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Demographic and socio-economic shifts partly explain the Martinican nutrition transition: an analysis of 10-year health and dietary changes (2003–2013) using decomposition models

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Abstract

Objective: The Caribbean has seen a dramatic shift in the obesity and chronic disease prevalence over the past decades, suggesting a nutrition transition. Simultaneously, Martinique has faced a demographic transition marked by significant population ageing. We aimed to differentiate the contribution of changes in health status and dietary intakes due to shifts in demographic and socio-economic characteristics (DSEC) from that due to unobserved factors.

Design: Two cross-sectional surveys conducted in 2003 (*n* 743) and 2013 (*n* 573) on representative samples were used. Dietary intakes were estimated by 24-h recalls. The contribution of changes in health status and dietary intakes due to shifts in observed DSEC was differentiated from that due to unobserved factors over a 10-year interval, using Oaxaca–Blinder decomposition models.

Setting: Martinique, French region in the Caribbean.

Participants: Martinican adults (≥16 years).

Results: Over the study period, health status deteriorated, partly owing to shifts in DSEC, explaining 62 % of the change in the prevalence of hypertension (+13 percentage points (pp)) and 48 % of waist circumference change (+3 cm). Diet quality decreased (mean adequacy ratio –2pp and mean excess ratio + 2 pp) and energy supplied by ultra-processed food increased (+4 pp). Shifts in DSEC marginally explained some changes in dietary intakes (e.g. increased diet quality), while the changes that remained unexplained were of opposite sign, with decreased diet quality, lower fruits, tubers and fish intakes and higher energy provided by ultra-processed foods.

Conclusion: Explained dietary changes were of opposite sign to nutrition transition conceptual framework, probably because unobserved drivers are in play, such as food price trends or supermarkets spread.

Keywords
Nutrition transition
Caribbean
French West Indies
Dietary changes
Oaxaca–Blinder decomposition

Worldwide, first industrialised countries and then developing ones have experienced a nutrition transition[1,2]. This transition usually includes a major shift towards high intakes of saturated fats, sugars and refined foods, low intakes of nutrient-dense foods[3] and a more sedentary lifestyle, resulting in increased chronic disease prevalence[1]. Despite urgent public health issues in the Caribbean, including Martinique, due to very high obesity and chronic disease prevalence[4,5], little is known about the nutrition transition and its determinants in this area. The scant available studies show that energy availability in the Caribbean has increased continuously since the 1960s, owing to a growing availability of animal source foods, fats and oils and simple sugars, while complex carbohydrate source

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food availability has consistently declined[4,6–8]. Besides, no study has assessed changes in individual food consumption and nutritional status in this area.

The nutrition transition is known to be driven by rapid demographic, social and economic changes and growing urbanisation[1,2]. In recent decades, Martinique has experienced rapid ageing of its population due to the demographic transition combined with a migratory balance deficit caused by significant emigration of young adults[9]. Also, there has been an improvement in education level yet parallel with increased number of recipients of social assistance benefits[10,11]. However, these shifts in demographic and socio-economic characteristics (DSEC) are probably not the only drivers that have impacted the health status and food consumption of Martinicans: shifts in consumer habits and food environment are also well-known drivers of the nutrition transition[12]. The contribution of each driver, however, is difficult to disentangle and thus remains unclear. To better understand the nutrition transition process by evaluating the contribution of each driver on changes in health status, nutrient and food intakes in the French West Indies, we used decomposition methods. Indeed, these decomposition methods can differentiate the sources of changes over time or differences between two groups in outcome distributions into observed characteristics and unobserved factors[13–15]. Most of the literature use decomposition methods to study the disparities and inequalities between groups, including for health[16,17], and several studies used these methods to decompose the distributional changes in health status over time, mostly obesity, and to identify the contribution of individual variables, such as age or education level in these changes[18–20]. These decomposition methods have been used in some studies exploring the nutrition transition[15,21,22]. The results are interesting, showing that food expenditure and household size were main drivers of energy intake changes in Vietnam (2004–2014)[15], and dietary pattern changes in Bangladesh (1985–2010)[21] were partly explained by increased real per capita expenditure. In the USA, 20 % of dietary quality changes (1994–2010) were driven by shifts towards more ethnic diversity, more polarised income distribution and higher educational attainment[22].

In the light of the demographic and socio-economic changes in the Martinican population over the last decade, the current study aimed at differentiate the contribution of changes in health outcomes and dietary intakes resulting from shifts in observed DSEC from that due to unobserved factors, in Martinican adults (2003–2013).

Subjects and methods

Population

We used two cross-sectional surveys conducted in adults (≥16 years) of Martinique, a French overseas region: the Escal survey conducted in 2003, and the Kannari survey, conducted in 2013, described elsewhere[23–25]. Briefly, each survey was based on multistage stratified random sample of the Martinican population to describe food intakes, health and nutritional status. Sample selection was based on a three-stage cluster design (geographic areas, household and individuals in the household) for the Kannari survey and on a two-stage cluster design (geographic areas and household) for the Escal survey. To achieve identical designs and to guarantee the randomness, we randomly selected one adult per household in the Escal survey.

Data collection

Questionnaires regarding DSEC and qualitative food frequency (FFQ), covering the last 12 months, were administered at home through face-to-face interviews. Dietary data were collected using two non-consecutive randomly assigned 24-h recalls conducted by trained interviewers. The method used to estimate usual dietary intake was previously described elsewhere[25]. Briefly, we used the Multiple Source Method[26], estimating intakes using the amounts of consumption from 24-h recalls combined with consumption frequencies declared in the FFQ. Energy under-reporters were identified by the method proposed by Black[27] and excluded from the analysis, using a physical activity level of 1·55[27]. BMR was estimated using Mifflin equations[28].

Diet quality

We used a simplified version of the Programme National Nutrition Santé-Guideline Score2 (sPNNS-GS2), that reflects adherence to the 2017 French dietary guidelines: the higher the sPNNS-GS2, the more the diet complies with recommendations[29]. This score is based on large food groups, accessing the balance and variety of the diet through six adequacy components (fruits and vegetables, nuts, legumes, whole-grain food, milk and dairy product, fish and seafood) and six moderation components (red meat, processed meat, added fat, sugary products, drinks and salt). Additionally, we used mean adequacy ratio, corresponding to the mean percentage of the daily recommended intakes for twenty-three key nutrients, and mean excess ratio, corresponding to the mean percentage of the daily maximum recommended value for nutrients whose intake should be limited: Na, SFA and free sugars[30].

Finally, we estimated the percentage of energy intake provided by the ultra-processed food group using the NOVA classification[31].

Health status

Weight, height and waist circumference were measured in adults using standard procedures[32]. BMI was calculated and categorised: underweight or normal weight, overweight and obese[32]. Blood pressure was measured in adults using an automatic device and recorded as the mean of eight measurements (four sets of two consecutive measurements) with at least 1 min interval for the Escal survey and the mean of two consecutive measurements with at

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least 1 min interval for the Kannari survey. Hypertension was defined as a systolic blood pressure ≥140 mmHg and/or a diastolic blood pressure ≥90 mmHg[33], or as receiving antihypertensive drug treatment. Self-reported diabetes meant having been diagnosed by a physician.

Statistical analysis

Descriptive comparisons between Escal and Kannari participant characteristics were performed using Rao-Scott's χ^2 tests. Changes in health status, nutrient and food intakes between 2003 and 2013 were broken down using the two-fold Oaxaca–Blinder decomposition method[13,14] into one part 'explained' by shifts in DSEC between the two studied populations and another part that cannot be accounted for by such shifts. First, the change over time ($\Delta\overline{Y}$) of the mean outcome is the difference of the mean observed at two different point; here 2013 ($\overline{Y}_{2013}$) and 2003 ($\overline{Y}_{2003}$):

$$\Delta\overline{Y} = \overline{Y}_{2013} - \overline{Y}_{2003} \tag{1}$$

In the linear regression case, the outcome is related to a set of demographic and socio-economic characteristics, and thus the observed mean can be expressed as $\overline{Y}_{2003} = \overline{X}_{2003}\hat{\beta}_{2003} + \overline{\varepsilon}_{2003}$; with $\overline{X}_{2003}$ being the mean value of the explanatory variable (e.g. age, education), $\hat{\beta}_{2003}$ being the estimated regression coefficient and $\overline{\varepsilon}_{2003}$ capturing the residual influence of all the unobserved characteristics. Since the mean of $\overline{\varepsilon}_{2003}$ is by construction 0, the change we wish to study can be rewritten as

$$\Delta\overline{Y} = (\overline{X}_{2013}\hat{\beta}_{2013}) - (\overline{X}_{2003}\hat{\beta}_{2003}) \tag{2}$$

Alternatively, we can introduce a reference coefficient ($\hat{\beta}_R$), and thus decompose the studied change as

$$\Delta\overline{Y} = \underbrace{(\overline{X}_{2013} - \overline{X}_{2003})\hat{\beta}_R}_{\substack{\text{Composition}\\ \text{or}\\ \text{Explained}}} + \underbrace{\overline{X}_{2013}(\hat{\beta}_{2013} - \hat{\beta}_R) + \overline{X}_{2003}(\hat{\beta}_R - \hat{\beta}_{2003})}_{\substack{\text{Structure}\\ \text{or}\\ \text{Unexplained}}} \tag{3}$$

The latter part, the 'unexplained' contribution, can be attributed to shifts in unobserved factors. It also subsumes the effect of shifts that may occur over time in the relationship linking DSEC and the outcome variable. The two parts will be hereafter referred to as 'explained' and 'unexplained' rather than the classical terms used in the economics literature, namely 'composition' and 'structure', since these can have an interpretation directly linked to economic theory[34].

The decomposition was defined from the 2003 population standpoint: the predictors' population shifts were weighted by the coefficients of the 2003 population, i.e. $\hat{\beta}_R - \hat{\beta}_{2003}$:

$$\Delta\overline{Y} = \underbrace{(\overline{X}_{2013} - \overline{X}_{2003})\hat{\beta}_{2003}}_{\substack{\text{Composition}\\ \text{or}\\ \text{Explained}}} + \underbrace{\overline{X}_{2013}(\hat{\beta}_{2013} - \hat{\beta}_{2003})}_{\substack{\text{Structure}\\ \text{or}\\ \text{Unexplained}}} \tag{4}$$

The observed DSEC included in the models were sex, age, employment status, education, social assistance benefits, presence of child in the household, single-parent household and urban size. For models related to diabetes and hypertension, BMI was added.

To be representative of the Martinican population and guarantee the balanced data, sex-specific weightings based on age, education, marital status, birthplace, urban size and living in a chlordecone contaminated area, and additionally for the presence of at least one child in the household for 2013, were calculated using iterative proportional fitting procedure according to the French national census reports[35]. We used the 1999 census data for the Escal survey and the 2011 census data for the Kannari survey.

Statistical analyses were performed using STATA (14.1; StataCorp.), using Oaxaca package[36].

Results

Of the 1504 Martinicans (≥16 years) enrolled in the Escal survey (2003), 1353 subjects were eligible in 743 households (see online Supplemental Fig. 1). After random selection of one adult per household, 743 participants were included in the analyses. Among the 919 Martinicans (≥16 years) enrolled in the Kannari survey (2013), 573 subjects were included in the analyses (see online Supplemental Fig. 2).

Differences between the two samples include a lower percentage of individuals aged 16–45 years, a lower share of low-educated participants, and fewer participants living with children in the Kannari than in the Escal survey (Table 1).

Health status

The mean BMI increased by 1·2 kg/m^2 between 2003 and 2013, but this did not translate into a significant difference in the distribution of the samples across BMI categories (Table 2). While the overall shifts in DSEC did not significantly explain this change in the mean BMI, the decomposition analysis showed 33 % of the BMI change (0·4 kg/m^2) was accounted for by the shift in age distribution (Fig. 1). The mean waist circumference increased by 3·2 cm, of which 48 % was accounted for by shifts in DSEC, mainly age (data not shown). The hypertension prevalence increased by 13·4 percentage points (pp), decomposed into: (i) a 8·3 pp increase explained by shifts in DSEC, mainly driven by age (accounting for a 6·9 pp increase, Fig. 1) and (ii) a 5·1pp increase due to shifts in unobserved factors. No significant change in self-reported diabetes prevalence was found.

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Table 1 Characteristics of the sample of Martinican subjects (≥16 years) from the Escal (*n* 743) and the Kannari (*n* 573) studies*

	Escal (2003)		Kannari (2013)		
	%	SE	%	SE	*P*-value
Women	54·2	2·6	57·2	3·1	0·46
Age class					< 0·01
16–45 years	58·0	2·4	40·5	3·1†	
46–60 years	20·6	1·9	31·8	2·8†	
>60 years	21·4	1·7	27·7	2·5†	
Education					< 0·01
Low	62·4	2·5	45·4	3·0†	
Medium	17·6	2·0	20·1	2·3	
High	19·9	2·0	34·5	3·0†	
Employment status					0·07
Unemployed, disabled, homemakers or students	38·6	2·6	31·0	3·0	
Employed	40·9	2·6	42·8	3·0	
Retired	20·5	1·7	26·2	2·5	
Received social assistance benefits	18·6	2·2	18·0	2·6	0·87
At least one child in the household	45·9	2·6	35·0	3·1	0·01
Single-parent household	5·0	1·0	4·3	1·0	0·60
Urban size					0·15
<10 000	26·2	2·2	31·3	2·9	
≥ 10 000	73·8	2·2	68·7	2·9	

*Sex-specific data weighted for age, education, marital status, birthplace, urban size and living in an area with chlordecone contamination and additionally for the presence of at least one child in the household for 2013 (calculated using the iterative proportional fitting procedure according to the 1999 and 2011 French national census reports).
†*P*-value in categorical variable < 0·05.
Values are presented as percentage (%) and SE.

Diet quality and macronutrient intakes

The mean sPNNS-GS2 (ranging from –4·9 to 10·2 points in 2003 and from –3·7 to 8·7 points in 2013) decreased by 0·5 point, the mean adequacy ratio decreased by 2·4 pp and the mean excess ratio increased by 2·2 pp (Table 3). Shifts in DSEC, mainly in age, explained a 0·4-point increase in the average sPNNS-GS2 and a 0·9 pp decrease in the mean excess ratio, counterbalanced by changes of opposite sign due to unobserved characteristics. Also, the shift in education explained a 0·4 pp increase in the mean adequacy ratio ($P < 0.01$, data not shown).

A decrease in energy intake was observed. The lipid contribution to energy intake decreased, with a decrease in the energy supplied by PUFA and an increase in the energy supplied by MUFA. All these changes were not explained by shifts in DSEC. Shifts in DSEC explained a 27 % decrease in complex carbohydrate intakes, counterbalanced by a change of opposite sign due to shifts in unobserved factors. An unexplained decrease in energy from animal protein was observed.

Food intakes

Few changes in food intakes were highlighted (Table 4). Fruit intakes did not change, although shifts in DSEC explained an increase offset by a larger decrease due to unobserved characteristics. An increase in vegetable intakes was observed and a large part of which was explained mostly by shifts in age and education (Fig. 2). Bread and tuber intakes decreased, while whole-grain product intakes increased, and none of these changes were accounted for by shifts in DSEC. Rice and legume intakes increased owing to shifts in unobserved factors counterbalancing a decrease explained by shifts in DSEC. Regarding animal-source foods, unexplained decreases in red meat and milk consumptions were observed. A decrease in poultry consumption was observed, only 23 % of which was explained, mostly by shifts in age distribution (14 %, data not shown). Decreases in fish and yogurt intakes were observed, although shifts in DSEC explained some increases. Shifts in DSEC, particularly age, explained changes in some food group intakes such as processed meat, snack and fast food, biscuit and sweetened beverage intakes, offset by changes of opposite sign due to unobserved characteristics, resulting in a non-significant overall change (Fig. 2). The percentage of energy supplied by ultra-processed foods increased but could not be attributed to shifts in observed characteristics (Table 3).

Discussion

The present study found that shifts in the observed DSEC explained about half of the reported health status deterioration but explained few changes in dietary intakes. Additionally, the few explained dietary changes, mainly due to population ageing, showed an improvement in diet quality, while the changes that remained unexplained were of opposite sign, with a decrease in diet quality, in traditional food intakes and an increase in convenience food intakes, suggesting a nutrition transition driven by shifts in unobserved factors.

In line with census data[9], shifts in the distribution of DSEC were observed between 2003 and 2013, such as

Public Health Nutrition

Public Health Nutrition

Table 2 Changes in health status of Martinican subjects (≥16 years) between 2003 (*n* 743) and 2013 (*n* 573)*

	Estimate in 2003	SE	Estimate in 2013	SE	Change between 2003 and 2013	SE	*P*-value†	Explained part of change‡				Unexplained part of change‡			
								Change	SE	% of change	*P*-value§	Change	SE	% of change	*P*-value§
BMI (mean, kg/m²)	25·7	0·3	26·9	0·3	1·2	0·4	0·01	0·1	0·2	11·2	0·52	1·1	0·4	88·8	0·01
BMI class															
Underweight or normal weight (%)	46·4	2·5	40·8	3·0	−5·6	3·9	0·15	−0·1	2·1	0·8	0·98	−5·6	3·9	99·2	0·16
Overweight (%)	34·6	2·3	34·0	2·8	−0·6	3·6	0·85	−0·8	1·8	118·9	0·67	0·1	3·7	−18·9	0·97
Obese (%)	18·9	1·9	25·2	2·5	6·3	3·2	0·05	0·7	1·6	11·3	0·66	5·6	3·3	88·7	0·09
Waist circumference (mean cm)	87·4	0·7	90·6	0·8	3·2	1·1	< 0·01	1·5	0·6	48·3	0·02	1·6	1·0	51·7	0·12
Hypertension‖ (%)	28·3	1·9	41·7	2·9	13·4	3·5	< 0·01	8·3	2·4	61·9	< 0·01	5·1	3·5	38·1	0·15
Self-reported diabetes (%)	8·9	1·3	9·8	1·6	0·9	2·1	0·67	2·5	1·6	284·3	0·12	−1·7	2·4	−184·3	0·49

*Sex-specific data weighted for age, education, marital status, birthplace, urban size, and living in an area with chlordecone contamination and additionally for the presence of at least one child in the household for 2013 (calculated using the iterative proportional fitting procedure according to the 1999 and 2011 French national census reports).

†To evaluate the significance level of the change.

‡Changes were broken down into two parts, using an Oaxaca–Blinder decomposition method: changes explained by the shifts in the demographic and socio-economic characteristics ('explained' part) and by unobserved factors ('unexplained' part). Demographic and socio-economic characteristics included were sex, age, employment status, education, social assistance benefits, presence of at least one child in the household, single-parent household and urban size. For models related to diabetes and hypertension, BMI was added.

§To evaluate the significance level of the explained or unexplained part of change.

‖Blood pressure ≥140/90 mmHg or receiving an antihypertensive drug treatment.

Values are presented as mean or percentage (%) (SE).

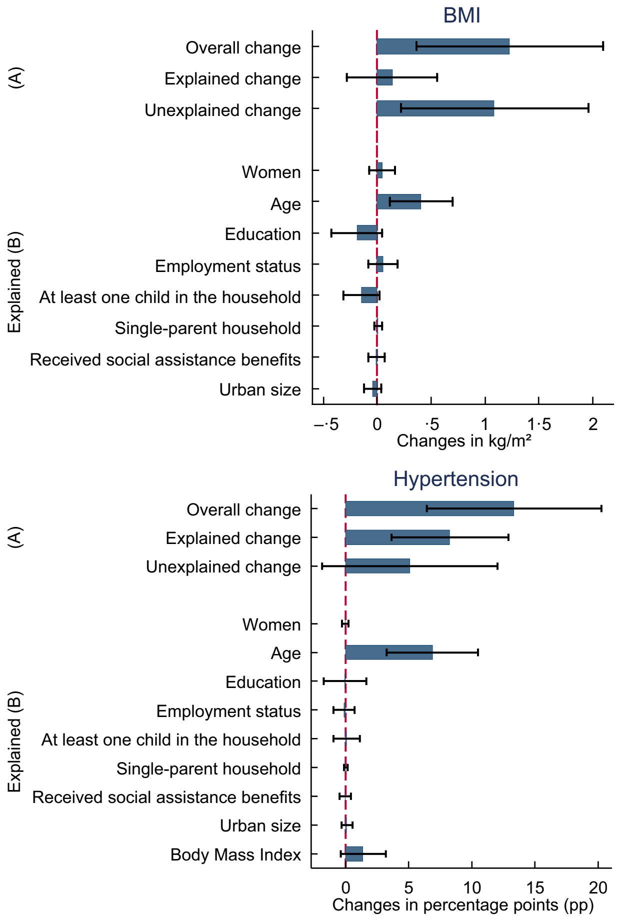

Fig. 1 (colour online) Changes in BMI and prevalence of hypertension[1] in Martinican subjects (≥16 years) between 2003 (*n* 743) and 2013 (*n* 573), decomposed by an Oaxaca–Blinder decomposition method[2]
A: aggregate changes. B: changes explained by shifts in demographics and socioeconomic characteristics.
[1]blood pressure ≥140/90 mm Hg, orreceiving an antihypertensive drug treatment.
[2]Sex-specific data weighted for age, education, marital status, birthplace, urban size, and living in an area with chlordecone contamination and additionally for presence of at least one child in the household for 2013 (calculated using the iterative proportional fitting procedure according to the 1999 and 2011 French national census reports).

the Martinican population ageing, higher educational attainment and a change in household composition. Unlike our study, census data also showed increases in the percentages of recipients of social assistance benefits between 2000 and 2010[10,11].

As expected, the demographic transition impacted population health status[37] as the shifts in observed DSEC over the 2003–2013 decade partly explained changes in health indicators in Martinique. The shift in age distribution appeared to be the main driver of these changes, explaining 33 % of the increase in mean BMI, 50 % of the increase in mean waist circumference and 66 % of the increase in hypertension prevalence. Even so, the demographic transition did not explain all changes in health status, suggesting contributions from other unobserved risk factors such as more sedentary behaviour or changes in food environment and food habits[5]. Our results were in line with a Caribbean study showing that shifts in individual characteristics partly explained changes in BMI (51 % of +0·3 kg/m²) and waist circumference (20 % of +2·6 cm) in Cuba between 2001 and 2010[20]. Regarding DSEC, the population ageing was also the main driver of the explained changes (26 % of the BMI change and 14 % of the waist circumference change), but they also found a positive contribution of education (12 % and 5 %, respectively)[20]. In our study, despite an increased educational attainment shown to be associated with lower health risks in both 2003 and 2013[25,38], shifts in education did not explain changes in health status. However, stratified sensitivity analyses showed that hypertension prevalence increased among the low-educated (from 48 % to 59 %, $P = 0·03$, data not shown) unlike the medium- and high-educated (from 31 % to 27 % and from 23 % to 25 %, $P > 0·50$), and that obesity prevalence increased among social assistance recipients (from 17 % to 37 %, $P = 0·02$), unlike non-recipients (from 21 % to 23 %, $P = 0·50$). Health indicators seemed to change over time differently across socio-economic classes, probably related to the increase in social inequality observed in Martinique[39,40]. This is in line with studies showing increases in the education-related inequalities in BMI in France, with obesity rates increasing much faster in the low-education groups[18,41].

In our study, the shifts in DSEC made only a small contribution to changes in the overall diet quality and dietary intakes, concordantly with the few available studies using decomposition methods[21,22]. Population ageing and higher educational attainment explained an increase in diet quality and in fruit, vegetable and yogurt intakes and a decrease in poultry intake. This is concordant with the literature, as ageing is often associated with increased health consciousness[42], and higher educated individuals are more receptive to nutritional information and are better able to match dietary behaviour to nutritional recommendations[43,44]. Also, population ageing was found to have a positive impact on fish and traditional tuber intakes and a negative one on some ‘modern’ food intakes such as sweetened beverages, biscuits, snacks and fast foods. Our findings are in line with the literature showing that the nutrition transition generally affects younger individuals first, due to a stronger adoption of ‘Westernised’ lifestyles and foods[3] and to different responses to advertising and marketing[45]. In our study, most of the assessed changes in nutrient and food intakes were not explained by the demographic transition, and those that were explained were of opposite sign to the changes that remained unexplained. The effects of the demographic transition, particularly the Martinican population ageing, on dietary changes therefore tend to counterbalance the decline in diet quality and changes towards unhealthier food consumptions, indicators of the

Table 3 Changes in diet quality and daily macronutrient intakes of Martinican subjects (≥16 years) between 2003 (*n* 743) and 2013 (*n* 573)*

	Mean in 2003	SE	Mean in 2013	SE	Change between 2003 and 2013	SE	*P*-value†	Explained part of change‡				Unexplained part of change‡			
								Change	SE	% of change	*P*-value§	Change	SE	% of change	*P*-value§
sPNNS-GS2 (points)‖	2·3	0·1	1·7	0·1	−0·5	0·2	< 0·01	0·4	0·1	−67·8	0·01	−0·9	0·2	167·8	< 0·01
MAR (% adequacy)¶	72·3	0·3	69·9	0·4	−2·4	0·5	< 0·01	0·5	0·3	−20·8	0·07	−2·9	0·5	120·8	< 0·01
MER (% excess)**	38·7	0·5	40·9	0·5	2·2	0·6	< 0·01	−0·9	0·4	−41·3	0·03	3·1	0·6	141·3	< 0·01
Energy intake (kcal/d)	1734·0	27·3	1585·3	25·2	−148·7	37·2	< 0·01	−35·9	29·6	24·1	0·23	−112·8	31·1	75·9	< 0·01
Energy intake without alcohol (kcal/d)	1706·0	26·3	1553·8	23·5	−152·2	35·3	< 0·01	−37·6	28·3	24·7	0·18	−114·6	29·8	75·3	< 0·01
Lipids (% energy intake without alcohol)	35·1	0·2	33·6	0·3	−1·4	0·4	< 0·01	0·2	0·2	−12·4	0·30	−1·6	0·4	112·4	< 0·01
SFA (% of total lipids)	35·4	0·3	36·1	0·3	0·7	0·4	0·10	−0·2	0·2	−33·1	0·32	0·9	0·4	133·1	0·03
MUFA (% of total lipids)	35·9	0·1	37·1	0·2	1·2	0·2	< 0·01	−0·03	0·1	−2·1	0·78	1·3	0·2	102·1	< 0·01
PUFA (% of total lipids)	21·0	0·2	18·6	0·2	−2·4	0·3	< 0·01	0·3	0·2	−12·8	0·12	−2·7	0·3	112·8	< 0·01
Carbohydrates (% of energy without alcohol)	44·7	0·3	47·6	0·3	2·9	0·5	< 0·01	−0·4	0·2	−13·5	0·08	3·3	0·5	113·5	< 0·01
Complex carbohydrates (% of energy without alcohol)	26·4	0·3	28·3	0·3	1·9	0·4	< 0·01	−0·5	0·2	−27·0	0·04	2·4	0·4	127·0	< 0·01
Simple carbohydrates (% of energy without alcohol)	18·2	0·3	19·2	0·3	1·0	0·4	0·03	0·2	0·2	16·8	0·48	0·8	0·4	83·2	0·06
Proteins (% of energy without alcohol)	19·5	0·2	18·6	0·2	−0·9	0·2	< 0·01	0·2	0·1	−17·6	0·21	−1·1	0·2	117·6	< 0·01
Proteins from animal sources (% of proteins)	74·0	0·4	70·0	0·4	−4·0	0·6	< 0·01	0·5	0·3	−11·4	0·11	−4·4	0·6	111·4	< 0·01
Share of energy intake from ultra-processed foods (%)	19·9	0·5	24·3	0·7	4·4	0·9	< 0·01	−0·6	0·4	−12·6	0·21	5·0	0·8	112·6	< 0·01

*Sex-specific data weighted for age, education, marital status, birthplace, urban size and living in an area with chlordecone contamination and additionally for the presence of at least one child in the household for 2013 (calculated using the iterative proportional fitting procedure according to the 1999 and 2011 French national census reports).
†To evaluate the significance level of the change.
‡Changes were broken down into two parts, using an Oaxaca–Blinder decomposition method: changes explained by the shifts in the demographic and socio-economic characteristics ('explained' part) and by unobserved factors ('unexplained' part). Demographic and socio-economic characteristics included sex, age, employment status, education, social-assistance benefits, presence of at least one child in the household, single-parent household and urban size.
§To evaluate the significance level of the explained or unexplained part of change.
‖Simplified version of the Programme National Nutrition Santé – Guideline Score 2 (sPNNS-GS2), which reflects the adherence to the 2017 French dietary guidelines.
¶Mean adequacy ratio (MAR), defined as the mean daily percentage recommended intakes for twenty-three essential nutrients.
**Mean excess ratio (MER), defined as the main daily percentage of maximum recommended values for nutrients of which intake should be limited (Na, SFA and free sugars).
Values are presented as mean (SE).

Table 4 Changes in daily food and beverage intakes of Martinican subjects (≥16 years) between 2003 (*n* 743) and 2013 (*n* 573)*

								Explained part of change§				Unexplained part of change§			
Daily food and beverage intakes (g/d)†	Mean in 2003	SE	Mean in 2013	SE	Change between 2003 and 2013	SE	*P*-value‡	Change	SE	% of change	*P*-value‖	Change	SE	% of change	*P*-value‖
Fruits	119·6	5·3	113·5	5·7	−6·1	7·8	0·43	13·4	3·5	−217·8	< 0·01	−19·5	8·3	317·8	0·02
Vegetables	122·5	3·6	136·7	5·2	14·2	6·3	0·03	9·2	3·0	65·0	< 0·01	5·0	6·3	35·0	0·43
Bread and rusks	71·5	2·1	60·8	2·4	−10·7	3·2	< 0·01	−2·6	2·2	24·4	0·24	−8·1	2·7	75·6	< 0·01
Potatoes	20·5	1·2	18·1	0·5	−2·4	1·3	0·08	−0·8	1·1	35·3	0·43	−1·5	1·3	64·7	0·25
Tubers (other than potatoes)	89·6	5·1	70·4	3·4	−19·2	6·2	< 0·01	3·3	3·5	−17·1	0·36	−22·5	6·2	117·1	< 0·01
Pasta	39·1	1·1	34·1	2·4	−5·1	2·6	0·06	−2·2	1·1	43·3	0·04	−2·9	2·5	56·7	0·25
Rice	60·6	2·2	70·2	3·2	9·6	3·9	0·01	−3·7	1·8	−38·6	0·04	13·3	3·8	138·6	< 0·01
Semolina and other cereals	16·6	1·7	20·7	2·0	4·0	2·6	0·12	0·3	1·3	7·4	0·81	3·7	2·7	92·6	0·17
Legumes	28·3	1·0	32·4	1·8	4·1	2·0	0·04	−1·8	0·9	−43·7	0·04	5·9	2·0	143·7	< 0·01
Whole-grain products	3·3	0·6	7·7	1·2	4·3	1·3	< 0·01	0·6	0·4	13·5	0·16	3·7	1·3	86·5	0·01
Red meat	52·6	1·3	43·3	1·3	−9·3	1·8	< 0·01	−1·6	1·2	16·7	0·20	−7·7	1·7	83·3	< 0·01
Poultry	87·7	2·6	58·3	2·4	−29·3	3·5	< 0·01	−6·6	2·3	22·7	< 0·01	−22·7	3·2	77·3	< 0·01
Processed meat	16·9	0·8	18·7	0·9	1·8	1·2	0·12	−1·5	0·7	−85·3	0·03	3·3	1·1	185·3	< 0·01
Offal	10·0	0·4	9·2	0·5	−0·8	0·6	0·19	0·2	0·3	−23·0	0·60	−1·0	0·6	123·0	0·14
Fish	69·0	2·3	45·0	1·8	−24·0	2·9	< 0·01	5·0	2·2	−20·7	0·02	−29·0	2·9	120·7	< 0·01
Seafood	5·8	0·2	6·5	0·7	0·7	0·8	0·38	−0·7	0·2	−99·0	< 0·01	1·3	0·8	199·0	0·09
Eggs	9·4	0·5	9·6	0·6	0·2	0·8	0·79	0·8	0·4	379·1	0·03	−0·6	0·9	−279·1	0·49
Milk	87·6	4·1	53·2	4·4	−34·4	6·0	< 0·01	3·6	3·0	−10·6	0·22	−38·0	6·2	110·6	< 0·01
Cheese	9·7	0·4	10·6	0·5	0·9	0·7	0·18	0·6	0·3	63·6	0·10	0·3	0·7	36·4	0·63
Yogurts	26·2	2·0	18·9	1·7	−7·3	2·6	0·01	4·1	1·5	−55·3	0·01	−11·4	2·8	155·3	< 0·01
Salad dressing and sauces	25·4	0·7	27·3	0·7	1·9	0·9	0·05	0·4	0·4	20·5	0·37	1·5	0·9	79·5	0·10
Butter	3·3	0·3	2·4	0·2	−0·9	0·3	0·01	−0·4	0·2	48·2	0·04	−0·5	0·3	51·8	0·08
Snacks and fast foods	27·1	1·4	26·8	1·8	−0·3	2·3	0·89	−2·4	1·2	743·1	0·05	2·1	2·1	−643·1	0·32
Biscuits, cakes and pastries	30·4	1·1	33·9	1·7	3·5	2·1	0·09	−2·8	1·1	−80·4	0·01	6·3	2·0	180·4	< 0·01
Fatty and sweet products (chocolate, ice cream, etc.)	11·4	0·8	12·7	1·0	1·3	1·3	0·32	−0·4	0·5	−30·1	0·48	1·7	1·3	130·1	0·20
Sweet products	16·1	1·0	14·2	1·0	−1·9	1·4	0·17	0·9	0·6	−47·2	0·16	−2·8	1·6	147·2	0·08
Non-alcoholic and non-sweetened beverages (water, coffee, tea)	1365·8	30·6	1385	29·2	19·2	42·4	0·65	−16·3	27·3	−84·8	0·55	35·5	40·4	184·8	0·38
Sweetened beverages and juices	202·2	7·6	188·2	8·1	−14·0	11·1	0·21	−25·1	7·6	179·6	< 0·01	11·1	9·5	−79·6	0·24
Alcoholic beverages	36·7	3·1	42·7	5·9	6·0	6·7	0·37	1·2	2·8	20·5	0·66	4·8	6·2	79·5	0·44

*Sex-specific data weighted for age, education, marital status, birthplace, urban size and living in an area with chlordecone contamination and additionally for the presence of at least one child in the household for 2013 (calculated using the iterative proportional fitting procedure according to the 1999 and 2011 French national census reports).

†Adjusted for daily energy intake according to sex and sample, using the residual method.

‡To evaluate the significance level of the change.

§Changes were broken down into two parts, using an Oaxaca–Blinder decomposition method: changes explained by the shifts in the demographic and socio-economic characteristics ('explained' part) and by unobserved factors ('unexplained' part). Demographic and socio-economic characteristics included sex, age, employment status, education, social assistance benefits, presence of at least one child in the household, single-parent household and urban size.

‖To evaluate the significance level of the explained or unexplained part of change.

Values are presented as mean (SE) in g/d.

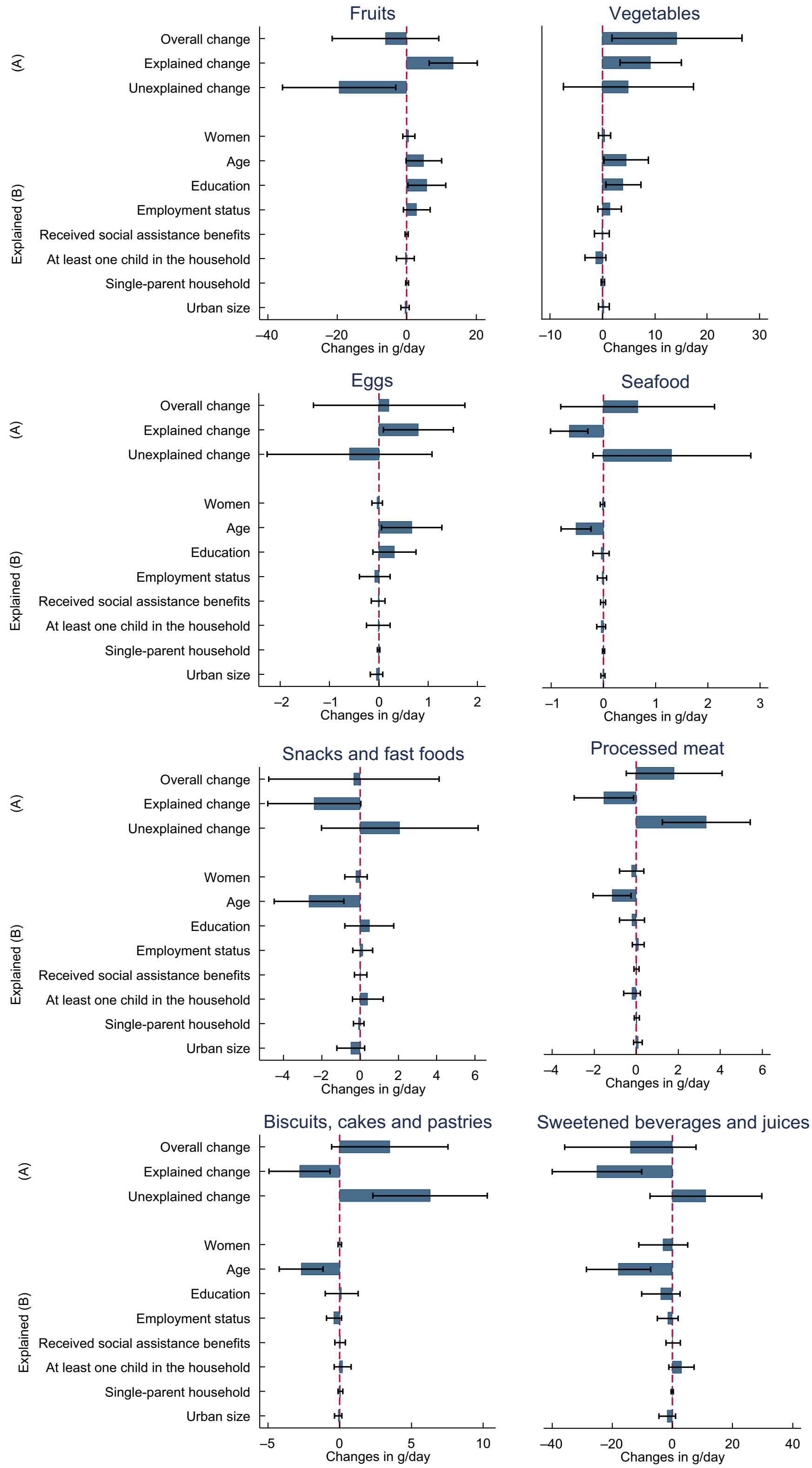

Fig. 2 (colour online) Changes in some dietary intakes[1] of Martinican subjects (≥16 years) between 2003 (*n* 743) and 2013 (*n* 573), decomposed by an Oaxaca–Blinder decomposition method[2]
A: aggregate changes. B: changes explained by shifts in demographic and socioeconomic characteristics.
[1]Adjusted for daily energy intake according to sex and sample, using the residual method.
[2]Sex-specific data weighted for age, education, marital status, birthplace, urban size, and living in an area with chlordecone contamination and additionally for presence of at least one child in the household for 2013 (calculated using the iterative proportional fitting procedure according to the 1999 and 2011 French national census reports).

Public Health Nutrition

nutrition transition as described by Popkin's conceptual framework[3]. Regarding the unexplained changes observed over the period, the nutritional quality of the diet clearly decreased. Consistently with the literature describing the nutrition transition as populations shifting from traditional diets to 'modern' diets, with higher intakes of convenience foods[1,3,5], we observed a decrease in fish, bread, red meat, poultry, fruit and traditional tuber intakes, part of the Martinican traditional dietary habits[38]. Also, we observed a decrease in dairy product intakes, an increase in ultra-processed food, processed meat, rice and biscuit intakes and an increasing trend (non-significant) in the sweetened beverage, snack and fast food intakes. However, observed changes in macronutrient intakes (decrease in animal protein and fat intakes and increase in simple and complex carbohydrates intakes) were not in line with literature[3]. Even so, our findings were consistent with observations on Martinique availability from food imports between 2000 and 2010, showing stable energy availability, with a decrease in the share of fats, especially from animal sources, an increase in carbohydrates and a decrease in animal protein share (V Lamani, S Drogue, Z Colombet, P Terrieux, A Ducrot and C Méjean, unpublished results)[38].

Our results suggest a nutrition transition driven by shifts in unobserved factors, such as food environment, prices, preferences or habits[12,22]. A study conducted in 2008 on a representative sample of 1000 Martinicans showed that around 40 % of adults (18–75 years) reported changing some of their habits since learning about chlordecone, an insecticide used until 1993 that have polluted soils[38]. They mostly reported limiting the consumption of products considered to be more contaminated[46], such as root vegetables, tubers, eggs, poultry, fish and seafood[47]. Meanwhile, shifts in prices and food environment in the last few decades may explain observed dietary intake changes, such as the large-chain retailing spread observed in Martinique since the 1990s (V Lamani *et al.*, unpublished results), which contributed to an increased availability of ultra-processed and unhealthy foods[48]. Broadly, food expenditure has increased in Martinique since the 2000s, with an increase of food prices (+3·3 % in 2013), driven by fruits, meats, bread and cereals[49], whose intakes decreased in our study. Inflation and economic crises, such as the 2007–2010 mortgage crisis and the 2009 French Caribbean general strike over high cost of living and high food prices[50], may also have substantially impacted individual food consumptions[51,52].

The interpretation of our results presents several limitations. First, we observed a significant decrease in energy intake that was not explained by differences in DSEC, and which was probably due to the very low energy intake declared in the Kannari survey. To overcome this limitation, energy under-reporters were excluded from analyses, and food group intakes were adjusted for daily energy intake according to sex. The measurement of blood pressure was slightly different between the Escal and Kannari surveys. The HTA prevalence and consequently the difference between 2003 and 2013 have been overestimated as the Kannari survey had only one set of measurements. Although other distributional features such as quantiles may have been used for some outcomes, we chose to apply the Oaxaca–Blinder decomposition, based on linear regression modelling, only allowing assessment of the changes in the mean. Finally, our analysis used dated data and a relatively short timescale. In view of the fast evolution of food consumption and habits, it is important to have more recent data. Repeating the current study with a new survey, and thus having a longer comparison timespan, would be of interest to better characterise the nutrition transition.

Conclusion

Changes between 2003 and 2013 in Martinique suggest an ongoing nutrition transition. Shifts in DSEC partly contributed to the health status deterioration and the dietary intake changes of opposite sign to the nutrition transition conceptual framework, underlining that the key drivers are unobserved factors. Further studies are therefore needed to assess the identification of these unobserved factors and their effects on the nutrition transition, which will guide food and nutrition policies to curb the transition by proposing actions on the food environment, e.g. taking into account the nutritional composition when designing dock dues schemes for food products to promote healthier foods.

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were as follows: Z.C. and C.M. designed the study and drafted the manuscript, Z.C. performed the statistical analysis, MS supervised the statistical analysis, M.S., S.D., V.L., M.P., Y.M.P., M.J.A., N.D. and L.G.S. contributed to the data interpretation and revised each draft for important intellectual content. All authors read and approved the final manuscript. *Ethics of human subject participants:* The Escal and Kannari surveys were conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the French Data Protection Authority (Commission Nationale Informatique et Libertés, N°12-777 and N°05-1170, respectively). Written informed consent was obtained from all participants. The Kannari protocol was also approved by an ethical research committee (Comité de protection des personnes Sud-Ouest et Outre-mer.II, CPP N°2-13-10). Written informed consent was obtained from all subjects.

Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S136898002100327X

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