

Diet, physical activity, obesity and related cancer risk: strategies to reduce cancer burden in the Americas

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Abstract

With increased globalization, Latin America is experiencing transitions from traditional lifestyle and dietary practices to those found in higher income countries. Healthy diets, physical activity and optimal body fat can prevent approximately 15% of cancers in low-income and 20% in high-income countries. We discuss links between diet, obesity, physical activity and cancer, emphasizing strategies targeting children to decrease risk of obesity, control obesity-related risk factors, and reduce sedentary lifestyles, as this will have high impact on adult cancer risk. We focus on individual behaviors, economic, cultural and societal changes that may guide future interventions in the Americas.

Keywords: diet; physical activity; cancer; exercise; Latin America

Resumen

América Latina está experimentando transiciones desde estilos de vida tradicional y prácticas dietéticas a las de países de ingresos altos. Las dietas saludables, la actividad física y la grasa corporal óptima pueden prevenir aproximadamente el 15% de cánceres en países de bajos ingresos y 20% en países de ingresos altos. Discutimos los vínculos entre la dieta, obesidad, actividad física y cáncer; haciendo hincapié en estrategias dirigidas a niños, para disminuir el riesgo de obesidad y reducir la vida sedentaria. Nos enfocamos en comportamientos individuales, cambios económicos, culturales y sociales que pueden guiar futuras intervenciones en las Américas.

Palabras clave: dieta; actividad física; ejercicio; cáncer; América Latina

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With increased globalization, many countries in Latin America are experiencing transitions from traditional lifestyle and dietary practices to those found in higher income countries such as the USA.^{1,2} Mexican, and other Latin American foods, have become popular in the USA, and American fast food chains are growing in popularity throughout Latin America, and much of the rest of the world. Therefore, children and adults are often exposed to some of the same risk factors regardless of country of residence: the globalization of health and risk factors does not recognize international borders.

Together, healthy diets, physical activity and optimal body fatness can prevent approximately 15% of cancers in low-income and 20% in high-income countries.³ Diet and physical activity prevention strategies need strong components focusing on childhood, as this will impact adult cancer risk, either through reducing obesity and/or diabetes, or directly through benefits specific to diet or exercise and sedentary behavior. For example, the incidence of colorectal cancer is increasing among adolescents and young adults in the USA,⁴ and diet, obesity and a sedentary lifestyle are known contributing factors for colorectal cancer; thus, their role in childhood might be relevant. Therefore, as obesity trends increase across the Americas⁵ interventions to improve diet and increase physical activity among children have a great potential to reduce the cancer burden across the Americas. Previous and ongoing intervention studies among Latino children in the USA can help us leverage our current knowledge about the efficacy of these interventions to design future interventions that might help prevent and control risks for chronic disease among children and adults throughout the Americas.

The distribution of risk and protective factors is changing throughout the Americas, with many Latin American countries experiencing transitions from traditional diets and lifestyles to those found in the USA. We can learn from the experience of Latino immigrants to the USA and Canada many important lessons that may apply to Latin American. The 'healthy immigrant effect' asserts that the health status of immigrants at the time of arrival in a receiving country (such as the USA or Canada) is generally good, but over time declines and converges toward that of the native born population.⁶ It is estimated that first generation immigrants are relatively healthy in terms of morbidity and mortality, while the health of second generation individuals within these families worsens and that of the third generation equates to the native born population. Among Latino immigrant populations, the "Hispanic health paradox" has been coined,⁷ which states that even though most Hispanic subgroups in the USA are characterized by lower socioeconomic status they still have better than

expected health and mortality outcomes than other ethnic groups. The "healthy immigrant hypothesis" (i.e. usually healthier people immigrate into the USA from Latin America, as they are more able to take advantage of economic opportunities) or the "salmon hypothesis" (i.e. older immigrants who are losing their health and have short life expectancy returned to their native lands to live out their last years) do not seem to fully explain the observations that led to the suggestion of a "Hispanic paradox".⁶ This suggests that Latino immigrants in the USA are doing well, despite the adoption of diets and lifestyle characteristic of more industrialized countries. However, there are several emerging factors that challenge this notion and the Hispanic Health Paradox. First, Mexico is the single largest "sending" region of Hispanics living in the USA, and Mexico now evidences many of the same chronic disease patterns as the USA (e.g. childhood and adult obesity).⁸ Second, Latinos immigrating to the USA are a very heterogeneous population, in terms of countries of origin, genetic ancestry, nativity, dietary practices, place of residence, and level of acculturation to the USA way of life.⁹ Lack of consideration of such sources of heterogeneity can cloud interpretation of cancer incidence patterns within Latino subgroups. Finally, many descendants from Latino immigrants have multiracial/ethnic backgrounds, contributing further to heterogeneity in this population. Newer studies that take into account appropriate sources of heterogeneity, show differences in cancer patterns and tumor characteristics across Latino subpopulations in the USA.⁹ Moreover, studies comparing cancer mortality between the USA and Mexico highlight differences across the two countries in both directions, suggesting that for some cancers, risks increases with immigration, whereas others decrease.¹⁰

From the perspective of the Americas, we provide an overview of the links between diet, obesity, physical activity and cancer, with special emphasis on strategies targeting children to decrease risk of obesity, prevent and control obesity related risk factors, including studies done in the USA and in Latin America. We focus on interventions that consider individual behavior and economic, cultural and societal changes. We also discuss what lessons have been learned that might serve as guidelines for interventions targeting children and adults in the Americas.

Development of the topic

Diet, physical activity and cancer risk

In their landmark paper in 1981, Sir Doll and Sir Peto reported that ~30% of cancer deaths could be attributed

to dietary factors.¹¹ Since then, through decades of studies of diet and cancer risk, important facts have emerged. The most conclusive findings are a protective role for dietary fiber and colorectal cancer risk; the carcinogenic role of processed meats and probably carcinogenic role of red meats,¹² in particular for colorectal, esophagus, pancreas and prostate cancers; a carcinogenic role for foods preserved by salting and stomach cancer; and higher risk of liver cancer through exposure to aflatoxin from moldy foods (e.g. grains, peanuts, etc.) (World Cancer Research Fund- Continuous Update Project). Moreover, high consumption of alcoholic drinks has been linked with at least five cancers (mouth/pharynx/larynx, esophagus, liver, colorectal, and breast cancer) (World Cancer Research Fund- Continuous Update Project). Body fatness has also emerged as an important risk factor, with at least 11 cancers showing convincing positive associations with obesity (esophagus, pancreas, liver, colorectal, breast, endometrium, prostate, gallbladder, ovarian, stomach and kidney cancer) (World Cancer Research Fund- Continuous Update Project). There is convincing evidence that physical activity reduces the risk of colorectal cancer, and some evidence of protecting against breast and endometrial cancer (World Cancer Research Fund- Continuous Update Project). It is a possibility that these dietary, body composition and physical activity exposures among children and young adults might contribute to higher rates of cancer during adult years. For example, higher red meat and processed meat consumption during adolescence and young adulthood years is associated with increased breast cancer risk.^{13,14}

As in the USA, diets in many Latin American countries are converging to high-energy diets, with increasing consumption of added sugars, more processed foods, more saturated or trans fats, higher red meat intake, and decreased fruits, vegetables, whole grains and legumes intake.¹⁵ For example, red meat consumption has been growing faster in South America than in developed countries (USDA Agricultural Projections to 2024), with the USA and most Latin American countries currently consuming above 30 kg per person per year, which is way above the recommended amount to reduce cancer risk, which is 26 kg/person/year. These dietary changes, along with increases in sedentary lifestyles, are contributing to higher rates of obesity, and possibly, changes in cancer patterns across the Americas. We discuss below the role of food marketing in promoting many of these foodstuffs that contribute to cancer risk and/or obesity, and strategies to reduce its impact, as well as strategies to reduce obesity among children and increase physical activity across all ages.

Food marketing and the obesity epidemic

Food marketing has been found to be a key environmental factor that promotes childhood weight gain.¹⁶ Current evidence yields that food marketing to children is abundant, in multiple venues (e.g., point of sale, television, product placement) and mostly involves energy-dense and nutrient-poor foods.¹⁷ Furthermore, marketing influences children's brand preferences and taste preferences that favor less healthy foods.¹⁸ In addition to the traditional advertising venues (e.g., television, billboards), the school environment has been found to be obesogenic to children in the USA.¹⁶ Similar observations have been made in other countries; therefore, many are already exploring food marketing restrictions as a strategy to halt the obesity epidemic among children. For example, England has implemented a restriction on advertising of unhealthy foods to children.¹⁹ In Chile, a law was passed in 2002 that prohibits the marketing and sale in schools of unhealthy foods (high in calories, saturated fats, sugars and sodium) to children under 14 years old.²⁰

There is scarce data on the experience and consequences for public health of food marketing in Latin American countries. Important findings have emerged from studies done in Guatemala, a low/middle income country that has one of the highest prevalence rates of chronic malnutrition worldwide (47%),^{21,22} while also having 4.7% of children under five years and 36.8% of school age children who are overweight or obese.²² This dual status of malnutrition and obesity is present in many countries across the Americas.²³ Therefore, in recognizing the role of marketing as a promoter of childhood weight gain, the Central American Council of Ministries of Health (COMISCA), including Guatemala, in its 2014-2025 plan to combat obesity in the region has included marketing restrictions as a policy strategy.²⁴ Unfortunately, as of 2017, Guatemala has not implemented any policies to restrict marketing of less healthy foods to children. Several food marketing strategies have been documented in schools in Guatemala. The point of sale (POS), as evident with tobacco advertising,²⁵ is a nontraditional venue that the food industry is using to reach to consumers and where purchases decisions are frequently made. Schools in Guatemala are surrounded by unregulated small stores and kiosks. These have previously been found to be a source of exposure to tobacco advertising. Similarly, a survey of more than 300 ads in these stores shows that the POS is an advertising venue frequently used by the beverage and food industry. Stores had on average

five ads and 47% of the ads displayed at the counter were child oriented.²⁶ More than 60% advertised sugar sweetened beverages and soft drinks.²⁶ Unfortunately, only two ads were found for bottled water.²⁶ Another advertising channel for the food industry is the packaging, such as child oriented packaging with brand specific or licensed characters from popular movies and television programs, which are designed to attract children's attention. Food branding and licensed characters on packaging have been found to significantly influence children's snack preferences.^{18,27} These are mostly used for high sugar, fat and sodium foods²⁷ and affect food preference, purchase and consumption of these foods,^{28,29} and therefore contribute to an increased risk of obesity. Most of these data comes from high-income country. However, an assessment of snack food packages in Guatemala has found that the vast majority have promotional characters and ~30% include premium offers,³⁰ and promotional characters were found to significantly increase four to 11-year old children's preferences and taste for snack foods.³¹ Interestingly, the use of promotional characters was also reported to increase the consumption of carrots, suggesting that this could be a potential strategy to increase children's intake of healthy foods. More data from Guatemala and New Zealand,³² show that the packages of breakfast cereals are also being used to reach out to consumers, often with misleading health claims. In Guatemala, more than 80% of purchased breakfast cereals had a product claim on the front of the package and they had on average ~5 claims per package.³³ Nearly all had health evoking imagery and half were child oriented.³³ Furthermore, those that were child oriented were found to be less healthy and to have significantly higher sugar content compared to those not child oriented.³³ Therefore, it is evident that the food industry is using multiple strategies to reach to children in Guatemala. Given that most of these companies are multinational, it is likely that similar strategies are being used in other Latin American countries, with comparable consequences. Therefore, this topic deserves further investigation.

Fast food consumption has also been found a risk factor for weight gain.³⁴ In Guatemala, it is estimated that nearly half of students (13 to 15 years of age) in private and public schools eat fast food at least once a day.³⁵ In addition to the high density of fast food chain restaurants in Guatemala City, delivery options make accessibility ubiquitous. Marketing of fast food targeting children is likely a driver of the high consumption observed in school children. An analysis of six fast food chain restaurants in Guatemala, five international (McDonald's, Burger King, Wendy's, Kentucky Fried Chicken, and Pizza Hut) and one local (Pollo Campero),

found that they all have children's combo meals, ranging from five (McDonald's) to two different combos per chain (Pizza Hut).³⁶ Even though taxation is promising strategy to decrease fast food consumption,³⁷ this might not be the case in Guatemala. Children's combo meals have been found to be expensive, ranging from a median of 3.77 (Pizza Hut) to 3.50 dollars (Kentucky Fried Chicken).³⁶ This accounts for nearly a third of the daily minimum wage in Guatemala (11 dollars). Regardless, on average, children's combo meals are 1.93 dollars less expensive than purchasing children's meal items individually ($p=0.01$), and most meals also included a toy giveaway. This marketing strategy has already been restricted in the USA by the 2010 Santa Clara, California "Toy Ordinance". The ordinance prohibits toy giveaways and foods that do not meet minimal nutritional criteria and has the potential to positively influence marketing of healthful menu items and toys.³⁸ If the children's combo meals from Guatemalan fast food chain restaurants were subject to the same standards of the Toy Ordinance, none would meet the minimal nutritional criteria and therefore would be prohibited.³⁶

Strategies to reduce obesity in childhood among Latinos

The prevalence of obesity is increasing rapidly across Latin America.²³ An evidence-based review of childhood obesity interventions in Latin America and among Latino children in the USA showed that school-based interventions balancing nutritional and physical activity change, delivered either by school or project staff, were effective in both regions especially with interventions of longer duration (up to three years).³⁹ A randomized trial is ongoing in Chile (KIND study) testing the role of school based interventions targeting food marketing, physical activity and nutritional information, which will yield useful results.²⁰ School interventions focused on physical activity also were supported in the literature whether or not obesity was a targeted outcome. Evidence also exists for primary health care interventions delivered by professionals in pediatric settings, again, favoring programs of longer duration.

Three different obesity prevention studies conducted among children in Mexico or of Mexican heritage in the USA, illustrate common lessons to consider in designing efforts to control and prevent obesity. First the *Aventuras Para Niños* study⁴⁰ emphasized the need to make changes in the macroenvironments and "microenvironments" in which schoolchildren grew up. The macroenvironment targets included restaurants in terms of offering child sized portions, grocery stores in terms of their promotion of fresh vegetables and fruit, and parks in terms of their maintenance and safety. The

microenvironmental interventions looked specifically at homes and housing complexes and promoted the use of more active toys, healthier shopping, and cooking arrangement of the household environment (e.g., getting televisions out of children's bedrooms, not eating in front of the TV) and other behaviors. Significant improvements were observed in various aspects of parenting related to children's risk for obesity and related health outcomes.

A second study, "Water For Kids / Agua Para Niños", led by the *Instituto Nacional de Salud Pública* in Cuernavaca, México and San Diego. This binational study was carried out in elementary schools outside of Cuernavaca and near the San Diego, USA / Tijuana, Mexico border crossing. The specific goal of this intervention was to increase the consumption of water among children, with the assumption that they would do so if clean and non-contaminated water were made readily available and water drinking was promoted. This innovative program included a variety of K-3 classroom activities, the provision of water bottles to children, access to water at recess, and the "Pipimetro", a poster that was put on bathroom doors in both boys and girls restrooms that equated more yellow urine to dehydration and clear urine to being adequately hydrated. The results of the program were substantial in terms of increasing student water bottle possession and drinking water at lunch and recess, a finding that was more apparent in the USA compared to the Mexican school.⁴¹

The combined effects on obesity of physical activity, sedentary life, and smoking

Obesity, alcohol consumption, hypertension, hyperglycemia, and tobacco use can contribute to inflammation,⁴²⁻⁴⁵ which can contribute to cancer formation, as well as cardiovascular disease, among other chronic disorders.^{46,47} When combined with those risk factors, sedentary behaviors have proinflammatory effects.⁴⁸ Interactions between sedentary life and carcinogens present in cigarette smoke, can worsen conditions such as obesity, among others. Therefore, it is important to consider the joint effect of lifestyle behaviors such as smoking when investigating the effects of diet and physical activity and their effect on obesity and cancer risk.

Mexican immigrants to the USA are not only exposed to changes in dietary intake,⁴⁹ but also changes in risky health behaviors such as smoking.⁵⁰ As discussed above, across Latin America there is a transition to more high income country diets, with higher obesity rates, and more sedentary lifestyles. It is unclear as to the cumulative impact on health outcomes of combined conditions such as being sedentary, obese, and using

tobacco. In the USA, the addition of acculturative stress among immigrants must also be considered. Thus, studies focused on the joint associations of risk factors as precursors of cardiovascular diseases and cancer in Latin American countries, as well as among immigrants to the USA compared to their non-migrating peers, are needed.⁵¹

A recent study examined the joint associations of lifestyle factors, such as sedentary behaviors, with obesity and smoking status using national survey data from the USA and Mexico, to assess if these associations were different for Mexicans, Mexicans immigrants in the USA versus their USA born Mexican American peers. These findings showed that common conditions with a pro-inflammatory effect, such as screen time, seem to be positively associated with other determinants of inflammation such as obesity and tobacco use. The associations were stronger among obese Mexican American smokers than in the Mexican Immigrants or Mexicans living in Mexico who were rated as obese and defined to be tobacco users as well. These findings suggest that with greater acculturation to 'US lifestyle' there is greater potential for a combined effect of behaviors that are detrimental for many health conditions, including cancer.

Discussion

We are observing a trend of increased exposure across the Americas to many of the risk factors that have been convincingly linked to cancer risk (e.g. red meat, processed meats), with concomitant reduction of cancer protective factors (grains, legumes, fruits and vegetables) as well as increased high energy diets that contribute to increasing obesity trends, including children,²³ which in turn can also fuel higher cancer rates. From a public health perspective, reducing exposure to cancer causing factors during childhood and young adulthood might be one of the most impactful ways to invest in cancer prevention. The data from Latin American countries, such as the case of Guatemala described above, highlights the importance of passing legislation to restrict advertising of nutrient poor, energy dense foods to children, including snack foods, breakfast cereals, and fast food. Moreover, there is an urgent need to explore potential strategies to decrease key contributors to obesity, such as sugar sweetened beverage consumption. For example Guatemala has one of the highest per capita consumption in the region.⁵² Taxation, one of the most promising tools, needs to be adequately designed as it might not be applicable to all products (e.g., fast food is already expensive). It is likely that other Latin American countries are experiencing similar consequences from the

strategies used by the food industry to target children, and some countries, like Chile, have started to take action against this. Therefore, awareness and research on this topic is an urgent matter across Latin America.

In the aggregate, several lessons emerged about childhood obesity prevention and control studies among Latino kids both in the USA and in selected countries in Latin America, such as those described above. First, gender matters. Parent oriented interventions function differently for girls than they do for boys. More research is needed to understand the most effective messages for each of the two genders, by working with fathers in addition to mothers. Second, parents often misperceive their child's weight problems, especially at an early stage. Parents (especially mothers) are of course very committed to their children and their children's welfare. In the case of obesity prevention, the notion that a child is being given nutrition in some sort of incorrect manner can be very embarrassing or offensive to parents. Intervention developers always need to find the fine line between being too subtle or "blaming the victim", which may drive away mothers and other caregivers from future assistance. Third, intervention messages should not be too complicated. The "Water For Kids/ Agua Para Niños" project, described above, showed that focusing on a simple behavior (i.e. consuming more water rather than comparing and contrasting sugar free sodas to fruit juice to sugared drinks) was well accepted. Similarly, simply walking or jogging with children may be sufficient to improve physical activity profiles, especially if accompanied by reducing screen time and other sedentary behavior. Complex materials integrating detailed nutritional advice with physical activity issues, weight monitoring and other obesity specific activities, may overwhelm parents and lead them to lose track of the important themes. Fourth, measures of obesity intervention outcomes may be inappropriate. Body mass index, for instance, may be affected by other factors (e.g. bone structure) and may not be sensitive to healthy body fat changes. The use of skin folds conversely may be an appropriate measure, but may yield lower levels of reliability. Imaging techniques especially with the dual energy x-ray absorptiometry (DXA)⁵³ may be highly sensitive to obesity changes but are relatively expensive and involve higher participant burden. Finally, more emphasis maybe needs to be placed on simple measures such as fitness and lunch plate assessment. With such measures we can hope to come to a greater consensus on appropriate obesity prevention or at least fitness promotion among children throughout the Americas.

Altogether, the examples discussed here targeting dietary factors, physical activity, and other lifestyle behaviors, like smoking, highlight the importance of de-

signing multilevel interventions to promote and prevent highly prevalent diseases such as cancer and cardiovascular disease, through modifiable risk behaviors such as quitting smoking, increasing physical activity, reducing consumption of high-energy foods, and obesity. Latino immigrants in the USA would be an ideal vulnerable population to target, as well as Latinos throughout the Americas in countries who are experiencing higher rates of some of these detrimental behaviors.

Conclusions

Latinos in the USA and throughout Latin America are experiencing a transition away from traditional diets high in grains, legumes, fruits and vegetable, trending towards higher proportion of processed foods, energy dense foods, higher added sugar foods in drinks, and in many instances, higher red meat consumption. This transition tracks with increasing trends for sedentary behaviors, obesity, and other health outcomes, such as cardiovascular disease, diabetes and cancer. Whereas Latino immigrants to the USA were initially perceived to have favorable health outcomes in spite of low socioeconomic status, suggesting that they brought protective behaviors and traits from their home countries, this so called 'Hispanic paradox' seems to be quickly eroding. In the USA, there is already evidence that at least one preventable cancer, such as colorectal cancer, that is decreasing in incidence among adults and it is linked to diet, obesity, diabetes and sedentary lifestyle, is on the rise among adolescents and young adults.⁴ Therefore, interventions among children to prevent the adoption of unhealthy diets and lifestyles are imperative. These interventions need to target points of purchase, schools, homes, and places of recreation. In the USA, and in selected Latin American countries, such interventions have proven successful. Important lessons have emerged that may help guide future interventions across the Americas, to raise awareness about the detrimental effects of high income country diets and the benefits of physical activity and healthy weight to reduce cancer incidence.

Declaration of conflict of interests. The authors declare that they have no conflict of interests.

References

1. Bermudez OI, Tucker KL. Trends in dietary patterns of Latin American populations. *Cad Saude Publica*. 2003;19(suppl 1):S87-99. <https://doi.org/10.1590/S0102-311X2003000700010>
2. Popkin BM, Reardon T. Obesity and the food system transformation in Latin America. *Obes Rev*. 2018;19(8):1028-64. <https://doi.org/10.1111/obr.12694>

3. World Cancer Research Fund International. Cancer preventability estimates 2017. Available from: <https://wcrf.org/cancer-preventability-estimates>
4. Teng A, Lee DY, Cai J, Patel SS, Bilchik AJ, Goldfarb MR. Patterns and outcomes of colorectal cancer in adolescents and young adults. *J Surg Res*. 2016;205(1):19-27. <https://doi.org/10.1016/j.jss.2016.05.036>
5. Uauy R, Albala C, Kain J. Obesity trends in Latin America: transitioning from under- to overweight. *J Nutr*. 2001;131(3):893S-9S. <https://doi.org/10.1093/jn/131.3.893S>
6. Abraido-Lanza AF, Dohrenwend BP, Ng-Mak DS, Turner JB. The Latino mortality paradox: a test of the "salmon bias" and healthy migrant hypotheses. *Am J Public Health*. 1999;89(10):1543-8. <https://doi.org/10.2105/aiph.89.10.1543>
7. Franzini L, Fernandez-Esquer ME. Socioeconomic, cultural, and personal influences on health outcomes in low income Mexican-origin individuals in Texas. *Soc Sci Med*. 2004;59(8):1629-46. <https://doi.org/10.1016/j.socscimed.2004.02.014>
8. Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, United Nations Children's Fund, World Food Programme, World Health Organization. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome: FAO, 2018. Available from: <http://www.fao.org/3/i9553EN/i9553en.pdf>
9. Stern MC, Fejerman L, Das R, Setiawan VW, Cruz-Correa MR, Perez-Stable EJ, Figueiredo JC. Variability in cancer risk and outcomes within US latinos by national origin and genetic ancestry. *Curr Epidemiol Rep*. 2016;3:181-90. <https://doi.org/10.1007/s40471-016-0083-7>
10. Pinheiro PS, Callahan KE, Stern MC, de Vries E. Migration from Mexico to the United States: A high-speed cancer transition. *Int J Cancer*. 2018;142(3):477-88. <https://doi.org/10.1002/ijc.31068>
11. Doll R, Peto R. The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today. *J Natl Cancer Inst*. 1981;66(6):1191-308. <https://doi.org/10.1093/jnci/66.6.1192>
12. Bouvard V, Loomis D, Guyton KZ, Grosse Y, Ghissassi FE, Benbrahim-Tallaa L, et al. Carcinogenicity of consumption of red and processed meat. *Lancet Oncol*. 2015;16(16):1599-600. [https://doi.org/10.1016/s1470-2045\(15\)00444-1](https://doi.org/10.1016/s1470-2045(15)00444-1)
13. Farvid MS, Cho E, Chen WY, Eliassen AH, Willett WC. Adolescent meat intake and breast cancer risk. *Int J Cancer*. 2015;136(8):1909-20. <https://doi.org/10.1002/ijc.29218>
14. Farvid MS, Cho E, Chen WY, Eliassen AH, Willett WC. Dietary protein sources in early adulthood and breast cancer incidence: prospective cohort study. *BMJ*. 2014;348:g3437. <https://doi.org/10.1136/bmj.g3437>
15. Romieu I, Margetts B, Barquera S, Gomes Fda S, Gunter M, Hwalla N, et al. Strengthening the evidence base for nutrition and cancer in low and middle income countries. *J Glob Health*. 2016;6(2):020306. <https://doi.org/10.7189/jogh.06.020306>
16. Sonntag D, Schneider S, Mdege N, Ali S, Schmidt B. Beyond Food Promotion: A systematic review on the influence of the food industry on obesity-related dietary behaviour among children. *Nutrients*. 2015;7(10):8565-76. <https://doi.org/10.3390/nu7105414>
17. Harris JL, Pomeranz JL, Lobstein T, Brownell KD. A crisis in the marketplace: how food marketing contributes to childhood obesity and what can be done. *Annu Rev Public Health*. 2009;30:211-25. <https://doi.org/10.1146/annurev.publhealth.031308.100304>
18. Kraak VI, Story M. Influence of food companies' brand mascots and entertainment companies' cartoon media characters on children's diet and health: a systematic review and research needs. *Obes Rev*. 2015;16(2):107-126. <https://doi.org/10.1111/obr.12237>
19. Jebb SA, Aveyard PN, Hawkes C. The evolution of policy and actions to tackle obesity in England. *Obes Rev*. 2013;14(suppl 2):42-59. <https://doi.org/10.1111/obr.12093>
20. Bustos N, Olivares S, Leyton B, Cano M, Albala C. Impact of a school-based intervention on nutritional education and physical activity in primary public schools in Chile (KIND) programme study protocol: cluster randomised controlled trial. *BMC Public Health*. 2016;16(1):1217. <https://doi.org/10.1186/s12889-016-3878-z>
21. Ministerio de Salud Pública y Asistencia Social, Instituto Nacional de Estadística, Secretaría de Planificación y Programación de la Presidencia. VI Encuesta Nacional de Salud Materno Infantil 2014-2015. Guatemala: MSPAS/INE/ICF, 2015. Available from: https://www.ine.gov.gt/images/2017/encuestas/ensmi2014_2015.pdf
22. Centers for Disease Control and Prevention. Guatemala Global School-Based Student Health Survey [internet]. Guatemala: CDCP, 2015 [cited March 2017]. Available from: <https://www.cdc.gov/gshs/countries/americas/guatemala.htm>
23. Corvalan C, Garmendia ML, Jones-Smith J, Lutter CK, Miranda JJ, Pedraza LS, et al. Nutrition status of children in Latin America. *Obes Rev*. 2017;18(suppl 2):7-18. <https://doi.org/10.1111/obr.12571>
24. Consejo de Ministros de Salud de Centroamérica y República Dominicana. Estrategia para la prevención del sobrepeso y obesidad en la niñez y adolescencia de Centroamérica y República Dominicana. Guatemala: Comisca, 2014.
25. Robertson L, McGee R, Marsh L, Hoek J. A systematic review on the impact of point-of-sale tobacco promotion on smoking. *Nicotine Tob Res*. 2015;17(1):2-17. <https://doi.org/10.1093/ntr/ntu168>
26. Chacon V, Letona P, Villamor E, Barnoya J. Snack food advertising in stores around public schools in Guatemala. *Crit Public Health*. 2015;25(3):291-8. <https://doi.org/10.1080/09581596.2014.953035>
27. Harris JL, Schwartz MB, Brownell KD. Marketing foods to children and adolescents: licensed characters and other promotions on packaged foods in the supermarket. *Public Health Nutr*. 2010;13(3):409-17. <https://doi.org/10.1017/S1368980009991339>
28. World Health Organization. A framework for implementing the set of recommendations on the marketing of foods and non-alcoholic beverages to children. Geneva: WHO, 2012. Available from: https://www.who.int/dietphysicalactivity/framework_marketing_food_to_children/en/
29. Halford JC, Boyland EJ, Hughes G, Oliveira LP, Dovey TM. Beyond-brand effect of television (TV) food advertisements/commercials on caloric intake and food choice of 5-7-year-old children. *Appetite*. 2007;49(1):263-7. <https://doi.org/10.1016/j.appet.2006.12.003>
30. Chacon V, Letona P, Barnoya J. Child-oriented marketing techniques in snack food packages in Guatemala. *BMC Public Health*. 2013;13:967. <https://doi.org/10.1186/1471-2458-13-967>
31. Letona P, Chacon V, Roberto C, Barnoya J. Effects of licensed characters on children's taste and snack preferences in Guatemala, a low/middle income country. *Int J Obes*. 2014;38(11):1466-9. <https://doi.org/10.1038/ijo.2014.38>
32. Devi A, Eyles H, Rayner M, Ni-Mhurchu C, Swinburn B, Lonsdale-Cooper E, Vandevijvere S. Nutritional quality, labelling and promotion of breakfast cereals on the New Zealand market. *Appetite*. 2014;81:253-60. <https://doi.org/10.1016/j.appet.2014.06.019>
33. Soo J, Letona P, Chacon V, Barnoya J, Roberto CA. Nutritional quality and child-oriented marketing of breakfast cereals in Guatemala. *Int J Obes*. 2015;40(1):39-44. <https://doi.org/10.1038/ijo.2015.161>
34. Nago ES, Lachat CK, Dossa RA, Kolsteren PW. Association of out-of-home eating with anthropometric changes: a systematic review of prospective studies. *Crit Rev Food Sci Nutr*. 2014;54(9):1103-16. <https://doi.org/10.1080/10408398.2011.627095>
35. Ministerio de Salud Pública y Asistencia Social. Encuesta Mundial de Salud Escolar 2009. Guatemala: Ministerio de Salud Pública de Guatemala, 2009.
36. Mazariegos S, Chacon V, Cole A, Barnoya J. Nutritional quality and marketing strategies of fast food children's combo meals in Guatemala. *BMC Obes*. 2016;3:52. <https://doi.org/10.1186/s40608-016-0136-y>
37. Powell LM, Chiqui JF, Khan T, Wada R, Chaloupka FJ. Assessing the potential effectiveness of food and beverage taxes and subsidies for improving public health: a systematic review of prices, demand and body

- weight outcomes. *Obes Rev.* 2013;14(2):110-28. <https://doi.org/10.1111/obr.12002>
38. Otten JJ, Hekler EB, Krukowski RA, Buman MP, Saelens BE, Gardner CD, King AC. Food marketing to children through toys: response of restaurants to the first U.S. toy ordinance. *Am J Prev Med.* 2012;42(1):56-60. <https://doi.org/10.1016/j.amepre.2011.08.020>
39. Holub CK, Elder JP, Arredondo EM, Barquera S, Eisenberg CM, Sanchez Romero LM, et al. Obesity control in Latin American and U.S. Latinos: a systematic review. *Am J Prev Med.* 2013;44(5):529-37. <https://doi.org/10.1016/j.amepre.2013.01.023>
40. Ayala GX, Elder JP, Campbell NR, Arredondo E, Baquero B, Crespo NC, Slymen DJ. Longitudinal intervention effects on parenting of the Aventuras para Niños study. *Am J Prev Med.* 2010;38(2):154-62. <https://doi.org/10.1016/j.amepre.2009.09.038>
41. Elder JP, Holub CK, Arredondo EM, Sanchez-Romero LM, Moreno-Saracho JE, Barquera S, Rivera J. Promotion of water consumption in elementary school children in San Diego, USA and Tlaltizapan, Mexico. *Salud Publica Mex.* 2014;56(suppl 2):s148-56.
42. Rodríguez-Iturbe B, Pons H, Quiroz Y, Johnson RJ. The immunological basis of hypertension. *Am J Hypertens.* 2014;27(11):1327-37. <https://doi.org/10.1093/ajh/hpu142>
43. Esposito K, Nappo F, Marfella R, Giugliano G, Giugliano F, Ciotola M, et al. Inflammatory cytokine concentrations are acutely increased by hyperglycemia in humans: role of oxidative stress. *Circulation.* 2002;106(16):2067-72.
44. Berg AH, Scherer PE. Adipose tissue, inflammation, and cardiovascular disease. *Circ Res.* 2005;96(9):939-49. <https://doi.org/10.1161/01.RES.0000163635.62927.34>
45. Aggarwal BB, Vijayalekshmi RV, Sung B. Targeting inflammatory pathways for prevention and therapy of cancer: short-term friend, long-term foe. *Clin Cancer Res.* 2009;15(2):425-30. <https://doi.org/10.1158/1078-0432.CCR-08-0149>
46. Libby P. Inflammation and cardiovascular disease mechanisms. *Am J Clin Nutr.* 2006;83(2):456S-60S. <https://doi.org/10.1093/ajcn/83.2.456S>
47. Coussens LM, Werb Z. Inflammation and cancer. *Nature.* 2002;420(6917):860-7. <https://doi.org/10.1038/nature01322>
48. Henson J, Yates T, Edwardson CL, Khunti K, Talbot D, Gray LJ, et al. Sedentary time and markers of chronic low-grade inflammation in a high risk population. *PLoS One.* 2013;8(10):e78350. <https://doi.org/10.1371/journal.pone.0078350>
49. Ayala GX, Baquero B, Klinger S. A systematic review of the relationship between acculturation and diet among Latinos in the United States: implications for future research. *J Am Diet Assoc.* 2008;108(8):1330-44. <https://doi.org/10.1016/j.jada.2008.05.009>
50. Kaplan RC, Bangdiwala SI, Barnhart JM, Castaneda SF, Gellman MD, Lee DJ, et al. Smoking among U.S. Hispanic/Latino adults: the Hispanic community health study/study of Latinos. *Am J Prev Med.* 2014;46(5):496-506. <https://doi.org/10.1016/j.amepre.2014.01.014>
51. Ro A, Fleischer N. Changes in health selection of obesity among Mexican immigrants: a binational examination. *Soc Sci Med.* 2014;123:114-24. <https://doi.org/10.1016/j.socscimed.2014.10.047>
52. Singh GM, Micha R, Khatibzadeh S, Lim S, Ezzati M, Mozaffarian D, Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE). Estimated Global, Regional, and National Disease Burdens Related to Sugar-Sweetened Beverage Consumption in 2010. *Circulation.* 2015;132(8):639-66. <https://doi.org/10.1161/CIRCULATIONAHA.114.010636>
53. Kohrt WM. Body composition by DXA: tried and true? *Med Sci Sports Exerc.* 1995;27(10):1349-53. <https://doi.org/10.1249/00005768-199510000-00001>