Dietary Westernisation: conceptualisation and measurement in Mauritius

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Abstract

Objectives: The aims of the study were to provide information that will contribute to conceptualising what is called 'dietary Westernisation', and to provide an example of measuring it on an individual level.

Design: Food consumption frequency and demographic data on adults in Mauritius were examined in 1988, 1992 and 1998. In 1992, a 24-hour recall was also included. The cross-sectional samples consisted of 1115 (age 25–74 years) Mauritians in 1987/88, 1917 (age 30–74 years) in 1992 and 2239 (age 20–74 years) in 1998. Principal components analysis was carried out on daily consumption frequencies of 10 indicator foods (white rice, white bakery bread, pulses, processed meat, poultry, fresh/frozen fish, butter, margarine, whole milk and skimmed/low-fat milk). Correlations between dietary patterns and selected food consumption frequencies were examined in each survey year.

Results: Four dietary patterns were identified as being related to dietary Westernisation. The Traditional dietary pattern was characterised by higher consumption frequencies of Indian breads, salted/smoked fish and sugar-sweetened tea. The Western dietary pattern was characterised by higher consumption frequencies of cakes/pastries, meat and many Western fast foods like burgers, but, surprisingly, also by brown bread, breakfast cereals and salad. The Bread/butter dietary pattern predominantly described more frequent consumption of bread compared with rice. The Margarine/milk dietary pattern was inconsistently related with staple foods. Younger, educated and wealthier Mauritians appeared to adopt Western dietary patterns earlier.

Conclusions: This study suggests that relatively few indicator foods are needed for measuring dietary Westernisation. Dietary Westernisation in a non-Western country may also include shifts towards voluntary consumption of healthier foods.

Societies in Western Europe and North America have developed cultures that emphasise rationality, individuality, science and technological development[1,2]. These societies are often labelled 'Western', in contrast to many 'Eastern' societies in Asia and 'Southern' societies in Africa and other regions of the Southern hemisphere[3], although the 'Western world' has become more than a geographical or historical concept as Japan and other nations have widely adopted aspects of Western culture[4,5]. The diffusion and adoption of Western culture in other places is often termed 'Westernisation', whereby societies and individuals adopt particular ideas and practices from more economically developed and commercialised countries[6,7] rather than their indigenous ones. A world-wide standardisation of lifestyles is occurring as a result of the global diffusion of the Western model of daily living, particularly American consumer culture[8].

Culture related to diet and nutrition in Western societies has distinctive characteristics, with diets that emphasise wheat as the primary starchy staple food, often as ready-made refined white bread[9], meats as a central element of meals[10], and processed foods and dairy products[11]. The diffusion and adoption of Western food culture can be termed 'dietary Westernisation', wherein societies and individuals adopt Western food and eating practices. Dietary transitions in developing nations typically begin with major increases in the

domestic production and imports of oilseeds and vegetable oils, often enhanced by globalisation of production and processing[10–12], that affect the whole of society relatively homogeneously. Dietary Westernisation, on the other hand, is primarily a consequence of Western influences being incorporated into an indigenous food culture, where it is diffused at different paces among sub-populations[13].

No consensus exists about the specific foods that are involved in Westernisation, because there are substantial differences in food and nutrient intakes among Western countries[10]. Not many studies have specifically delineated Western foods, but rather they tend to vaguely and generally explain what foods are considered Western. Table 1 presents some examples of descriptions of Western foods and indigenous foods in societies experiencing Westernisation. According to the literature, common Western foods include breads, meats and fat spreads, and there is great variety in the non-Western indigenous foods. Foods involved in dietary Westernisation may vary by geographical setting, local food culture, historical period, and the extent of dietary transition that the society has undergone.

The goals of the present paper are:

1. to provide information that will contribute to conceptualising dietary Westernisation,
2. to provide an example of measuring dietary Westernisation on an individual level using dietary pattern analysis based on food consumption frequencies and
3. to describe the food consumption patterns that are related to dietary Westernisation in Mauritius.

Dietary intake data on adult Mauritians will be used. Mauritius is an example of a country that has gone through very rapid economic, dietary, nutrition and epidemiological transitions[24–27], and provides thus an ideal setting for studying changes in diet related to Westernisation. Few papers before, if any, have made an attempt to describe dietary Westernisation on an individual level.

Methods

Study population

The subtropical island of Mauritius is situated in the south-western Indian Ocean. The country experienced considerable economic growth associated with industrialisation, and currently most overseas earnings are derived from sugarcane, textiles and tourism[28]. The multi-ethnic population of Mauritius consists of Asian Indian Hindus (54%), Asian Indian Muslims (16%), Creoles (28%) and Chinese (2%).

As a response to emergent non-communicable diseases (NCD) in Mauritius, the Ministry of Health launched an NCD Prevention Programme, including a large population-based NCD risk factor survey in 1987. To monitor the risk factor levels of Mauritians, independent surveys were carried out again in 1992 and 1998. Diet was studied as part of risk factor monitoring.

Sampling

Dietary surveys were performed on sub-samples of the NCD surveys. After the baseline risk factor survey in 1987, 1115 food frequency interviews were carried out in 1988 on a sample that was randomly selected from the risk factor survey population, stratified according to sex and ethnicity. The sample included 561 men and 554 women aged 25–74 years.

In 1992, a target sub-sample of 2059 Mauritians aged 30–64 years was randomly chosen (stratified by age, sex and ethnicity) from the respondents to the risk factor survey. The overall response rate was 95%, giving a sample size of 1956. However, 39 questionnaires were excluded due to incomplete or unreliable information. The final analytical sample of respondents to the 1992 dietary survey was 1917, including 930 men and 987 women.

In 1998, the dietary survey was carried out simultaneously with the risk factor survey. All participants in 1988 and 1992 dietary surveys who still lived in the area were invited to participate again ($n = 2711$) as well as a new cohort age group of 20–29 years ($n = 786$). Age thus

Table 1 Indigenous foods versus Western foods in selected studies on dietary transitions

Indigenous foods	Western foods	Country/study
Coconut, fresh fish, taro, yam, sweet potato, bananas	Imported meat and fish, imported wheat and rice	Cook Islands[14]
Rice, fish, vegetables, fruits, soybeans, visceral organs, green tea	Eggs, dairy products	China[15,16]
	Lunch meats, snack chips, skimmed milk, butter	North American Chinese[17]
Corn, beans	Rice, bread, fish, cheese, pasta, processed foods	Mexico[18]
Wild game, cultivated crops, domesticated animals (meat, milk), vegetables	A wide variety of foods, high proportion of processed foods	Global[19]
Meat of marine mammals and fish	Bread, sugar, butter, margarine	Greenland[20,21]
Rice, fish, miso soup, pickles	Bread, coffee, European tea	Japan[22]
Cod, olive oil, legumes	Meat, dairy, sugar, refined grains, beer ('Northern foods')	Portugal[23]

varied between 20 and 74 years in the 1998 dietary survey sample. Out of 3487 eligible, 2259 participated, giving a response rate of 65%. Twenty subjects were excluded because of incomplete information. The final sample size was 2239, including 1017 men and 1222 women. Subjects aged less than 30 years totalled 535, and thus were first-time participants to the survey in 1998.

Dietary assessment and other interviews

Information on dietary intake was gathered using food frequency interviews and basic demographic characteristics were assessed using a general questionnaire in each survey year[13]. The food-frequency questionnaire included 22 food items in 1988, 44 in 1992, and 102 in 1998. People were asked to concentrate on the past 3 months and indicate how many times they usually ate the particular food. All the records were converted into daily food consumption frequencies by dividing the daily, weekly and monthly frequencies by one, seven or 30, respectively. In addition, food consumption was recorded in 1992 using 24-hour recall interviews.

The consumption frequencies of 10 foods (white rice, white bakery bread, pulses, poultry, processed meat, fresh/frozen fish, butter, soft margarine, whole milk/milk powder, and skimmed/low-fat milk/milk powder) were asked in a comparable way in each survey year and are therefore included in the longitudinal analysis. Most of them represent commonly eaten indigenous or Western foods in Mauritius. Therefore they are used as indicator foods for dietary Westernisation. Rice, pulses and whole milk are considered indigenous foods, and bakery bread, processed meat and other processed products like skimmed/low-fat milk/milk powder and soft margarine are considered Western in Mauritius (U Haw, personal communication, Ministry of Health Mauritius, Port Louis, Mauritius, 1992). It was known from earlier reports that rice consumption is decreasing and wheat consumption is increasing in Mauritius[29,30], and therefore special attention was paid to the possible shifts in the starchy staples of rice and bakery bread as indicators of early dietary Westernisation. Poultry, fresh/frozen fish and butter could not be allocated explicitly to either the indigenous or the Western category. Selected food consumption frequencies were included as comparisons for cross-sectional validation of the measurement of dietary Westernisation. Table 2 describes the selected food groups.

In the 1992 food consumption data, the focus was only on food groups assumed to be eaten daily, in addition to the 10 indicator foods. Exclusion of many infrequently eaten foods was justified because the method concentrated only on the past 24 hours and it would have not been possible to get accurate information on the consumption of such foods on an individual level during a period of 1 day. Indigenous and regularly consumed foods in this study included tubers, tea, sugar, traditional sauces, vegetables and fruit. Respective Western foods

consisted of breakfast cereals, snacks, coffee, soft drinks, diet soft drinks, fruit juice and sweets.

Statistical analysis

Identification of the major dietary patterns was done by principal components analysis (PCA)[31–34], because the goal was to find principal components that could explain as much as possible of the total variation of the 10 food consumption frequencies. This method was first used in an exploratory manner to examine the underlying structure

Table 2 Description of selected indigenous and Western foods in Mauritius

	Description
Indigenous foods	
Indian breads	Nan and chapatti, traditional Indian breads
Faratha	Traditional Indian pan-baked bread, made with either whole-grain or white wheat flour
Puri	Traditional fried thin Indian bread
Salted/smoked fish	Fish preserved with salt or by smoking
Lean meat	Venison, goat
Curry/*daube/rougaille*	Typical Mauritian sauces eaten with rice or with Indian breads
Vegetables	E.g. tomato, onion, potato, peppers, carrots, various greens, okra, eggplant, cucumber
Tomatoes	Fresh tomatoes only
Mango/papaya/guava	Typical fruits grown on the island
Pickles	Condiments made from fruit
Tea	Traditional drink in Mauritius
Sugar in tea/coffee	Added sugar in tea/coffee
Western foods	
Brown bakery bread or whole-grain bread	Commercial bread baked of less refined wheat flour
Cakes/pastries	Includes all European type of cakes, pies and pastries
Breakfast cereal	Breakfast cereals, e.g. Weetabix, oatmeal
Cheese	Commercially processed cheese
Beef, pork, mutton	Non-processed meats
Barbecued/grilled foods	Refers to the cooking method, mostly meat
Lettuce, other salad greens	Lettuces of various types
Tomato sauce	Ketchup or other commercial tomato sauces
Apples	Apples, imported
Salad dressing	Oily dressings eaten with salad greens
Coffee	Coffee drinks
Salty snacks	Potato chips, Twisties, salty nuts
Burgers	Usually chicken burgers, occasionally beef
Commercial fried chicken	Fried chicken in fast-food restaurants, e.g. Kentucky Fried Chicken
French fries	Deep-fried potatoes, includes also home-made French fries
Pizza	Fast-food restaurant pizzas, e.g. Pizza Hut
Soft drinks, regular	All sugar-sweetened soft drinks/sodas
Soft drinks, diet	All artificially sweetened soft drinks/sodas

of relationships between the 10 foods, and to determine the number of principal components explaining a sufficient amount of the variation in the diet from each survey year data. PCA also confirmed that a Western pattern of eating was one of the underlying principal components, and was used to obtain the weights for the 10 indicator foods in developing dietary pattern scores.

PCA was run separately for data from each survey year. Eigenvalue (>1.0) and Cattell's scree test were taken into consideration in determining how many principal components should be extracted[35]. According to these criteria, four components were extracted in every survey year. A principal component is a weighted linear combination of the original variables. 'Weights' can also be called scoring coefficients that are usually standardised into Z-score form[32]. The scoring coefficients and the labels of the principal components that were extracted in this analysis are given in Table 3. The four principal components or dietary patterns of Western, Bread/butter, Traditional/high protein and Margarine/milk were named based on the magnitude of loadings on the foods.

The Traditional/high protein dietary pattern is hereafter referred to as the Traditional pattern, because it is the common theme in this pattern over the survey years.

Development of dietary pattern scores
PCA provided the weights/standardised scoring coefficients for individual food frequencies from each survey year in developing survey-specific and participant-specific dietary pattern scores (Table 3). The scores for each participant and for each survey year were calculated as a sum variable of food frequencies that were first multiplied by the respective standardised scoring coefficients of the principal component.

Data analysis
A correlation analysis was carried out between the four dietary pattern scores and the selected food consumption frequencies in 1988, 1992 and 1998, and between the dietary pattern scores and actual food consumption in 1992. The basic demographic characteristics age (in years), education (full-time education in years) and monthly

Table 3 Description and standardised scoring coefficients of the principal component (PC) extracted from 1988, 1992 and 1998 food frequency data (indicator foods)

	PC1 Western	PC2 Margarine/whole milk	PC3 Bread/butter	PC4 Traditional/high protein
Survey year 1988 (n = 1115)				
Rice	**−0.43**	−0.03	**−0.32**	−0.01
Bread	**0.27**	**0.21**	**0.47**	0.06
Pulses	**−0.30**	**0.26**	0.13	**0.41**
Poultry	**0.24**	**−0.43**	**−0.16**	0.10
Processed meat	**0.15**	−0.01	0.02	**0.69**
Fresh/frozen fish	0.14	**−0.30**	**−0.26**	**0.40**
Butter	**−0.18**	**−0.32**	**0.51**	0.12
Margarine	**0.24**	**0.44**	**−0.31**	0.12
Whole milk	**−0.16**	**0.18**	0.04	**0.26**
Skimmed/low-fat milk	**0.33**	0.07	0.06	−0.14
Variance explained	*15.0%*	*13.8%*	*12.8%*	*10.8%*
Survey year 1992 (n = 1917)				
Rice	**−0.34**	−0.01	**−0.35**	**0.24**
Bread	**0.20**	**0.18**	**0.49**	**−0.34**
Pulses	−0.10	−0.06	0.05	0.12
Poultry	**0.24**	**0.23**	0.11	**0.44**
Processed meat	0.14	**0.25**	−0.05	**0.36**
Fresh/frozen fish	**0.25**	0.14	0.11	**0.34**
Butter	−0.10	**−0.31**	**0.52**	**0.19**
Margarine	0.08	**0.49**	**−0.21**	**−0.26**
Whole milk	**−0.39**	**0.34**	**0.25**	0.00
Skimmed/low-fat milk	**0.41**	**−0.27**	**−0.23**	−0.08
Variance explained	*15.6%*	*14.2%*	*12.1%*	*13.6%*
Survey year 1998 (n = 2239)				
Rice	−0.11	**0.21**	**−0.51**	**0.25**
Bread	0.12	**0.21**	**0.62**	**−0.17**
Pulses	0.00	**0.19**	**−0.28**	0.02
Poultry	**0.40**	0.03	−0.02	**0.19**
Processed meat	**0.40**	0.13	−0.09	0.10
Fresh/frozen fish	**0.42**	−0.02	−0.14	0.13
Butter	−0.02	−0.12	**0.36**	**0.58**
Margarine	0.11	**0.38**	0.00	**−0.44**
Whole milk	−0.09	**0.44**	**0.17**	**0.24**
Skimmed/low-fat milk	**0.17**	**0.38**	−0.02	**−0.25**
Variance explained	*17.5%*	*15.6%*	*11.0%*	*12.4%*

Absolute values $\geq$ 0.15 are in bold.

income score from 1 (low) to 4 (high) were examined as quintiles of the dietary pattern scores. Trends in demographic variables according to dietary pattern score quintiles were tested using general linear models using SAS[36]. Means of education years and income scores were adjusted for age and ethnicity (Tukey), because in an earlier study these variables were associated with Westernisation of lifestyles in Mauritius[13].

Results

The Western dietary pattern was discerned from 1988, 1992 and 1998 dietary data (Table 3). This Western dietary pattern explained the most variation in the diet in each of the three survey years: 15.0%, 15.6% and 17.5%, respectively. The Western dietary pattern reflected consistently higher consumption frequencies of white

bakery bread, poultry, processed meat, fresh/frozen fish, margarine and skimmed/low-fat milk. Simultaneously it reflected lower consumption frequencies of white rice, legumes, butter and whole milk/milk powder. The second dietary pattern, Margarine/milk, presented higher consumption frequencies for margarine and whole milk/milk powder, but this eating pattern did not reflect consistent loadings on rice and bread. The third dietary pattern of Bread/butter emphasised the consumption of butter and the substitution of bread for rice, but not other characteristics of dietary Westernisation. The fourth dietary pattern was called the Traditional dietary pattern because it contrasted with Western ways of eating. It was characterised by inconsistent changes in some of the correlated food consumption frequencies (Table 3). At baseline it had high loadings on pulses and whole milk, and a low loading on skimmed milk, but it also had a high

Table 4 Demographic characteristics of participants according to dietary pattern quintile in 1988 ($n = 1115$), 1992 ($n = 1917$) and 1998 ($n = 2239$)

Dietary pattern/ demographic variable*	Year	Quintile					P for trend
		Q1 (low)	Q2	Q3	Q4	Q5 (high)	
Western							
Age	1988	49 (1.0)	47 (1.0)	48 (1.0)	48 (1.0)	48 (1.0)	0.799
	1992	46 (0.5)	47 (0.5)	46 (0.5)	46 (0.5)	45 (0.6)	0.092
	1998	50 (0.7)	47 (0.7)	44 (0.7)	44 (0.7)	45 (0.7)	0.0001
Education	1988	4.7 (0.24)	4.8 (0.24)	4.9 (0.24)	5.7 (0.24)	6.0 (0.24)	0.0001
	1992	5.3 (0.18)	5.4 (0.18)	5.2 (0.18)	6.5 (0.18)	6.9 (0.18)	0.0001
	1998	5.6 (0.15)	6.7 (0.15)	7.3 (0.15)	7.4 (0.15)	8.2 (0.15)	0.0001
Income	1988	1.7 (0.06)	1.7 (0.06)	1.9 (0.06)	1.9 (0.06)	2.0 (0.06)	0.0001
	1992	1.7 (0.05)	1.7 (0.05)	1.7 (0.05)	1.9 (0.05)	2.2 (0.05)	0.0001
	1998	1.8 (0.05)	2.1 (0.05)	2.3 (0.05)	2.4 (0.05)	2.4 (0.05)	0.0001
Bread/butter							
Age	1988	50 (1.0)	50 (1.0)	47 (1.0)	48 (1.0)	45 (1.0)	0.001
	1992	46 (0.6)	47 (0.6)	46 (0.6)	46 (0.6)	45 (0.6)	0.0921
	1998	47 (0.7)	46 (0.7)	47 (0.7)	45 (0.7)	46 (0.7)	0.118
Education	1988	4.0 (0.24)	5.1 (0.24)	5.2 (0.24)	5.9 (0.23)	5.8 (0.24)	0.0001
	1992	5.3 (0.18)	5.5 (0.18)	5.9 (0.18)	5.9 (0.18)	6.6 (0.18)	0.0001
	1998	6.4 (0.15)	7.2 (0.15)	6.9 (0.15)	7.6 (0.15)	7.3 (0.15)	0.0001
Income	1988	1.7 (0.06)	1.7 (0.06)	1.9 (0.06)	2.0 (0.06)	1.9 (0.06)	0.0004
	1992	1.7 (0.05)	1.7 (0.05)	1.9 (0.05)	1.8 (0.05)	2.0 (0.05)	0.002
	1998	2.1 (0.05)	2.2 (0.05)	2.2 (0.05)	2.2 (0.05)	2.2 (0.05)	0.116
Traditional							
Age	1988	51 (1.0)	47 (1.0)	47 (1.0)	48 (1.0)	47 (1.0)	0.012
	1992	46 (0.5)	45 (0.6)	45 (0.6)	46 (0.6)	46 (0.6)	0.595
	1998	46 (0.7)	45 (0.7)	45 (0.7)	47 (0.7)	49 (0.7)	0.0001
Education	1988	4.6 (0.24)	5.4 (0.24)	5.6 (0.24)	5.0 (0.24)	5.5 (0.24)	0.023
	1992	6.9 (0.18)	5.8 (0.18)	5.8 (0.18)	5.5 (0.18)	5.2 (0.18)	0.0001
	1998	7.7 (0.15)	7.2 (0.15)	7.5 (0.16)	6.3 (0.15)	6.6 (0.16)	0.0001
Income	1988	1.7 (0.06)	1.9 (0.06)	1.9 (0.06)	1.9 (0.06)	1.8 (0.06)	0.101
	1992	2.0 (0.05)	1.9 (0.05)	1.8 (0.05)	1.7 (0.05)	1.7 (0.05)	0.0001
	1998	2.3 (0.05)	2.3 (0.05)	2.2 (0.05)	2.1 (0.05)	2.0 (0.05)	0.0001
Margarine/milk							
Age	1988	47 (1.0)	47 (1.0)	48 (1.0)	49 (1.0)	48 (1.0)	0.380
	1992	46 (0.6)	46 (0.6)	46 (0.6)	45 (0.6)	45 (0.6)	0.704
	1998	46 (0.7)	47 (0.7)	47 (0.7)	45 (0.7)	46 (0.7)	0.408
Education	1988	5.2 (0.25)	5.2 (0.24)	5.3 (0.24)	5.0 (0.24)	5.3 (0.24)	0.947
	1992	5.8 (0.18)	5.5 (0.18)	5.8 (0.18)	5.8 (0.18)	6.4 (0.18)	0.018
	1998	7.6 (0.15)	7.0 (0.15)	6.8 (0.15)	6.9 (0.15)	6.9 (0.15)	0.004
Income	1988	1.9 (0.06)	1.9 (0.06)	1.9 (0.06)	1.8 (0.06)	1.8 (0.06)	0.568
	1992	1.9 (0.05)	1.7 (0.05)	1.8 (0.05)	1.8 (0.05)	2.0 (0.05)	0.011
	1998	2.3 (0.05)	2.2 (0.05)	2.1 (0.05)	2.2 (0.05)	2.1 (0.05)	0.026

Values are mean (standard error).
* Age and education in years; income scored from 1 to 4, where 1 = lowest and 4 = highest.

loading on a Western food, processed meat. In 1992 and 1998, however, the Traditional dietary pattern described consistently higher rice consumption frequencies in relation to bread consumption, and margarine and skimmed/low-fat milk consumption frequencies were low in relation to other foods.

Demographic characteristics that were linked to dietary Westernisation were younger age (only in 1998), higher education and higher income (Table 4). In contrast, older and less educated Mauritians, whose income level was also lower, preferred a Traditional dietary pattern. Those whose dietary pattern was based on the substitution of bread for rice seemed to be younger in 1988 but later this eating pattern was equally prevalent for each age category (Table 4). The Bread/butter dietary pattern was directly associated with income in 1988 and 1992, but not in the last survey in 1998.

Comparison of dietary Westernisation scores with the consumption frequencies of foods linked to the Western diet confirmed that the Western dietary pattern was directly associated with Western foods like cakes/pastries and red meat in 1988, and in 1998 with most of the foods listed under Western foods in Table 5. Consumption of salted/smoked fish and traditional Indian breads was indirectly related to the Western dietary pattern in each survey, but not statistically significantly in 1992. Tea and sugar were also indirectly associated with the Western dietary pattern in 1998.

The Bread/butter dietary pattern that also reflected Western influences in Mauritian food culture was directly linked with many Western foods and indirectly with many indigenous foods, although the association was not so strong and consistent as in the Western dietary pattern (Table 6).

The Traditional dietary pattern portrayed a mirror image of the Western way of eating (Table 7). The Traditional dietary pattern was associated with higher consumption frequencies of Indian breads, salted/smoked fish, traditional sauces, tea and sugar in tea. Consumption frequencies of foods like brown bakery bread, salad

Table 5 Pearson correlation coefficients between Western dietary pattern scores and mean daily food consumption frequencies in each survey year

	Western dietary pattern		
	Pattern score 1988	Pattern score 1992	Pattern score 1998
Indigenous foods			
Indian breads: nan and chapatti	**−0.09 (0.006)**		
Faratha		−0.06 (0.1539)	**−0.05 (0.035)**
Puri			−0.01 (0.717)
Salted/smoked fish	**−0.16 (0.0001)**	−0.02 (0.5306)	**−0.06 (0.009)**
Curry/*daube*/*rougaille* sauce			0.03 (0.165)
Lean meat			0.38 (0.0001)
Vegetables	0.02 (0.592)	−0.01 (0.7244)	
Tomatoes			**−0.04 (0.072)**
Mango/papaya/guava			0.11 (0.0001)
Pickles			−0.01 (0.491)
Tea	−0.03 (0.410)	0.03 (0.4637)	**−0.09 (0.0001)**
Sugar in tea/coffee		−0.01 (0.298)	**−0.15 (0.0001)**
Western foods			
Brown bakery bread		−0.03 (0.421)	**0.07 (0.001)**
Cakes/pastries	**0.07 (0.029)**	**0.07 (0.089)**	**0.25 (0.0001)**
Breakfast cereal			**0.13 (0.0001)**
Cheese	0.01 (0.952)	0.03 (0.414)	**0.16 (0.0001)**
Beef, pork and mutton	**0.10 (0.002)**		
Beef		0.02 (0.697)	**0.21 (0.0001)**
Pork		−0.02 (0.657)	**0.36 (0.0001)**
Barbecued/grilled foods			**0.29 (0.0001)**
Lettuce, other salad greens			**0.24 (0.0001)**
Tomato sauce		0.04 (0.130)	**0.21 (0.0001)**
Apples (imported)			**0.20 (0.0001)**
Salad dressing			**0.18 (0.0001)**
Coffee		0.01 (0.827)	**0.10 (0.0001)**
Salty snacks			**0.05 (0.023)**
Burgers			**0.20 (0.0001)**
Commercial fried chicken			**0.14 (0.0001)**
French fries			0.03 (0.198)
Pizza			**0.07 (0.002)**
Soft drinks, regular		0.04 (0.347)	0.02 (0.261)
Soft drinks, diet			**0.14 (0.0001)**
Sweets/chocolate/soft drinks	**0.06 (0.065)**		

Data are *r* (*P*-value).
Values in bold support the validity of the dietary pattern in the description of dietary Westernisation.

Table 6 Pearson correlation coefficients between Bread/butter dietary pattern scores and mean daily food consumption frequencies in each survey year

	Bread/butter dietary pattern		
	Pattern score 1988	Pattern score 1992	Pattern score 1998
Indigenous foods			
Indian breads: nan and chapatti	−0.01 (0.766)		
Faratha		−0.03 (0.280)	**−0.04 (0.058)**
Puri			0.01 (0.535)
Salted/smoked fish	0.02 (0.602)	−0.02 (0.406)	**−0.09 (0.001)**
Curry/*daube*/*rougaille* sauce			−0.01 (0.677)
Lean meat			0.01 (0.576)
Vegetables	0.07 (0.038)	0.02 (0.488)	
Tomatoes			−0.03 (0.168)
Mango/papaya/guava			−0.03 (0.131)
Pickles			−0.00 (0.974)
Tea	−0.01 (0.742)	0.11 (0.0001)	0.10 (0.0001)
Sugar in tea/coffee		0.07 (0.004)	0.09 (0.0001)
Western foods			
Brown bakery bread		−0.08 (0.003)	−0.09 (0.001)
Cakes/pastries	0.05 (0.143)	**0.05 (0.064)**	**0.04 (0.063)**
Breakfast cereal			0.02 (0.266)
Cheese	**0.14 (0.0001)**	0.03 (0.256)	**0.09 (0.0001)**
Beef, pork and mutton	−0.05 (0.112)		
Beef		−0.01 (0.568)	**0.06 (0.004)**
Pork		0.01 (0.715)	−0.05 (0.032)
Barbecued/grilled foods			**0.04 (0.043)**
Lettuce, other salad greens			**0.05 (0.017)**
Tomato sauce		0.02 (0.404)	**0.06 (0.006)**
Apples (imported)			0.01 (0.635)
Salad dressing			0.01 (0.698)
Coffee		0.03 (0.234)	**0.11 (0.0001)**
Salty snacks			**0.04 (0.061)**
Burgers			**0.08 (0.0001)**
Commercial fried chicken			**0.06 (0.006)**
French fries			−0.00 (0.888)
Pizza			0.02 (0.356)
Soft drinks, regular		−0.03 (0.274)	−0.00 (0.955)
Soft drinks, diet			**0.04 (0.080)**
Sweets/chocolate/soft drinks	**0.09 (0.007)**		

Data are *r* (*P*-value).
Values in bold support the validity of the dietary pattern in the description of dietary Westernisation.

greens, pork, burgers and diet soft drinks were all indirectly associated with this traditional way of eating (Table 7).

The Margarine/milk dietary pattern resembled the Traditional pattern. It was associated with higher consumption frequencies of Indian breads, salted or smoked fish, traditional sauces, tea and sugar (Table 8). In fact, some of the associations were stronger than in the traditional way of eating, e.g. for tea and sugar. However, in 1992 and 1998 it was also positively linked to consumption frequencies of bread (in all surveys), processed meat and cheese, which are considered Western foods in Mauritius.

The food intake data based on 24-hour recalls in 1992 confirmed that those who ate in a Western way consumed more foods like breakfast cereals, soft drinks, fruit juice and sweets than people with a more traditional dietary pattern (Table 9). Their dietary intake was characterised by higher consumption of tubers, sugar, and traditional sauces that are eaten mainly with rice.

Discussion

This study showed that, with a relatively small number of indicator foods and their consumption frequencies, it is possible to detect dietary patterns that can be used in examining dietary Westernisation. Four dietary patterns related to the Mauritian dietary transition under Western influences were examined in this study: Western, Bread/butter, Traditional and Margarine/milk.

The food-frequency questionnaire was modified for every dietary survey and thus did not have complete ability to make comparisons between all items. The dietary patterns in the 1992 survey differed from those at baseline and in the final survey. Several explanations are plausible. The Ministry of Health of Mauritius had just carried out an extensive health and nutrition education campaign prior to the 1992 survey. This may have caused real changes in the eating patterns and/or biased reporting of the diet, but the effect faded by the time of the last survey in 1998.

Table 7 Pearson correlation coefficients between Traditional dietary pattern scores and mean daily food consumption frequencies in each survey year

	Traditional dietary pattern		
	Pattern score 1988	Pattern score 1992	Pattern score 1998
Indigenous foods			
Indian breads: nan and chapatti	**0.13 (0.0001)**		
Faratha		0.04 (0.128)	**0.07 (0.0007)**
Puri			−0.01 (0.717)
Salted/smoked fish	**0.24 (0.0001)**	**0.13 (0.0001)**	**0.12 (0.0001)**
Curry/*daube*/*rougaille* sauce			**0.13 (0.0001)**
Lean meat			−0.00 (0.874)
Vegetables	−0.09 (0.005)	0.01 (0.748)	
Tomatoes			**0.11 (0.0001)**
Mango/papaya/guava			0.01 (0.538)
Pickles			**0.07 (0.0007)**
Tea	−0.05 (0.143)	−0.05 (0.064)	**0.10 (0.0001)**
Sugar in tea/coffee		−0.03 (0.295)	**0.19 (0.0001)**
Western foods			
Brown bakery bread		0.01 (0.720)	**−0.09 (0.0001)**
Cakes/pastries	0.01(0.676)	0.04 (0.137)	0.03 (0.189)
Breakfast cereal			−0.03 (0.177)
Cheese	0.11 (0.0006)	−0.04 (0.125)	−0.02 (0.320)
Beef, pork and mutton	**−0.06 (0.064)**		
Beef		0.05 (0.045)	0.03 (0.098)
Pork		0.01 (0.787)	**−0.069 (0.001)**
Barbecued/grilled foods			−0.02 (0.410)
Lettuce, other salad greens			**−0.05 (0.012)**
Tomato sauce		0.04 (0.122)	−0.01 (0.479)
Apples (imported)			−0.02 (0.371)
Salad dressing			−0.01 (0.725)
Coffee		−0.02 (0.505)	−0.03 (0.161)
Salty snacks			0.04 (0.073)
Burgers			**−0.05 (0.028)**
Commercial fried chicken			0.00 (0.906)
French fries			0.09 (0.0001)
Pizza			−0.02 (0.345)
Soft drinks, regular		0.10 (0.0001)	0.09 (0.0001)
Soft drinks, diet			**−0.10 (0.0001)**
Sweets/chocolate/soft drinks	−0.00 (0.944)		

Data are *r* (*P*-value).
Values in bold support the validity of the dietary pattern in the description of dietary Westernisation.

Second, in 1992 a 24-hour recall was also carried out in connection with the food frequency assessment and this might have affected the interview process and the outcome. Third, a dietary transition may have reached its peak in 1992 and eating patterns may have been unstable.

Two underlying trends in Westernisation were detected in each of the three cross-sectional analyses. First, the Bread/butter dietary pattern seemed to be linked to the earlier stages of Westernisation, where Western starchy staples such as bread were replacing the indigenous staple, rice. Other foods indicating indigenous diet like fresh tomatoes (instead of commercial tomato sauce) and tea with sugar were still consumed frequently. At the same time, the associations with the consumption frequencies of most of the Western foods were still relatively weak. Second, the 'Western' dietary pattern described an advanced level of dietary Westernisation where most of the Western foods included in this study were strongly and directly associated with the pattern. The consumption frequencies of many Western fast foods, like burgers, commercially fried chicken, chips and other salty snacks, were directly associated with this Western pattern.

The Traditional dietary pattern was characterised by higher consumption frequencies of indigenous Indian breads and sauces like curry, tea, and salty/smoked fish. Simultaneously the pattern was negatively associated with brown bakery bread, lettuce, burgers and diet soft drinks. The Traditional dietary pattern seemed to be linked with higher consumption frequencies of regular soft drinks and sugar added to tea and coffee, whereas a Western dietary pattern was linked to more frequent consumption of diet soft drinks and sweets, demonstrating a transition in sugar consumption pattern with dietary Westernisation. The regular soft drinks consumption in the traditional dietary pattern also implies that the distinction between Western and traditional ways of consumption is not always so clear. In fact, a pure indigenous dietary pattern with no Western foods in the diet may already be extinct in Mauritius.

The Margarine/milk dietary pattern seemed to describe the first stages of movement away from the traditional way

Table 8 Pearson correlation coefficients between Margarine/milk dietary pattern scores and mean daily food consumption frequencies in each survey year

	Margarine/milk dietary pattern		
	Pattern score 1988	Pattern score 1992	Pattern score 1998
Indigenous foods			
Indian breads: nan and chapatti	**0.15 (0.0001)**		
Faratha		−0.08 (0.001)	−0.07 (0.002)
Puri			0.02 (0.446)
Salted/smoked fish	**0.08 (0.011)**	−0.01 (0.649)	**0.12 (0.0001)**
Curry/*daube*/*rougaille* sauce			**0.17 (0.0001)**
Lean meat			**0.08 (0.0001)**
Vegetables	−0.05 (0.151)	−0.03 (0.200)	
Tomatoes			**0.17 (0.0001)**
Mango/papaya/guava			0.02 (0.297)
Pickles			**0.08 (0.0001)**
Tea	−0.08 (0.009)	**0.28 (0.0001)**	**0.34 (0.0001)**
Sugar in tea/coffee		0.02 (0.548)	**0.39 (0.0001)**
Western foods			
Brown bakery bread		**−0.07 (0.008)**	**−0.18 (0.001)**
Cakes/pastries	−0.03 (0.353)	0.05 (0.071)	0.06 (0.004)
Breakfast cereal			−0.02 (0.279)
Cheese	−0.05 (0.113)	0.06 (0.011)	0.18 (0.0001)
Beef, pork and mutton	**−0.17 (0.0001)**		
Beef		0.08 (0.002)	0.10 (0.0001)
Pork		0.05 (0.043)	**−0.07 (0.002)**
Barbecued/grilled foods			0.01 (0.586)
Lettuce, other salad greens			**−0.06 (0.004)**
Tomato sauce		0.06 (0.024)	0.02 (0.443)
Apples (imported)			−0.02 (0.245)
Salad dressing			**−0.04 (0.089)**
Coffee		0.03 (0.182)	0.01 (0.754)
Salty snacks			0.07 (0.002)
Burgers			0.04 (0.044)
Commercial fried chicken			−0.01 (0.804)
French fries			0.06 (0.006)
Pizza			**−0.04 (0.054)**
Soft drinks, regular		−0.02 (0.420)	0.03 (0.168)
Soft drinks, diet			**−0.09 (0.0001)**
Sweets/chocolate/soft drinks	**−0.08 (0.011)**		

Data are *r* (*P*-value).
Values in bold support the validity of the dietary pattern in the description of dietary Westernisation.

of eating. The association between bread, processed meat and cheese consumption became positive, although tea consumption was still strongly related to this eating pattern.

The differences between the four dietary patterns imply that the process of dietary Westernisation on an individual level started with gradual replacement of rice by bread in Mauritius, which then led to changes in other components of the diet as the consumption of Western condiments – such as processed meats and cheese – became more frequent. After changes in sentinel foods like rice to wheat, meats replaced pulses and new cooking methods like barbecuing and grilling were adopted as well. Popularity of coffee increased but tea consumption frequency decreased. There was also a shift from sugar in tea towards higher consumption frequencies of sweets. Shifts from whole milk to less fatty milk seemed to come at later stages of dietary Westernisation. In the final stage of the Westernisation process, the consumption frequencies of brown bakery bread, breakfast cereals, salads, fruit and

unsweetened soft drinks increased. The first Western fast foods adopted were salty snacks and French fries. However, these are foods that can easily be mixed with indigenous foods like salted and roasted nuts and fried potatoes. After excluding them, burgers seemed to be the most favoured, and pizza and commercially fried chicken the least favoured Western fast foods. Owing to the cross-sectional study design we can describe only the pathway of dietary Westernisation and not estimate the proportion of the study population that moved from one dietary pattern to another over the follow-up period examined here.

Dietary pattern analysis has recently been recognised as a promising dietary assessment tool[37]. Earlier studies on dietary patterns have supported their reproducibility[38] and validity when compared with 3-day records[39]. The method has been successfully applied also in population-level comparisons of dietary patterns[40]. The present study supports the capacity of the dietary pattern analysis method to describe dietary changes of individuals in a

Table 9 Pearson correlation coefficients between Western, Bread/butter, Traditional and Margarine/milk dietary pattern scores and food consumption according to 24-hour recall in 1992

	Dietary pattern			
	Western	Bread/butter	Traditional	Margarine/milk
Indicator foods				
Rice	**−0.31 (0.0001)**	**−0.25 (0.0001)**	**0.31 (0.0001)**	−0.01 (0.837)
Bakery bread	**0.26 (0.0001)**	**0.35 (0.0001)**	**−0.44 (0.0001)**	0.18 (0.0001)
Pulses	**−0.13 (0.0001)**	−0.03 (0.250)	**0.08 (0.0007)**	0.00 (0.933)
Meat (all)	−0.01 (0.739)	0.01 (0.620)	0.02 (0.309)	0.04 (0.132)
Poultry	0.02 (0.384)	0.04 (0.103)	0.03 (0.183)	−0.02 (0.406)
Fish (all)	−0.03 (0.257)	0.02 (0.370)	0.04 (0.076)	−0.00 (0.896)
Butter	−0.05 (0.059)	0.33 (0.0001)	**0.16 (0.0001)**	−0.23 (0.0001)
Margarine	**0.06 (0.025)**	−0.05 (0.038)	**−0.34 (0.0001)**	0.41 (0.0001)
Whole milk	**−0.39 (0.0001)**	0.15 (0.0001)	0.00 (0.915)	**0.35 (0.0001)**
Skimmed/low-fat milk	**0.37 (0.0001)**	−0.10 (0.0001)	**−0.10 (0.0001)**	**−0.22 (0.0001)**
Indigenous foods				
Tubers	−0.03 (0.156)	0.01 (0.639)	**0.05 (0.049)**	−0.05 (0.061)
Tea	**−0.28 (0.0001)**	0.15 (0.0001)	−0.05 (0.031)	**0.31 (0.0001)**
Sugar	**−0.31 (0.0001)**	0.05 (0.025)	**0.09 (0.0002)**	**0.18 (0.0001)**
Curry/*daube*/*rougaille*	**−0.07 (0.004)**	−0.03 (0.198)	**0.07 (0.007)**	−0.03 (0.219)
Vegetables	0.03 (0.171)	**−0.05 (0.052)**	−0.01 (0.638)	−0.01 (0.740)
Fruit	0.12 (0.0001)	0.02 (0.341)	−0.05 (0.051)	−0.00 (0.952)
Western foods				
Breakfast cereals	**0.07 (0.007)**	**0.06 (0.009)**	**−0.07 (0.006)**	0.02 (0.439)
Snacks	0.02 (0.385)	**0.05 (0.025)**	−0.02 (0.463)	0.01 (0.554)
Coffee	0.03 (0.223)	0.03 (0.276)	−0.02 (0.351)	0.04 (0.132)
Soft drinks	**0.05 (0.038)**	0.04 (0.092)	0.01 (0.557)	−0.02 (0.329)
Unsweetened soft drinks	0.04 (0.124)	0.01 (0.640)	−0.01 (0.690)	0.00 (0.894)
Fruit juice	**0.08 (0.002)**	−0.02 (0.501)	0.01 (0.579)	−0.03 (0.217)
Sweets	**0.06 (0.013)**	**0.05 (0.041)**	**−0.06 (0.018)**	0.03 (0.264)

Data are *r* (*P*-value).
Values in bold support the validity of the dietary pattern in the description of dietary Westernisation.

society that is undergoing transitions in food choices and eating patterns.

Diffusion of Western dietary patterns took place at varying paces in the population subgroups. The early adopters of these patterns were younger, more educated and also had a higher monthly income, whereas the older and less-educated population favoured rice-based diets for longer. Younger Mauritians may be more sensitive to the Western mass media and to other Western influences, which would enhance their adoption of new foods and also transform their psychosocial values related to foods that will guide their future food choice[41]. An example of changing psychosocial values of foods is pork consumption. It has been low in Mauritius[42] because it is not very well accepted among the Indian population (U Haw, personal communication). Dietary Westernisation, however, seemed to change these values because both dietary patterns of Westernisation – Western and Bread/butter – correlated positively, but the Traditional pattern and the Margarine/milk pattern correlated negatively, with frequency of pork consumption.

Higher socio-economic status may facilitate the process of dietary Westernisation because wealthier population subgroups can afford to buy value-added processed foods, and foods of animal origin like meats and processed dairy products. It has been reported that a processed food like bread may be a less expensive option in a family diet than indigenous foods that require a longer preparation

time and more fuel for cooking[43,44]. This may partly explain why bakery bread is one of the first Western foods to be included in and to displace indigenous starches in the traditional diet. Processed meats like sausages may also be consumed more often because they are less expensive than other meats due to added cheaper ingredients.

Dietary pattern studies in Western countries have labelled an eating pattern 'Western' if the emphasis of factor loadings has been on energy-rich and saturated fat-rich foods[45–47]. However, a label of 'unhealthy' could perhaps more accurately describe the dietary pattern in the Western environment, at least with respect to chronic diseases. Western influences on diet in a non-Western setting are not always adverse. In the present study, the Western dietary pattern described increased consumption frequencies of foods that are connected with health-seeking behaviour. Examples of these foods include whole-grain bread, breakfast cereal, fruit, lettuce and other salad greens, and diet soft drinks. In the food consumption study in 1992, breakfast cereal intake was positively associated with both Western dietary patterns (Western and Bread/butter), but negatively with the Traditional dietary pattern. Bjerregaard *et al.*[48] also discovered another favourable effect of Westernisation: it was inversely associated with body mass index among Greenlanders.

The later stages of the epidemiological[49–51] and nutrition transition[52] are characterised by increased health

consciousness and intentional positive changes in health behaviour. Bah[26] has suggested that Mauritius has not yet reached this phase. Nevertheless, the increased consumption frequencies of healthier foods among early adopters of the Western way of eating (Western dietary pattern) in 1998 demonstrate that the situation is changing, and that the dietary transition in the country is now moving towards voluntary consumption of foods that are not associated with increased risk of chronic diseases.

Overall, from the policy planning perspective, it is important to examine the differences between dietary transition and dietary Westernisation, even though some overlap between them exists. Dietary transitions are involved with the adoption of agriculture by hunter-gatherers[53], with increases in local agricultural productions[11] and also with collective returns to indigenous foods[54], which all describe different dietary transition processes than dietary Westernisation. Society-level interventions[55] may be the most useful strategy to combat the adverse effects of dietary transitions in many countries, e.g. to affect the fatty acid composition of the diet[56]. Better understanding of dietary Westernisation will, however, help the targeting of appropriate, more specifically tailored interventions to selected sub-populations that are facing the negative impact of a Western diet, like overweight[13,57]. The complexities of dietary Westernisation and dietary transitions need to be considered more extensively in dealing with individual and societal undernutrition and overnutrition.

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