

Neighbourhood ethnic composition and diet among Mexican-Americans

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Abstract

Objectives: We explore the association between a neighbourhood's ethnic composition and the foods and nutrients consumed by Mexican-Americans.

Design: Cross-sectional survey of a large national sample, from the Third National Health and Nutrition Examination Survey (1988–94), was linked to the 1990 Census. The outcomes were food frequencies and serum levels of micronutrients. The variable of interest was percentage of Mexican-Americans at the census tract level.

Setting: United States.

Subjects: A total of 5306 Mexican-American men and women aged 17–90 years.

Results: Increased percentage of Mexican-Americans at the census tract level was associated with less consumption of fruits, carrots, spinach/greens and broccoli and with lower serum levels of Se, lycopene, α -carotene, vitamin C and folate. By contrast, increased percentage of Mexican-Americans at the census tract level was associated with more consumption of corn, tomatoes, hot red chilli peppers and legumes such as beans, lentils or chickpeas.

Conclusions: An increased percentage of Mexican-Americans at the census tract level was associated with less consumption of selective foods (e.g. some fruits, broccoli) and low levels of serum Se or vitamin C, but it was associated with more consumption of other foods (e.g. legumes, tomatoes, corn products) that may have positive effects on health in this population.

Keywords
Neighbourhood
Ethnic composition
Diet
Hispanics
Health

Assimilation and acculturation have long been recognized as important though complex correlates of change in health risk profiles of immigrants and the resulting ethnic populations^(1,2). The standard model that dominates research on acculturation and health suggests that new immigrant populations typically have a set of risk profiles that are distinctive from those of the population of the host society in which they have settled. These differences may reflect a combination of influences, including the maintenance of culturally distinctive behaviours characteristic of the country of origin; the distinctive influences of the immigration experience itself, including disruption of personal networks and exposure to discrimination; and the correlation of the decision to migrate across national boundaries with distinctive personal characteristics. Time spent in the host society – measured in years, and sometimes generations, among the descendants of immigrants – tends to erode these differences. Social epidemiologists frequently turn to the variables of time and, where relevant, linguistic change – the adoption of the language of the destination

society – as correlates of changes in social and behavioural risk profiles away from those characteristic of the immigrant group itself, and towards those characteristic of segments of the broader population of the country of destination^(1,3–5).

Recently, increased attention has been given in the social epidemiology literature to the influence of the social-spatial context of health. In particular, a growing literature investigates variation in local social environments with respect to variables such as quality of food supply, local modelling of healthy diets and personal habits, stressfulness of daily living and encouragement of physical activity^(6–10). In the context of the social scientific study of immigrant incorporation, this emphasis is concordant with a well-documented relationship linking ethnic residential enclaves with the maintenance and intergenerational transmission of ethnic-specific cultures^(11–13). Drawing on these broader social science research findings, epidemiologists have investigated the hypothesis that ethnic concentration of immigrant-derived populations in neighbourhoods is

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associated with the maintenance of group-specific social behavioural practices that influence health outcomes.

The Mexican-American population of the USA provides a particularly noteworthy case for the investigation of the effects of residential concentration on health. Compared with non-Hispanic whites, Mexican-Americans have lower mortality rates from all causes, and from leading causes including CVD and cancers at most common sites^(13–18). Mexican-American mortality rates are consistently reported to be lower for immigrants than they are for Mexican-Americans born in the USA^(13,15,17–19). That mortality rates are lower for a Mexican-American population that is on average socio-economically disadvantaged has been described as an epidemiological paradox^(20,21).

One of the leading hypotheses about the better than expected health and mortality outcomes for Mexican-Americans, as well as the apparently poorer outcomes for US-born Mexican-Americans compared with immigrants from Mexico, points to protective aspects of health-related behaviours among immigrants, including healthier diets, lower rates of smoking, substance and alcohol use, and higher rates of physical activity^(13,16,21,22). Indeed, studies of acculturation have documented a relationship between acculturation and less healthy lifestyles in the Mexican origin population, although effects of acculturation are not entirely negative. Notably, both health-care access and use of screening improves with greater acculturation.

A small but growing number of studies have examined the hypothesis that a high concentration of Mexican populations in residential communities is associated with better health outcomes. To date, results have been mixed. Some studies report evidence of lower mortality, lower chronic disease morbidity, better mental health and higher self-rated health^(23–31). Others report weak, contradictory or null results^(13,32,33).

In the present study we investigate the relationship between ethnic residential concentration of Mexican-Americans and dietary intake. Specifically, we investigate the hypothesis that there is a strong relationship between ethnic concentration, e.g. residence in a barrio community, and types of foods consumed. This hypothesis has a high degree of plausibility, because a high level of ethnic concentration in a local community creates a context for the supply of ethnic-specific food products and for the modelling of dietary practices. The Mexican-American population lives in very diverse residential settings, ranging from homogeneous ethnic environments in near-border areas in the south-west, to neighbourhoods throughout the USA where they are highly integrated with non-Hispanics. Do dietary practices among Mexican-Americans in different neighbourhood settings differ in ways that suggest that integration with other groups leads to deterioration of dietary practices that help explain the increasing rates of chronic disease prevalence among more acculturated Hispanics?

Methods

Data source

The Third National Health and Nutrition Examination Survey (NHANES III), a large US survey conducted from 1988 to 1994, is a major source of information on the nutritional and health status of the US population aged 2 months or more⁽³⁴⁾. The strength of this survey is that it used the same stratified multistage probability design as previous National Health and Nutrition Examination Surveys⁽³⁴⁾. Weights indicating the probability of being sampled were assigned to each respondent, enabling results to represent the US population for each group. Mexican-Americans were over-sampled to produce statistically reliable health estimates for the largest ethnic minority subgroup in the USA. The data were collected via standardized questionnaires administered by health professionals at participants' homes; standardized medical examinations by physicians, medical technicians and other health professionals at the National Health and Nutrition Examination Survey mobile examination centres (MEC); and laboratory tests on whole blood and sera. Interviews were conducted in English and Spanish after informed consents were obtained at the initial home interview. The interviewer gave each person selected for the survey a brochure which described the survey procedures using a question-and-answer format and included photographs of people being examined in the MEC rooms. The final page of the brochure was a paper that required the signature of each participant 18 years of age and older^(34,35). Response rates were high, 78% completed both the home interview and the medical examination. To get the percentage of Mexican-Americans at the census tract level, the NHANES III was merged with the 1990 US Census data. To avoid any potential identification of subjects, the merge of the NHANES III public database⁽³⁶⁾ with neighbourhood data (US Census Bureau, 1990)⁽³⁷⁾ was made by the National Center for Health Statistics (NCHS) Research Data Center (Hyattsville, MD, USA). We sent the statistical models needed for our analyses and the NCHS remote system sent us back the results. The study protocol was approved by the University of Texas Medical Branch Institutional Review Board.

Study sample

The sample for our analyses included 5306 Mexican-American men and women aged 17–90 years who completed both the home questionnaire and medical examination.

Measurements

The outcomes were food frequencies and serum levels of nutrients.

Food frequencies were assessed by a 1-month qualitative FFQ^(38,39). The NHANES III nutrient database for individual foods is derived from the US Department of

Agriculture's Survey Nutrient Database^(39,40). To ensure the accuracy of the nutrient contents of foods, substantial care was taken to include a wide variety of traditional Mexican foods (e.g. red chilli peppers)^(41,42). The FFQ, administered during the household interview, was used to ask respondents about the average number of times foods were eaten during the 1-month period preceding the interview date. Frequencies of consumption of foods from the following food groups were ascertained: fruits, vegetables, grains and legumes.

Serum levels of nutrients have been shown to correlate well with dietary intake of respective nutrients⁽⁴³⁾. The micronutrients examined included those considered to be of potential public health significance and thought to decrease the risk of cancer or CVD^(44–48). Serum levels of the following nutrients were obtained: lycopene, Se, vitamin E, vitamin D, vitamin A, vitamin C, vitamin B₁₂, folate, α -carotene and β -cryptoxanthin. Serum levels of nutrients were determined by nutritional biochemistry. MEC collected blood samples and used the following assay or instrumentation methods for laboratory assessments: 'Quanta-phase Folate' RIA Kit (Bio-Rad Laboratories, Hercules, CA, USA) for folate; HPLC (Waters Corporation, Milford, MA, USA) for vitamins A, C and E and carotenoids (lycopene, α -carotene, β -cryptoxanthin); INCSTAR 25-OH-D RIA Kit (INCSTAR, Stillwater, MN, USA) for vitamin D (25-hydroxy-vitamin D₃); ¹²⁵I-folic/⁵⁷Co-B-12 for vitamin B₁₂; and graphite furnace atomic absorption using Perkin–Elmer model 3030 and 5100 instruments (Perkin–Elmer Co., Norwalk, CT, USA) for Se⁽³⁴⁾.

A measure of contextual acculturation, the percentage of Mexican-Americans at the census tract level (a higher percentage indicates more isolation or less integration with other ethnic groups)⁽²⁵⁾ was used as a continuous variable. Other variables were age (years, used as a continuous variable) and gender (male and female).

Statistical analyses

All statistical analyses were carried out using the statistical software packages SAS for Windows version 9.1 (SAS Institute, Inc., Cary, NC, USA) and SUDAAN version 7.11 (Research Triangle Institute, Research Triangle Park, NC, USA). All analyses incorporated sampling weights that adjusted for unequal probabilities of selection. Because of the complex survey design used in NHANES III, traditional methods of statistical analysis based on the assumption of a simple random sample may not be reliable. Sample weights are needed to produce correct estimates of population quantities. Other aspects of the sample design (e.g. PSU (primary sampling units) pairings) should be taken into account to obtain correct standard errors and significance levels for hypothesis testing^(49,50). With continuous outcome variables, frequency of foods (e.g. cereals, tomatoes) or serum levels of nutrients (e.g. Se, lycopene), we used age- and gender-adjusted linear regression analyses (REGRESS procedure)

to examine the independent association of the percentage of Mexican-Americans at the census tract level with food frequencies and serum levels of nutrients.

Results

The study population comprised 2682 Mexican-American men (50.6%) and 2624 women (49.4%); 35% of subjects were aged 17–29 years, 29.2% were aged 30–44 years, 13.5% were aged 45–59 years, 17.5% were aged 60–74 years and 4.8% were 75 years of age and older. Age group distributions did not differ by gender. Eighty-eight per cent of subjects came from three of the four US–Mexico border states: California, Texas and Arizona. These states correspond to the south-west area of the USA where the majority of Mexican-Americans reside.

Table 1 shows the multivariate linear regression analyses for the relationship between consumption of specific foods (more detailed description is provided in the table) and percentage of Mexican-Americans at the census tract level. It shows that increased percentage of Mexican-Americans in the neighbourhood was associated with less consumption of melons (unstandardized beta coefficient (b) = -1.21 , SE 0.52, $P=0.0266$), any other fruits (e.g. apples, bananas; $b=-4.57$, SE 1.34, $P=0.0017$), carrots ($b=-1.61$, SE 0.70, $P=0.0273$), spinach/greens ($b=-1.17$, SE 0.27, $P=0.0001$) and broccoli ($b=-1.84$, SE 0.5, $P<0.0001$). On the other hand, increased percentage of Mexican-Americans in the neighbourhood was associated with more consumption of the group of fruits that included peaches, nectarines, apricots, guava, mango and papaya ($b=0.32$, SE 0.68, $P=0.63$). Although this association did not reach statistical significance, it suggests that these fruits – especially the traditional mango and papaya – may be important diet components of high-density Mexican-American neighbourhoods. By contrast, increased percentage of Mexican-Americans in the neighbourhood was associated with more consumption of corn products ($b=11.12$, SE 2.98, $P=0.0006$), flour tortillas ($b=7.17$, SE 2.63, $P=0.0097$), tomatoes ($b=2.76$, SE 0.94, $P=0.0060$), hot red chilli peppers ($b=4.05$, SE 1.48, $P=0.0097$) and legumes such as beans, lentils or chickpeas/garbanzos ($b=11.56$, SE 1.81, $P<0.0001$).

Table 2 shows the multivariate linear regression analyses for the relationship between serum levels of nutrients and percentage of Mexican-Americans at the census tract level. It shows that increased percentage of Mexican-Americans at the census tract level was associated with lower levels of lycopene ($b=-3.77$, SE 0.62, $P<0.0001$), Se ($b=-4.99$, SE 1.55, $P=0.0033$), vitamin C ($b=-0.10$, SE 0.03, $P=0.0025$) and folate ($b=-0.88$, SE 0.33, $P=0.0117$). Increased percentage of Mexican-Americans at the census tract level was also associated with higher levels of β -cryptoxanthin ($b=1.53$, SE 1.18, $P=0.20$) and

Table 1 Multivariate analysis results* for frequency of foods as a function of the percentage of Mexican-Americans at the census tract level: outcome data in Mexican-American men and women (*n* 5306) were obtained from the Third National Health and Nutrition Examination Survey (1988–94) and linked to the 1990 Census

Outcomes (times/month)	Percentage of Mexican-Americans at census tract level (continuous)		
	<i>b</i>	SE	<i>P</i>
Cereals: all bran, etc.	−0.27	0.36	0.46
Spaghetti/pasta/tomato sauce	−0.87	0.98	0.38
Corn bread, muffins and tortillas	11.12	2.98	0.0006
Flour tortillas	7.17	2.63	0.0097
Rice	−1.34	0.82	0.11
Citrus fruits: oranges, grapefruits and tangerines	−0.39	1.34	0.77
Melons: cantaloupe, honeydew and watermelon	−1.21	0.52	0.0266
Peaches, nectarines, apricots, guava, mango and papaya	0.32	0.68	0.63
Any other fruits: apples, bananas, pears, berries, cherries, grapes, plums and strawberries	−4.57	1.34	0.0017
Carrots and vegetable mixtures containing carrots	−1.61	0.70	0.0273
Spinach, greens, collards and kale	−1.17	0.27	0.0001
Broccoli	−1.84	0.35	<0.0001
Brussels sprouts/cauliflower	−0.28	0.42	0.51
Tomatoes	2.76	0.94	0.0060
Hot red chilli peppers	4.05	1.48	0.0097
Other peppers (green, red, yellow)	0.66	1.13	0.56
Beans (pinto, refried, black and baked), lentils, chickpeas or garbanzos	11.56	1.81	<0.0001

b, unstandardized beta coefficient; SE, standard error of the beta coefficient.

*Adjusted for age and gender.

Table 2 Multivariate analysis results* for serum levels of nutrients as a function of the percentage of Mexican-Americans at the census tract level: outcome data on Mexican-American men and women (*n* 5306) were obtained from the Third National Health and Nutrition Examination Survey (1988–94) and linked to the 1990 Census

Outcome (serum level)	Percentage of Mexican-Americans at census tract level (continuous)		
	<i>b</i>	SE	<i>P</i>
Lycopene (ug/dl)	−3.77	0.62	<0.0001
Selenium (ng/ml)	−4.99	1.55	0.0033
Vitamin E (ug/dl)	−22.61	28.12	0.43
Vitamin D (ng/ml)	−0.23	1.23	0.85
Vitamin A (μg/dl)	−2.00	1.01	0.0560
Vitamin C (mg/dl)	−0.10	0.03	0.0025
Folate (ng/ml)	−0.88	0.33	0.0117
Vitamin B ₁₂ (pg/ml)	191.2	179.1	0.32
α-Carotene (μg/dl)	−0.73	0.35	0.0427
β-Cryptoxanthin (μg/dl)	1.53	1.18	0.20

b, unstandardized beta coefficient; SE, standard error of the beta coefficient.

*Adjusted for age and gender.

vitamin B₁₂ (*b* = 191.2, SE 179.1, *P* = 0.32) but did not reach statistical significance.

Discussion

In the present study, we focused on spatial aspects of assimilation in relation to dietary quality using data from a geo-coded NHANES III data set, where the characteristics of tract populations from the 1990 census were attached to individual records to investigate the relationship between the social characteristics of tract populations and nutrient profiles measured through self-reported dietary recalls and measurement of serum nutrients. The emphasis on spatial characteristics of residential communities as a possible correlate of changes in nutrition is

consistent with a very old social science research finding that residential concentration of immigrant and ethnic populations serves to maintain ethnic-specific cultural patterns^(11,12). It is also consistent with a recent research stream in epidemiology that investigates the socio-economic characteristics of neighbourhoods of residence in relation to health-related behaviours and health outcomes⁽⁵¹⁾. It also identifies a variable with a broad range among Mexican-Americans, who are distributed across a broad spectrum of residential environments, ranging from a high degree of ethnic segregation in the border region of Texas, to full integration with non-Hispanics in urban and suburban communities throughout the USA⁽⁵²⁾.

Dietary patterns including vegetables and fruits have been associated with lower risk of all-cause mortality using data from the National Health Interview Surveys⁽⁵³⁾ and the

Breast Cancer Detection Demonstration Project⁽⁵⁴⁾; and with lower risk for CVD using data from the Physicians' Health Study⁽⁵⁵⁾, the Nurses' Health Study^(56,57), the Health Professionals' Follow-up Study^(57,58) and the Framingham Nutrition Studies⁽⁵⁹⁾. In addition, case-control and cohort studies showed that vegetables and fruits have been associated with reduction in the risk of some cancers including mouth and pharynx, oesophagus, stomach, colon-rectum, larynx, lung, breast (vegetables only), ovary (vegetables only), bladder (fruits only) and kidney⁽⁶⁰⁻⁶²⁾.

However, higher concentrations of Mexican-Americans in a neighbourhood are correlated with poverty and disadvantage; therefore, the pattern of low consumption of some fruits (e.g. cherries, berries) and some vegetables (e.g. broccoli) in our study may reflect unaffordable costs for foods or lower availability in a neighbourhood food environment⁽²⁶⁾. Indeed, in another study, Bodor *et al.*⁽⁶³⁾ reported that greater fresh vegetable availability within 100 metres of residences was a positive predictor of vegetable intake.

Studies of health and mortality patterns of Mexican-Americans living in the USA have previously reported greater longevity^(13,17-19) and lower biological risk profiles⁽⁶⁴⁾ for Mexican-American immigrants residing in the USA compared with non-Hispanic whites and US-born Mexican-Americans. US-born Mexican-Americans appear to have mortality rates and biological risk profiles similar to or not much worse than those of non-Hispanic whites, which some commentators appear to ascribe as unexpected because of the much lower average socio-economic status of US-born Mexican-Americans compared with non-Hispanic whites.

The explanation of the lower mortality and better than expected biological risk profiles of Mexican-Americans remains a matter of investigation and debate. Recent work has substantially removed data quality concerns as the principal explanation of these patterns^(19,65,66). A second hypothesis suggests that the greater propensity to immigrate of persons with better health may play a leading role, although direct evidence for this hypothesis remains weak. A third set of explanations points to healthier socio-cultural risk profiles as a contributing element. More nutritious diets for immigrants, lower rates of smoking and substance use, and stronger social support, are frequently hypothesized to contribute to the Mexican-American mortality advantage. These hypotheses are concordant with evidence showing decreases in the quality of diets and health-related behaviours with increasing time and generation in the USA^(1,39,67,68).

On the other hand, high consumption of legumes (especially beans) and hot red chilli peppers may reflect cultural preferences and more affordable foods for this Mexican-American population^(41,42). It has been reported that dietary patterns are different and generally less healthy for US-born compared with immigrant Mexican-Americans. Dixon *et al.*⁽⁴¹⁾ reported that US-born Mexican-Americans

consumed significantly more fat and less fibre and vitamins, and were less likely to meet dietary guidelines than were immigrant Mexican-Americans. Also, Guendelman and Abrams⁽⁶⁷⁾ reported that first-generation Mexican-American women had higher average intakes of protein, vitamins A and C, folic acid and Ca than second-generation Mexican women, whose nutrient intake resembles that of white non-Hispanic women. Other studies have shown that acculturation to the US culture among Mexican-Americans was associated with increased dietary fat and sugar along with higher waist circumference and abdominal obesity^(41,69-71). A potential explanation on how acculturation affects diet among Mexican-Americans is related to a higher food store availability and consumption of fast food in inner-city neighbourhoods^(72,73). The consumption of these other foods may influence the selection of a healthier diet profile in our study population of Mexican-Americans.

So the question we asked was whether there was evidence of dietary advantages in more rather than less ethnically homogeneous Mexican-American communities that could help explain lower rates of incidence and mortality for some chronic diseases for Mexican-Americans as a population group. Therefore, consumption of higher amounts of legumes (beans, lentils or chickpeas) may protect the health of a population with high concentration of Mexican-Americans in the neighbourhood. Indeed, consumption of higher amounts of legumes may have a protective effect against cancer. Kolonel *et al.*⁽⁷⁴⁾ reported that intake of legumes (whether total legumes, soya foods specifically, or other legumes) was inversely related to prostate cancer risk. Also, Correa⁽⁷⁵⁾ examined data from forty-one countries and found a significant inverse correlation between bean consumption and mortality due to prostate, breast and colon cancer. In other human or animal studies, high consumption of dry beans has been associated with lower rates of myocardial infarction among Costa Ricans or fewer colon adenocarcinomas among rats^(76,77). These findings may be part of the explanation why those Mexican-Americans living in neighbourhoods with a high concentration of Mexican-Americans exhibit lower cancer incidence or lower overall mortality^(25,26). In Mexico, common beans are the second source of protein, carbohydrates, vitamins and minerals after corn^(78,79). Beans contain complex carbohydrates and are rich in Mg, Cu and α -linoleic acid; these components may improve insulin sensitivity and lipid profiles⁽⁷⁶⁾. Beans are also an excellent source of non-nutritive constituents such as fibre, protease inhibitors, phytic acid, isoflavonoids, lignans and polyphenols such as tannins. These compounds have antioxidant, antimutagenic and anticarcinogenic activities and are also free radical scavengers⁽⁷⁸⁻⁸²⁾. In addition, capsaicin, the major pungent ingredient in red peppers, decreases the growth (e.g. inducing the apoptosis) of human and *in vitro* prostate cancer cells⁽⁸³⁾, human leukaemic cells⁽⁸⁴⁾, gastric⁽⁸⁵⁾ and hepatic carcinoma cells *in vitro*⁽⁸⁶⁾.

Finally, consumption of tomatoes has been found to have protective cardiovascular effects, with potential protection for prostate, oesophagus, stomach, lung and breast cancer^(87–89).

One limitation of our study is the cross-sectional design of the NHANES III, which prevented us from drawing causal inferences. Dietary assessment tools also have inherent limitations. A serum level of nutrients and 1-month qualitative FFQ are not representative of individual nutrient intakes because of day-to-day variation in food consumption. However, serum levels of nutrients are an objective measure, and we included a proxy for contextual acculturation – i.e. neighbourhood density (percentage of Mexican-Americans at the census tract level) – that may capture other contextual factors related to the environment where Mexican-Americans live^(25–28).

The NHANES III questionnaire does not distinguish between traditional and non-traditional fruits (e.g. papaya or mango *v.* apricots) or other foods (e.g. corn tortillas *v.* corn muffins) among Mexican-Americans; this may lead to biased estimations or underestimations of some traditional foods in this population. In addition, NHANES III includes a mixed group of unprocessed-corn products such as bread or muffins but, with the exception of corn tortillas, does not include the consumption of processed-corn and specifically *masa* products that are essential foods in the diet of countries of Hispanic origin in the Americas. *Masa* is used to make tortillas (or tortillas chips), tamales, pozole, arepas and empanadas^(90,91). *Masa* is obtained after thermal-alkaline treatment, or a nixtamalization process, of the corn kernels. It involves lime-cooking (calcium hydroxide solution), followed by steeping for 12–16 h, washing and stone-grinding the corn grains to produce *masa*. Cooking the corn with lime significantly increases its Ca (>700%), P and Fe content⁽⁹¹⁾. Ca from *masa* acquires great relevance because it represents almost the only source of Ca in some Latin American countries. *Masa* products provide an important source of energy, proteins, dietary fibre, antioxidants and nutrients such as phytochemicals and carotenoids (e.g. lutein, zeaxanthin, β -cryptoxanthin)⁽⁹²⁾. However, lime-cooking affects the amount of resistant starch and the quality of protein. For example, the partial removal of the pericarp or bran leads to finished products that are considered as semi-whole grain foods⁽⁹²⁾. Also, digestibility of the protein is decreased slightly, possibly because hydrophobic interactions, protein denaturation and cross-linking of proteins occur during maize processing that change the solubility of these components, which could affect amino acid release during enzymatic digestion⁽⁹³⁾.

The Hispanic population is the largest minority group in the USA, and Mexican-Americans constitute the majority of this group. Isolated Mexican-American communities tend to maintain many of their traditional foods; however, public health campaigns are necessary not only to promote these traditional foods but also to make accessible other essential

foods in their diet. On the other hand, more research is needed to assess potential health-protective effects of traditional Mexican-American foods such as avocados or specific kind of beans (e.g. pinto, black).

In conclusion, an increased percentage of Mexican-Americans at the census tract level was associated with less consumption of selective or non-traditional foods (e.g. some fruits such as melons, apples, berries; or vegetables such as broccoli) and low levels of serum Se and vitamin C, but it was associated with more consumption of traditional foods such as corn products, legumes (beans, lentils and chickpeas), tomatoes and hot red chilli peppers. Thus, consumption of these traditional foods may make a difference to the health risk profiles in this population. Further studies are needed to determine if other nutrients or foods (e.g. *masa* products) that were not included in the data may influence dietary profiles in high-density Mexican-American neighbourhoods. Also, research is needed to explore whether unhealthier practices such as the consumption of fast foods or sedentary lifestyles are common among isolated Mexican-American neighbourhoods.

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References

1. Lara M, Gamboa C, Kahramanian MI, Morales LS & Hayes-Bautista DE (2005) Acculturation and Latino Health in the United States: a review of the literature and its sociopolitical context. *Annu Rev Public Health* **26**, 367–397.
2. Williams DR & Collins C (1995) US socioeconomic and racial-differences in health-patterns and explanations. *Annu Rev Public Health* **21**, 349–386.
3. Arcia E, Skinner M, Bailey D & Correa V (2001) Models of acculturation and health behaviors among Latino immigrants to the US. *Soc Sci Med* **53**, 41–53.
4. Berry JW (1997) Immigration, acculturation, and adaptation. *Appl Psychol* **46**, 5–34.
5. Hunt LM, Schneider S & Corner B (2004) Should acculturation be a variable in health research? A critical

- review of research on US Hispanics. *Soc Sci Med* **59**, 973–986.
6. Sampson RJ, Raudenbush SW & Earls F (1997) Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science* **277**, 918–924.
 7. Popkin BM, Duffey K & Gordon-Larsen P (2005) Environmental influences on food choice, physical activity and energy balance. *Psychol Behav* **86**, 603–613.
 8. Cohen DA, Ashwood JS, Scott MM, Overton A, Evenson KR, Staten LK, Porter D, McKenzie TL & Catellier D (2006) Public parks and physical activity among adolescent girls. *Pediatrics* **118**, 1381–1389.
 9. Frank LD, Sallis JF, Conway TL, Chapman JE, Saelens BE & Bachman W (2006) Many pathways from land use to health – associations between neighborhood walkability and active transportation, body mass index, and air quality. *J Am Plann Assoc* **72**, 75–87.
 10. Moore LV & Roux AVD (2006) Association of neighborhood characteristics with the location and type of food stores. *Am J Public Health* **96**, 325–331.
 11. Gordon M (1964) *Assimilation in American Life*. New York: Oxford University Press.
 12. Massey DS (1985) Ethnic residential segregation: a theoretical synthesis and empirical review. *Sociol Soc Res* **69**, 315–350.
 13. Palloni A & Arias E (2004) Paradox lost: explaining the Hispanic adult mortality advantage. *Demography* **41**, 385–415.
 14. Sorlie PD, Backlund E, Johnson NJ & Rogot E (1993) Mortality by Hispanic status in the United States. *JAMA* **270**, 2464–2468.
 15. Hummer RA, Rogers RG, Nam CB & LeClere FB (1999) Race/ethnicity, nativity, and US adult mortality. *Soc Sci Q* **80**, 136–153.
 16. Singh GK & Siahpush M (2002) Ethnic-immigrant differentials in health behaviors, morbidity and cause-specific mortality in the United States: an analysis of two national databases. *Hum Biol* **74**, 83–109.
 17. Eschbach K, Kuo YF & Goodwin JS (2006) Ascertainment of Hispanic ethnicity on California death certificates: implications for the explanation of the Hispanic mortality advantage. *Am J Public Health* **96**, 2209–2215.
 18. Eschbach K, Stimpson JP, Kuo YF & Goodwin JS (2007) Mortality of foreign-born and US-born Hispanic adults at younger ages: a re-examination of recent patterns. *Am J Public Health* **97**, 1297–1304.
 19. Elo IT, Turra CM, Kestenbaum B & Ferguson RF (2004) Mortality among elderly Hispanics in the United States: past evidence and new results. *Demography* **41**, 109–128.
 20. Markides KS & Coreil J (1986) The health of Hispanics in the southwestern United States: an epidemiologic paradox. *Public Health Rep* **101**, 253–265.
 21. Franzini L, Ribble JC & Keddle AM (2001) Understanding the Hispanic paradox. *Ethn Dis* **11**, 496–518.
 22. Markides KS & Eschbach K (2005) Aging, migration, and mortality: current status of research on the Hispanic paradox. *J Gerontol B Psychol Sci Soc Sci* **60B**, Spec. No. 2, 68–75.
 23. Aneshensel CS & Sucoff CA (1996) The neighborhood context of adolescent mental health. *J Health Soc Behav* **37**, 293–310.
 24. LeClere F, Rogers RG & Peters KD (1997) Ethnicity and mortality in the United States: individual and community correlates. *Soc Forces* **76**, 169–198.
 25. Eschbach K, Ostir GV, Patel KV, Markides KS & Goodwin JS (2004) Neighborhood context and mortality among older Mexican Americans: is there a barrio advantage? *Am J Public Health* **94**, 1807–1812.
 26. Eschbach K, Mahnken JD & Goodwin JS (2005) Neighborhood composition and incidence of cancer among Hispanics in the United States. *Cancer* **103**, 1036–1044.
 27. Ostir GV, Eschbach K, Markides KS & Goodwin JS (2003) Neighborhood composition and depressive symptoms among older Mexican Americans. *J Epidemiol Community Health* **57**, 987–992.
 28. Patel KV, Eschbach K, Rudkin L, Peek MK & Markides KS (2003) Neighborhood context and self-rated health in older Mexican Americans. *Ann Epidemiol* **13**, 620–628.
 29. Bond Huie SA, Hummer RA & Rogers RG (2002) Individual and contextual risks of death among race and ethnic groups in the United States. *J Health Soc Behav* **43**, 359–381.
 30. Inagami S, Borrell LN, Wong MD, Fang J, Shapiro MF & Asch SM (2006) Residential segregation and Latino, black, and white mortality in New York City. *J Urban Health* **83**, 406–420.
 31. Cagney KA, Browning CR & Wallace DM (2007) The Latino paradox in neighborhood context: the case of asthma and other respiratory conditions. *Am J Public Health* **97**, 919–925.
 32. Lee MA & Ferraro KF (2007) Neighborhood residential segregation and physical health among Hispanic Americans: good, bad, or benign? *J Health Soc Behav* **48**, 131–148.
 33. Frank R, Cerda M & Rendon M (2007) Barrios and burbs: residential context and health-risk behaviors among Angelino adolescents. *J Health Soc Behav* **48**, 283–300.
 34. National Center for Health Statistics (1994) Plan and operation of the Third National Health and Nutrition Examination Survey, 1988–94. Series 1: Programs and collection procedures. *Vital Health Stat 1* issue 32, 1–407.
 35. Woteki CE, Briefel R, Hitchcock D, Ezzatfa T & Maurer K (1990) Selection of nutrition status indicators for field surveys: the NHANES III design. *J Nutr* **120**, 1440–1445.
 36. National Center for Health Statistics (1997) National Health and Nutrition Examination Survey: NHANES III Data Files, Documentation, and SAS Code. <http://www.cdc.gov/nchs/about/major/nhanes/nh3data.htm> (accessed April 2006).
 37. United States Census Bureau (1991) US Census 1990. <http://www.census.gov/main/www/cen1990.html> (accessed April 2006).
 38. Thompson FE & Byers T (1994) Dietary assessment resource manual. *J Nutr* **124**, Suppl., 2245S–2317S.
 39. Kant AK (2002) Nature of dietary reporting by adults in the Third National Health and Nutrition Examination Survey, 1988–1994. *J Am Coll Nutr* **21**, 315–327.
 40. US Department of Health and Human Services, National Center for Health Statistics (1996) *Third National Health and Nutrition Examination Survey, 1988–1994, NHANES II Laboratory Data File*. CD-ROM, Series 11, No. 1A. Hyattsville, MD: Centers for Disease Control and Prevention.
 41. Dixon LB, Sundquist J & Winkleby M (2000) Differences in energy, nutrient and food intakes in a US sample of Mexican-American women and men: findings from the third National Health and Nutrition Examination Survey, 1988–1994. *Am J Epidemiol* **152**, 548–557.
 42. Shah M, Coyle Y, Kavanaugh A, Adams-Huet B & Lipsky PE (2004) Focus group assessment of culturally specific cholesterol-lowering menus for Mexican Americans. *Int Electron J Health Educ* **7**, 9–19.
 43. Panel on Dietary Antioxidants and Related Compounds, Subcommittee on Upper Reference Levels of Nutrients and Interpretation and Uses of Dietary Reference Intakes & the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes (2000) *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids*. Washington, DC: National Academy Press.
 44. World Cancer Research Fund/American Institute for Cancer Research (2007) *Food, Nutrition, Physical Activity and the Prevention of Cancer: A Global Perspective*. Washington DC: AICR; available at <http://www.dietandcancerreport.org>

45. Gonzalez CA (2006) Nutrition and cancer: the current epidemiological evidence. *Br J Nutr* **96**, Suppl. 1, S42–S45.
46. Bazzano LA, He J, Ogden LG, Loria CM, Vupputuri S, Myers L & Whelton PK (2002) Fruit and vegetable intake and risk of cardiovascular disease in US adults: the First National Health and Examination Survey Epidemiologic Follow-up Study. *Am J Clin Nutr* **76**, 93–99.
47. Dauchet L, Amouyel P, Hercberg S & Dallongeville J (2006) Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. *J Nutr* **136**, 2588–2593.
48. He FJ, Nowson CA & MacGregor GA (2006) Fruit and vegetable consumption and stroke: meta-analysis of cohort studies. *Lancet* **367**, 320–326.
49. Skinner CN, Holt D & Smith TMF (editors) (1989) *Analysis of Complex Surveys*. New York: John Wiley & Sons, Inc.
50. Brogan D (2005) Sampling error estimation for survey data, Chapter XXI. http://unstats.un.org/unsd/HHsurveys/pdf/Chapter_21.pdf (accessed June 2008).
51. Kawachi I & Berkman LF (2003) *Neighborhoods and Health*. New York: Oxford University Press.
52. Lewis Munford Center (2000) Metropolitan Racial and Ethnic Change – Census 2000. <http://mumford.albany.edu/census/data.html> (accessed August 2008).
53. Kant AK, Graubard BI & Schatzkin A (2004) Dietary patterns predict mortality in a national cohort: The National Health Interview Surveys, 1987 and 1992. *J Nutr* **134**, 1793–1799.
54. Kant AK, Schatzkin A, Graubard BI & Schrairer C (2000) A prospective study of diet quality and mortality in women. *JAMA* **283**, 2109–2115.
55. Liu S, Lee I-M, Ajani U, Cole SR, Buring JE & Manson JE (2001) Intake of vegetables rich in carotenoids and risk of coronary heart disease in men: Physicians' Health study. *Int J Epidemiol* **30**, 130–135.
56. Forman JP, Rimm EB, Stampfer MJ & Curhan GC (2005) Folate intake and risk of incident hypertension among US women. *JAMA* **293**, 320–329.
57. Hung H-C, Joshipura KJ, Jiang R, Hu FB, Hunter D, Smith-Warner SA, Colditz GA, Rosner B, Spiegelman D & Willett WC (2004) Fruit and vegetable intake and risk of major chronic disease. *J Natl Cancer Inst* **96**, 1577–1584.
58. Hu FB, Rimm EB, Stampfer MJ, Ascherio A, Spiegelman D & Willett WC (2000) Prospective study of major dietary patterns and risk of coronary heart disease in men. *Am J Clin Nutr* **72**, 912–921.
59. Millen BE, Quatromoni PA, Nam B-H, O'Horo CE, Polak JF & D'Agostino RB (2002) Dietary patterns and the odds of carotid atherosclerosis in women: the Framingham Nutrition Studies. *Prev Med* **35**, 540–547.
60. Riboli E & Norat T (2003) Epidemiologic evidence of the protective effect of fruit and vegetables on cancer risk. *Am J Clin Nutr* **78**, Suppl., 559S–569S.
61. Vainio H & Weiderpass E (2006) Fruit and vegetables in cancer prevention. *Nutr Cancer* **54**, 111–142.
62. Pavia M, Pileggi C, Nobile CG & Angelillo IF (2006) Association between fruit and vegetable consumption and oral cancer: a meta-analysis of observational studies. *Am J Clin Nutr* **83**, 1126–1134.
63. Bodor JN, Rose D, Farley TA, Swalm C & Scott SK (2008) Neighbourhood fruit and vegetable availability and consumption: the role of small food stores in an urban environment. *Public Health Nutr* **11**, 413–420.
64. Crimmins EM, Kim JK, Alley DE, Karlamangla A & Seeman T (2007) Hispanic paradox in biological risk profiles. *Am J Public Health* **97**, 1305–1310.
65. Turra CM & Goldman N (2007) Socioeconomic differences in mortality among US adults: insights into the Hispanic paradox. *J Gerontol B Psychol Sci Soc Sci* **62**, S184–S192.
66. Turra CM & Elo IT (2008) The impact of salmon bias on the Hispanic mortality advantage: new evidence from Social Security data. *Popul Res Policy Rev* (online DOI 10.1007/s11113-008-9087-4).
67. Guendelman S & Abrams B (1995) Dietary intake among Mexican-American women: generational differences and a comparison with white non-Hispanic women. *Am J Public Health* **85**, 20–25.
68. Montez JK & Eschbach K (2008) Country of birth and language are uniquely associated with intakes of fat, fiber, and fruits and vegetables among Mexican-American women in the United States. *J Am Diet Assoc* **108**, 473–480.
69. Mazur RE, Marquis GS & Jensen HH (2003) Diet and food insufficiency among Hispanic youths: acculturation and socioeconomic factors in the third National Health and Nutrition Examination Survey. *Am J Clin Nutr* **78**, 1120–1127.
70. Sundquist J & Winkleby M (2000) Country of birth, acculturation status and abdominal obesity in a national sample of Mexican American women and men. *Int J Epidemiol* **29**, 470–477.
71. Perez-Escamilla R & Putnik P (2007) The role of acculturation in nutrition, lifestyle, and incidence of type 2 diabetes among Latinos. *J Nutr* **137**, 860–870.
72. Unger JB, Reynolds K, Shakib S, Spruijt-Metz D, Sun P & Johnson CA (2004) Acculturation, physical activity, and fast-food consumption among Asian-American and Hispanic adolescents. *J Community Health* **29**, 467–481.
73. Galvez MP, Morland K, Raines C, Kobil J, Siskind J, Godbold J & Brenner B (2008) Race and food store availability in an inner-city neighbourhood. *Public Health Nutr* **11**, 624–631.
74. Kolonel LN, Hankin JH, Whittemore AS *et al.* (2000) Vegetables, fruits, legumes and prostate cancer: a multi-ethnic case control study. *Cancer Epidemiol Biomarkers Prev* **9**, 795–804.
75. Correa P (1981) Epidemiological correlations between diet and cancer frequency. *Cancer Res* **41**, 3685–3690.
76. Kabagampe EK, Baylin A, Ruiz-Narvaez E, Siles X & Campos H (2005) Decreased consumption of dried mature beans is positively associated with urbanization and nonfatal myocardial infarction. *J Nutr* **135**, 1770–1775.
77. Hughes JS, Ganthavorn C & Wilson-Sanders S (1997) Dry beans inhibit azoxymethane-induced colon carcinogenesis in F344 rats. *J Nutr* **127**, 2328–2333.
78. Diaz-Batalla L, Widholm JM, Fahey GC, Castano-Tostado E & Paredes-Lopez O (2006) Chemical components with health implications in wild and cultivated Mexican common bean seeds (*Phaseolus vulgaris* L.). *J Agric Food Chem* **54**, 2045–2052.
79. Espinosa-Alonso LG, Lygin A, Widholm JM, Valverde ME & Paredes-Lopez O (2006) Polyphenols in wild and weedy Mexican common beans (*Phaseolus vulgaris* L.). *J Agric Food Chem* **54**, 4436–4444.
80. Mazur WM, Duke JA, Wahala K, Rasku S & Adlercreutz H (1998) Isoflavonoids and lignans in legumes: nutritional and health aspects in humans. *Nutr Biochem* **9**, 193–200.
81. Midorikawa K, Murata M, Oikawa S, Hiraku Y & Kawanishi S (2001) Protective effect of phytic acid on oxidative DNA damage with reference to cancer chemoprevention. *Biochem Biophys Res Commun* **288**, 552–557.
82. Gonzales de Mejia E, Castano-Tostado E & Loarca-Pina G (1999) Antimutagenic effects of natural phenolic compounds in beans. *Mutat Res Genet Toxicol Environ Mutagen* **441**, 1–9.
83. Mori A, Lehmann S, O'Kelly J, Kumagai T, Desmond JC, Pervan M, McBride WH, Kizaki M & Koeffler HP (2006) Capsaicin, a component of red peppers, inhibits the growth of androgen-independent, p53 mutant prostate cancer cells. *Cancer Res* **66**, 3222–3229.

84. Ito K, Nakazato T, Yamato K, Miyakawa Y, Yamada T, Hozumi N, Segawa K, Ikeda Y & Kizaki M (2004) Induction of apoptosis in leukemic cells by homovanilic acid derivative, capsaicin, through oxidative stress. Implications of phosphorylation of p53 at ser-15 residue by reactive oxygen species. *Cancer Res* **64**, 1071–1078.
85. Kim JD, Kim JM, Pyo JO, Kim SY, Kim BS, Yu R & Han IS (1997) Capsaicin can alter the expression of tumor forming-related genes which might be followed by induction of apoptosis of a Korean stomach cancer cell line, SNU-1. *Cancer Lett* **120**, 235–241.
86. Jung MY, Kang HJ & Moon A (2001) Capsaicin-induced apoptosis in SK-Hep-1 hepatocarcinoma cells involves Bel-2-down-regulation and caspase-3 activation. *Cancer Lett* **165**, 139–145.
87. O'Kennedy N, Crosbie L, van Lieshout M, Broom JI, Webb DJ & Duttaroy AK (2006) Effects of antiplatelet components of tomato extract on platelet function *in vitro* and *ex vivo*: a time-course cannulation study in healthy humans. *Am J Clin Nutr* **84**, 570–579.
88. Muller N, Alteheld B & Stehle P (2003) Tomato products and lycopene supplements: mandatory components in nutritional treatment of cancer patients? *Curr Opin Clin Nutr Metab Care* **6**, 657–660.
89. Giovannucci E, Rimm EB, Liu Y, Stampfer MJ & Willett WC (2002) A prospective study of tomato products, lycopene and prostate cancer risk. *J Natl Cancer Inst* **94**, 391–398.
90. Bello-Perez LA, Osorio-Diaz P, Agama-Acevedo E, Solorza-Feria J, Toro-Vazquez JF & Paredes-Lopez O (2003) Chemical and physicochemical properties of dried wet *masa* and dry *masa* flour. *J Sci Food Agric* **83**, 408–412.
91. Martinez-Flores HE, Figueroa JDC, Martinez-Bustos F, Gonzalez-Hernandez J, Rodriguez Garcia ME, Banos Lopez AML & Garnica-Romo MG (2002) Physical properties and composition of femurs of rat fed with diets based on corn tortillas made from different processes. *Int J Food Sci Nutr* **53**, 155–162.
92. De la Parra C, Serna Saldivar SO & Liu RH (2007) Effect of processing on the phytochemical profiles and antioxidant activity of corn for production of *masa*, tortillas, and tortilla chips. *J Agric Food Chem* **55**, 4177–4183.
93. Food and Agricultural Organization of the United Nations (1992) Maize in human nutrition. <http://www.fao.org/docrep/t0395e/t0395e07.htm> (accessed October 2008).