the change in patterns of consumption are due to conditions of poverty. Of the previously mentioned observations, it

should be highlighted that minimum wages have increased less than the prices of food over the years 1976 to 2010. Additionally, real mean wages grew, but they did not reach their level prior to the 1994 crisis<sup>22</sup>. For its part, economic growth has become stagnant, mainly from 2001 to the present day.

The information presented in this study shows that it is reasonable further investigating and with more specific quantitative instruments, to what extent the changes in alimentary patterns and their impact on diabetes increase are related to statistical evidence on the identified socioeconomic conditions.

In this sense, to poverty, to the still low coverage rate of the Mexican education system (80%, when in countries with high human development as that of Mexico is 92%)<sup>52</sup> and to the lack of education on how to have a healthy diet, we have to add the negative effect of food and beverages advertising that presents as being nutritional products that in reality are substances that affect health. According to observations in this study, it is fundamental taking into account that solutions require profound changes in public policies associated with the system of production, distribution and consumption of foods and the physical setting. It is very important for economic measures directed to the reduction of poverty to be identified, and for effective investments to be made, as well as regulations in public policies that allow for ways of life to be improved. It is priority to implement vigorous educational policies at the social level, in order to promote the traditional diet: the consumption of fruit, vegetables, grains and legumes to substitute the ingestion of caloric sweeteners and fat. Technical training of human resources is cardinal, but not enough. Although educational action is essential with regard to nutrition and exercise, people cannot be blamed for behaviors that have been insensitively but socially imposed on them, and their capability to decide and freely chose what to eat, has been mediated by their income, publicity and market offer. Therefore, in addition to population-directed dietary orientation, it is essential to promote its organized participation for the promotion of its own health; to collaborate in actions to regulate the alimentary industry, and at the local level, to redirect the sale of processed and ultraprocessed foods in convenience stores. The experience of Finland and other countries indicates that changes on alimentary habits are significant, more than the contribution of medication and surgery, and that these changes can be strengthened by the participation of the community. The example of North Karelia is quite demonstrative in this respect,



since heart disease mortality rates were extraordinarily reduced between the early seventies and 1995, an achievement largely attained owing to action by the community and pressure of the consumers' demand on the market of food<sup>53</sup>. Hence, the need for intersectorial actions to be implemented is clear, since this not exclusively a health problem. Inadequate nutrition and its relationship with conditions such as diabetes is a risk that affects not only health but economy as well and for this reason, alimentary topics should be a more active part of regulations by healthcare authorities. The magnitude of the problem of diabetes in terms of burden of care is not going to be solved with more and better pharmacological resources, but by addressing the socioeconomic determinants proposed in this study.

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