








A research agenda to guide progress on childhood obesity prevention in Latin America

L. Kline¹ ; J. Jones-Smith² ; J. Jaime Miranda³ ; M. Pratt⁴ ; R.S. Reis⁵ ; J.A. Rivera⁶; J.F. Sallis⁷  and B.M. Popkin^{*8} 

¹Fogarty International Center, National Institutes of Health, Bethesda, MD, USA;

²Department of Health Services, School of Public Health, University of Washington, Seattle, WA, USA; ³CRONICAS Center of Excellence in Chronic Diseases, Universidad Peruana Cayetano Heredia, Lima, Peru;

⁴University of California, San Diego School of Medicine, Institute for Public Health, La Jolla, CA, USA; ⁵George Warren Brown School of Social Work, Washington University in St. Louis, Saint Louis, MO, USA; ⁶National Institute of Public Health, Cuernavaca, Mexico; ⁷Family Medicine and Public Health, University of California, San Diego, CA, USA; ⁸Carolina Population Center, The University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

Summary

Childhood obesity rates in Latin America are among the highest in the world. This paper examines and evaluates the many efforts underway in the region to reduce and prevent further increases in obesity, identifies and discusses unique research challenges and opportunities in Latin America, and proposes a research agenda in Latin America for the prevention of childhood obesity and concomitant non-communicable diseases. Identified research gaps include biological challenges to healthy growth across the life cycle, diet and physical activity dynamics, community interventions promoting healthy child growth, and rigorous evaluation of national food and activity programs and regulatory actions. Addressing these research gaps is critical to advance the evidence-based policy and practice in childhood obesity tailored to the Latin American context that will be effective in addressing obesity.

Keywords: childhood obesity, Latin America, research agenda.

Received 10 April 2017; accepted 3 May 2017

Address for correspondence: BM Popkin, WR Kenan, Jr., Distinguished Professor, School of Public Health, Carolina Population Center, University of North Carolina at Chapel Hill, CB #8120 University Square, University of North Carolina at Chapel Hill, Chapel Hill, NC 27516-3997, USA.
E-mail: popkin@unc.edu

Introduction

In recent decades, Latin America has seen large increases in childhood obesity and nutrition-related, non-communicable diseases (NCDs) such as cardiovascular disease and type-2 diabetes. Unique regional features have created a complex web of factors impacting obesity, namely (i) rapid urbanization and globalization that brought packaged food and beverage companies, increased access to and consumption of processed food, decreased consumption of fresh food, decreased food preparation

time, and reduced space for leisure-time physical activity (1–3); and (ii) a transition to a modern food supply and related food system, characterized by global interactions geared towards decreasing costs and increasing production (3–6), linked to a nutrition transition – major shifts in diets and available foods (7–11). In general, the region has a climate supportive of policy change, which highlights the importance of robust obesity prevention research that can inform impactful and cost-effective new programs and policies (12). This rise in childhood obesity rates has outpaced the growth of the regional research capacity

needed to conduct research to address risk factors and identify interventions (13).

In this context, we propose a research agenda to guide child obesity prevention and control in Latin America in five areas: (i) biological challenges across the life cycle; (ii) direct and underlying drivers of dietary and physical activity/inactivity patterns; (iii) quality of current surveillance and measurement; (iv) efficacious interventions for healthy behaviour change; and (v) evaluation of current intervention programs and policies and exploration of potential future options. Conducting this research will require cross-disciplinary efforts, a commitment to capacity building (13), and a strong connection between research and policy and practice (14).

Biological challenges across the life cycle

In some Latin American countries, addressing obesity is complicated by the prevalence of undernutrition, creating a dual burden of overweight and undernutrition. These double burdens have been documented at the country, household and individual levels (6,8,15,16). Addressing childhood obesity in this context has important research and programmatic implications, particularly as many governments in Latin America fund projects targeted at undernutrition, primarily during the first 1,000 d of life. To better address the needs of children in the region, interventions will need to focus on population-wide diet quality and physical activity that promotes health throughout the life course. Given generations of undernutrition in some disadvantaged groups – low-income and less-educated populations, as well as indigenous children – that may be linked to long-term vulnerability to obesity and obesity-related NCDs, national governments also need to ensure research, programs and policies reach these vulnerable groups (17,18).

Data from Latin America on how growth and nutrition in the first 1,000 d of life affect future NCD risk as well as human capital is limited. A set of cohorts in low and middle income countries, including two Latin American countries (Guatemala and Brazil), found faster linear growth from birth to mid-childhood was strongly associated with a reduced risk of short adult stature and not completing secondary school, but it did slightly raise the likelihood of overweight and elevated blood pressure (19,20). Faster relative weight gain was associated with a larger increased risk of adult overweight and elevated blood pressure and was not associated with gains in adult stature. Neither linear growth nor relative weight gain were associated with dysglycaemia. Increased weight growth during infancy decreases the risk for central adiposity and systolic blood pressure in adolescents, while for infants who are not undernourished, excess weight gain is associated with

elevated risks of weight gain in childhood. Whether these risks continue over time and pose a similar risk in adolescence, and to what extent these findings can be generalized throughout Latin America, remain to be clarified. Stunting is disproportionately represented among indigenous populations, with early childhood stunting linked to adverse cardiometabolic conditions in adulthood. The relationship between undernutrition and obesity across the life cycle is still not well known, calling for additional areas of research in terms of biological challenges across the life cycle.

Direct and underlying drivers of dietary and physical activity/inactivity patterns

Diet

Food environment, food system changes and obesity

Latin America began to see profound changes in the food environment in the 1990s, as supermarkets, convenience stores, and smaller *tiendas* (stores), fast food restaurants and vending machines began to dominate the food scene (3,21,22). These establishments overwhelmingly provide energy-dense, processed, high-sugar, high-fat, and high-sodium foods and sugar-sweetened beverages (2,23,24). Despite this dramatic shift, little research has tracked the impact of these changes on food purchasing and consumption behaviours. In Mexico, over 58% of the calories consumed per capita among people over 2 years old come from packaged foods (3,25). Similarly, over half of the calories eaten in Brazil come from packaged foods, a significant proportion of which are ultra-processed (2) containing excessive amounts of added sugar and saturated fats (26). It is unclear what influences will be most effective to redirect food production towards healthier choices, particularly as changes in food consumption have made policies advocating return to unprocessed and minimally processed food extremely difficult (2,24,27–29). There is a clear need to better understand the global food system transformation and its determinants.

Evaluation of government efforts to create healthier diets

Governments throughout Latin America are implementing strategies that try to shift consumption away from unhealthy foods. To improve current food purchasing and consumption patterns, some countries are promoting healthier choices and healthier packaged food through front-of-the-package (FOP) labelling (30), food reformulation, and regulatory actions, such as taxation (31) and restricting marketing of unhealthy food to children

(12,30,32). While evidence on the impacts of different FOP labelling systems on food decision making is currently inconclusive (33–38), studies have shown that FOP can lead to product redevelopment (39,40). It is imperative to understand the effectiveness of different FOP labelling policies on consumer behaviour at the point of purchase, particularly as more countries adopt FOP systems. This research can also ensure that such initiatives complement other government efforts, such as the successful SSB and junk food taxes (5,41) and the regulation of foods and beverages offered in schools in Mexico (42) and FOP labelling and marketing, advertising, and sales restriction to children in Chile (30).

In addition, countries are also encouraging major changes in their food system. Brazil has developed dietary guidelines that encourage a return to a diet dominated by minimally processed foods, and its school feeding programs that requires 70% minimally processed food are in need of evaluation (23,24,27,28,43,44). It remains to be seen whether a push to shift diets to traditional, fresh food alone will be effective as a way to prevent child obesity or whether meaningful reformulation of extant packaged foods is possible and should also be considered. Rigorous surveillance could track whether processed food consumption slows in response to new dietary guidelines and, if so, among which subgroups. In addition, surveillance could evaluate the need for changes in food availability and pricing to complement guidelines.

These government efforts must include evaluation of governmental food assistance programs in the region, such as *Glass of Milk* in Peru (29,45,46), *Community Kitchens* in Peru (47–49), and *Diconsa* in Mexico, for their impact in increasing the availability of fresh fruit and vegetables in rural areas (50). Understanding both their impact and cost-effectiveness will be critical information for replication and scale-up. In addition, the effects of cash transfer programs on improving the nutritional status of children, including decreasing childhood obesity, should continue to be evaluated (51–54).

One cross-cutting factor is the role of media, education, and marketing; however, little is known about how these affect individual and household food purchasing and consumption. The few studies that have considered food marketing have not systematically monitored all media (55–57). Despite this lack of data, the region is rapidly moving forward with various controls on marketing with the strongest new laws and regulations emerging in Chile (30,32,44,58). Because the success or failure of interventions will be affected by economic, cultural and social factors, local and regional research is critical. Process and impact evaluations are key for appraising complex interventions and implementation approaches to ultimately advance effective solutions (59–61).

Physical activity

Environmental and Psychosocial Correlates of Physical Activity

Societal changes in Latin America – such as urbanization, growth in automobile transportation, mechanization and computerization of occupational and home tasks, electronic entertainment – are all likely to decrease physical activity and increase sedentary behaviours (62). However, little documentation of these trends exists outside Brazil, where occupational and time use data suggest declines in physical activity (63).

Social environments (e.g. crime and traffic), psychosocial variables (e.g. social support and perceived barriers) and biological variables (e.g. obesity and genetics) are important to understand independently and in concert, as there are likely interactions across these levels of influence. These influences are expected to be different across the leisure, transportation, occupational and household domains of physical activity. Some social, psychological, and environmental correlates appear to be consistent with patterns found in high-income countries. Among the unexpected findings in low- and middle-income countries (LMICs), more affluent adults and youth from urban household were found to have lower activity levels (64). These trends need to be evaluated throughout Latin America. Addressing the limited data on built (e.g. geographic information system) and social environments (65) and increasing multidisciplinary research capacity in this area is a priority (13).

Relatively little is known about correlates (cross-sectional) and determinants (longitudinal) of physical activity or inactivity in Latin America, which may be related to a limited integration of behavioural science into research on physical activity, nutrition, and chronic diseases (66,67). Research is needed to adapt theory-based measures of psychosocial and environmental correlates and determinants of physical activity in the Latin American context. The potentially important roles of maternal physical activity during pregnancy and physical activity during the early years of childhood are largely unknown. Periodic assessment of physical activity correlates in public health surveillance systems could identify trends in the drivers of physical activity across the transportation, leisure and occupational domains. Quantitative and qualitative studies are also needed in Latin American subpopulations with low levels of physical activity. Such studies could identify psychosocial and environmental variables related to the multiple domains of physical activity and inform the design of interventions.

Surveillance and measurement

Many research gaps related to measuring diet and physical activity exist across the globe. In Latin America, there is a

specific need for detailed measurement of foods and activities and the underlying food or energy expenditure/composition for these items to inform program and policy planning for child obesity prevention. In contrast to many other LMIC regions, Latin America is more urbanized; food systems and diets are highly influenced by ultra-processed foods and modern food systems (5,21,22), levels and types of physical activities differ widely in part due to climate and terrain; and a number of the region's governments, particularly Mexico, Colombia and Brazil, are monitoring obesity-related changes.

Diet

Nationally representative dietary surveys

Only a few Latin American countries have conducted nationally representative surveys with data on diet, physical activity, weight, height and waist circumference. In the last decade, the Demographic and Health Surveys have only collected weight and height for preschoolers and women aged 15 to 49 years and limited information on infant feeding in selected Latin American countries (68). All countries in the region collect income and expenditure data, yet only in a few countries do scholars use these data for nutritional analyses in part because of the limited data they provide. To create accurate food composition measures, national dietary surveys and up-to-date food composition tables are needed.

Food composition tables

Across the world, food composition tables are often not consistent with current recommendations and realities. The modern food system has hundreds of thousands of barcoded food products that are largely missing from the tables, and far too many Latin American countries rely on either the USDA food composition tables or very old chemical analyses of nutrient composition. To address this, the INFORMAAS project is documenting and creating limited databases of barcoded foods and beverages in Brazil, Chile, Mexico and other Latin American countries and in selected countries (i.e. Mexico, Brazil, Colombia and Chile) evaluation efforts are collecting complete databases of all packaged processed foods (69–71); however, these databases provide limited and in some cases questionable data on the quality of macronutrients, nutrients and ingredients, especially for many locally produced foods and beverages. Unless they are linked to actual food purchase data, the databases also do not give a sense of the population use of various products as will be done in Mexico and Chile in 2017 (72). Chemical analysis of the foods is needed to validate some of these data (71,73). Furthermore, with the array of new cultivation methods and new food varieties, the nutrient compositions of produce and staples will change. Similarly,

new livestock breeds and feeding methods will change the composition of animal-source food. Strategic food composition analysis is needed to understand these changes.

Improved surveillance through nationally or subnationally representative surveys (using valid instruments, such as the multipass 24-h dietary recall and locally appropriate food frequency questionnaires) in combination with improved food composition tables would enable researchers to better understand diets in Latin America throughout the life cycle and across different demographic subgroups. As a result, analysis could determine which foods in local diets are most responsible for excessive energy intake and the impacts of various foods and other factors, including the context and timing of food and beverage intake, on appetite and satiety (74–78). In Mexico, such data was critical to successfully enacting a sugar-sweetened beverages (SSB) tax (79–84). Technologies to ease the time and expense required for collecting dietary data are urgently needed; as with physical activity data, aggregate measures are inadequate to develop child obesity prevention policies and programs.

Physical activity

Surveillance

Surveillance in Latin American countries is limited to self-reports of individual behaviour and does not include environmental, social and individual correlates of physical activity (85). Comprehensive physical activity surveillance requires collaboration among public health and other agencies that collect relevant data. Public health agency data usually focuses on behaviours and occasionally on psychosocial correlates (such as social support) and perceived barriers. Largely absent is complementary data from other sectors, such as transportation (to document active travel by walking and bicycling), recreational physical activity (such as park use) and school physical education. The last is a large part of physical activity promotion in most countries, yet limited data exist on the quantity and quality of physical education or other physical activity opportunities during school.

Encouraging more Latin American countries to participate in systematic surveillance of physical activity across all age groups is important to document trends over time. Of the 33 countries in the World Health Organization Latin America region, 18 completed at least one national physical activity survey for adults (86). Fewer countries studied youth, although surveillance of adolescent physical activity is expanding in Latin America (86). Most adult surveys used a version of the International Physical Activity Questionnaire or the Global Physical Activity Questionnaire, endorsed by the World Health Organization as part of the Stepwise Approach to Surveillance (STEPS) program (87–89). Both International Physical Activity

Questionnaire and Global Physical Activity Questionnaire have been validated for use in Latin America (89,90). Despite this, few countries have data on trends in physical activity (63). Continued use of these surveys along with increased use of objective measures, such as accelerometers, would provide better data that can be used to develop more targeted and effective programs and policies.

Measurement technique gaps

As with dietary assessment, minimal work has been done to create measurement of the actual energy expenditures of different activities for Latin American youth. New technologies, including mobile phones and consumer-oriented wearable activity monitors, provide an exciting opportunity for surveillance research. If complex issues of standardization and sampling can be resolved, these technologies may make physical activity surveillance with objective measures and integration with measures of physical activity correlates more feasible. Research programs in Latin America should conduct the validation and sampling studies needed to develop surveillance protocols for the region using the most widely available information and monitoring technologies.

Efficacious interventions for behavioural change

Latin America is implementing a broad set of regulatory policies designed to alter dietary intake and, to a lesser extent, physical activity. Nevertheless, evidence-based interventions and education efforts are needed that will change the broader culture of healthy diet and activity to promote major lifestyle changes at the national, regional, community, household and individual levels. As behaviour change at these levels can be influenced by a variety of factors in the food and physical activity environments (10,11,64,91–93), research is needed in a variety of areas to inform evidence-based policy and programming. Behaviour change strategies, in particular, should be planned in combination with environment and policy change, because multi-level interventions are most likely to be effective (91). When designing programs, priority should be given to approaches that have the potential to be scaled-up for population impact; this will often require cost-effectiveness as well as impact assessments. The impact of behaviour change strategies is still not well known, requiring additional research.

Evaluation of policy and community interventions and an exploration of potential future options

The policy arena is potentially one of the most fruitful areas of future research, as Latin America has been a leader in initiating regulatory actions and multisectoral policies

(14). Currently, many policy interventions have been scaled-up and are considered state-of-the-art but lack evidence of efficacy (94). In countries, such as Mexico, Chile and Brazil, enacting childhood obesity prevention policies, it is critical to document and rigorously evaluate the implementation and impact of their policies and programs using multiple disciplines and methods (e.g. epidemiology, econometrics, system science and implementation science) (31,41). These evaluation efforts should include natural experiments and mixed-methods research. Policy evaluation can help identify best practices to understand accomplishments in terms of pricing (taxes), promotion (marketing and labelling) and the built environment, a component that is thus far a neglected aspect of research and action. Implementation research is critical to evaluate the on-the-ground impact of policies and programs, and identify any needed changes or additions.

Although some evaluations of community-wide physical activity interventions in Latin America have been published, there is a substantial deficit in comparison to the research literature from high-income countries. International evidence on the effectiveness of community-wide interventions suggests that multilevel interventions have been promising strategies to promote physical activity, including in Colombia and Brazil (95,96). As more Latin American countries adopt similarly innovative policies, it may soon be possible to evaluate multilevel interventions for both physical activity and diet in the region. These policies would ideally drive environmental changes and provide incentives that complement mass communication strategies and individual behaviour change assistance in settings such as primary care that may already be in place.

Latin America presents an unparalleled opportunity to understand the impact, cost-effectiveness and scalability of a multiplicity of large-scale interventions – not only on diet and activity patterns but also on childhood obesity prevention trends. Because of the expected push back and counteractions from food, transportation and other industries opposed to increased regulations, it will be critical to document the actions and reactions of these stakeholders during large-scale environmental interventions.

Research needs and priorities

Research will play a vital role as Latin America addresses childhood obesity. To confront this growing epidemic, we must understand the relationship between undernutrition and obesity across the life cycle, food and physical activity environments and individual behaviours affecting dietary and physical activity habits. This knowledge will inform the development and implementation of effective interventions. Underlying all of this is the need for more

Table 1 Research directions for preventing childhood obesity in Latin America**Longitudinal and prospective studies**

- Conduct long-term, multicountry pregnancy and birth cohort studies
- Examine dietary, physical activity and sedentary behaviour patterns through prospective studies
- Design and implement comprehensive national surveys of diet and physical activity

Biological challenges across the life cycle

- Assess the association of early feeding practices, physical activity and sedentary behaviour patterns on obesity and metabolic outcomes
- Understand the role of maternal physical activity during pregnancy and early childhood on physical activity outcomes
- Investigate whether ethnicity or indigenous ancestry is associated with a greater risk of obesity and concomitant non-communicable diseases

Dietary and physical activity patterns

- Understand the relationship between food environment factors, including marketing, availability and price, to consumption of foods that contribute to obesity
- Study the impact of media, education and marketing on individual and household food purchasing and consumption
- Develop multi-pronged interventions that address the dual burden of stunting and obesity.
- Evaluate the effectiveness of government food-based policies, such as front-of-the-package labelling, food reformulation and dietary guidelines to encourage healthier choices and prevent obesity-related behaviours

Surveillance and measurement

- Incorporate routine surveillance of physical activity and nutrition into national health surveys
- Collect data on active travel, recreational activity in parks, and physical education and other school-based programs from across relevant governmental departments
- Understand the factors that influence physical activity and nutrition across different populations by adapting theory-based measures of psychosocial and environmental correlates to the Latin American context
- Conduct descriptive studies of correlates of healthy/unhealthy food patterns and for all domains of physical activity, including transportation, leisure and occupational
- Examine physical activity environments and transportation systems and their impacts on activity

Individual behaviour change

- Evaluate behaviour change programs that target specific obesity-related behaviours, such as snacking, television viewing, computer/game use and eating highly processed foods and SSB
- Leverage the use of technology in children and adolescents to introduce or reinforce patterns of healthy eating and mobility
- Test interventions based on behavioural economics theories to alter food and physical activity patterns

Policy and community interventions

- Determine how effective models from other regions can be adapted and when unique interventions specifically designed for Latin American populations are needed; identify effective methods of adapting applications to local cultures and building theory-based interventions in Latin America
- Design research to help guide governments in instituting effective approaches to deal with the dual burden of stunting and obesity; evaluate implementation of adopted policies related to food and physical activity

robust surveillance and resources dedicated to long-term, population-level epidemiological studies. While by no means comprehensive, Table 1 presents a list of priority research needs that if addressed, will improve our ability to combat childhood obesity across the region. Of note, many of these priorities are not exclusive to Latin America; however, they do take into account factors that are of particular importance to the region.

Latin America faces important child obesity challenges related to rapidly growing obesity rates; a triple burden of undernutrition, micronutrient malnutrition and obesity; economic and health inequalities; and limited public health data and infrastructure related to obesity prevention. At the same time, Latin American countries have adopted some of the world's most innovative obesity control policies, and the body of research on diet and physical activity is rapidly growing, as is the implementation of evidence-based physical activity interventions. By building on the strengths of the region, Latin American researchers can provide evidence to develop effective policies, ensure good evaluation of these policies, enhance dissemination of proven approaches,

and work towards implementation of comprehensive, multilevel interventions to control the childhood obesity epidemic over the next decade. Given the number of countries already attempting to focus on large-scale interventions (e.g. taxation, FOP labelling, restrictions on marketing to children, regulations of foods and beverages in schools and community-based physical activity promotion), impact evaluation research is critical. This research in conjunction with more basic research such as healthier growth trajectories during the first thousand days of life will go a long way towards preventing childhood obesity and related NCDs. Research capacity and targeted funding in the region must be increased to address this research agenda.

Acknowledgements

The *Preventing Childhood Overweight and Obesity in Latin America: Linking Evidence to Policy and Practice* workshop and the publication of its proceedings were supported by the US National Institutes of Health Fogarty International Center.

Conflict of interest

The Fogarty International Center at the U.S. National Institutes of Health sponsored travel for each, non-local author to attend the 'Preventing Childhood Overweight and Obesity in Latin America: Linking Evidence to Policy and Practice' workshop, the precursor for this article. The following authors declare a further conflict of interest as specified in their ICMJE disclosure: Barry M. Popkin, Rodrigo S. Reis, Juan A. Rivera, and James F. Sallis.

The content is solely the responsibility of the authors and does not necessarily represent the official views of the US Department of Health and Human Services, the National Institutes of Health, or the Fogarty International Center.

References

- Monteiro CA, Moubarac JC, Cannon G, Ng SW, Popkin B. Ultra-processed products are becoming dominant in the global food system. *Obes Rev* 2013; **14**: 21–28.
- Monteiro CA, Levy RB, Claro RM, de Castro IR, Cannon G. Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. *Public Health Nutr* 2011; **14**: 5–13.
- Popkin BM. Nutrition, agriculture and the global food system in low and middle income countries. *Food Policy* 2014; **47**: 91–96.
- Zhou Y, Du S, Su C, Zhang B, Wang H, Popkin BM. The food retail revolution in China and its association with diet and health. *Food Policy* 2015; **55**: 92–100.
- Anand SS, Hawkes C, de Souza RJ *et al.* Food Consumption and its impact on cardiovascular disease: importance of solutions focused on the globalized food system a report from the workshop convened by the World Heart Federation. *J Am Coll Cardiol* 2015; **66**: 1590–1614.
- Corvalán C, Garmendia ML, Jones-Smith J, *et al.* Nutrition status of children in Latin America. *Obes Rev* 2017; **18** (Suppl. 2): 7–18.
- Kroker-Lobos MF, Pedroza-Tobias A, Pedraza LS, Rivera JA. The double burden of undernutrition and excess body weight in Mexico. *Am J Clin Nutr* 2014; **100**: 1652S–1658S.
- Rivera JA, de Cossío TG, Pedraza LS, Aburto TC, Sánchez TG, Martorell R. Childhood and adolescent overweight and obesity in Latin America: a systematic review. *Lancet Diabetes Endocrinol* 2014; **2**: 321–332.
- Rivera JA, Pedraza LS, Martorell R, Gil A. Introduction to the double burden of undernutrition and excess weight in Latin America. *Am J Clin Nutr* 2014; **100**: 1613S–1616S.
- Kroker-Lobos MF, Pedroza-Tobias A, Pedraza LS, Rivera JA. The double burden of undernutrition and excess body weight in Mexico. *Am J Clin Nutr* 2014; **100**: 1652S–1658S.
- Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev* 2012; **70**: 3–21.
- Pratt M, Perez LG, Goenka S *et al.* Changing population levels of physical activity: global evidence and experience. *Prog Cardiovasc Dis* 2015; **54**: 356–367.
- Parra DC, Vorkoper S, Kohl III HW, *et al.* Research capacity for childhood obesity prevention in Latin America: an area for growth. *Obes Rev* 2017; **18** (Suppl. 2): 39–46.
- Pérez-Escamilla R, Lutter CK, Rabadan-Diehl C *et al.* Prevention of childhood obesity and food policies in Latin America: from research to practice. *Obes Rev* 2017; **18**(Suppl 2): 28–38.
- Doak CM, Adair LS, Bentley M, Monteiro C, Popkin BM. The dual burden household and the nutrition transition paradox. *Int J Obes (Lond)* 2005; **29**: 129–136.
- Doak C, Adair L, Bentley M, Fengying Z, Popkin B. The underweight/overweight household: an exploration of household sociodemographic and dietary factors in China. *Public Health Nutr* 2002; **5**: 215–221.
- Montenegro RA, Stephens C. Indigenous health in Latin America and the Caribbean. *Lancet* 2006; **367**: 1859–1869.
- The Department of Economic and Social Affairs of the United Nations Secretariat. The State of the World's Indigenous Peoples. United Nations: New York, 2009.
- Adair LS, Fall CH, Osmond C *et al.* Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income: findings from five birth cohort studies. *Lancet* 2013; **382**: 525–534.
- Adair LS, Martorell R, Stein AD *et al.* Size at birth, weight gain in infancy and childhood, and adult blood pressure in 5 low- and middle-income-country cohorts: when does weight gain matter? *Am J Clin Nutr* 2009; **89**: 1383–1392.
- Reardon T, Timmer CP, Barrett CB, Berdegue JA. The rise of supermarkets in Africa, Asia, and Latin America. *Am J Agric Econ* 2003; **85**: 1140–1146.
- Reardon T, Berdegue J. The rapid rise of supermarkets in Latin America: challenges and opportunities for development. *Dev Policy Rev* 2002; **20**: 371–388.
- Monteiro CA, Moubarac JC, Cannon G, Ng SW, Popkin B. Ultra-processed products are becoming dominant in the global food system. *Obes Rev* 2013; **14**: 21–28.
- Monteiro CA, Gomes FS, Cannon G. The snack attack. *Am J Public Health* 2010; **100**: 975–981.
- Romero-Martínez M, Shamah-Levy T, Franco-Núñez A *et al.* Encuesta Nacional de Salud y Nutrición 2012: diseño y cobertura. *Salud Publica Mex* 2013; **55**: S332–S340.
- Pereira RA, Duffey KJ, Sichieri R, Popkin BM. Sources of excessive saturated fat, trans fat and sugar consumption in Brazil: an analysis of the first Brazilian nationwide individual dietary survey. *Public Health Nutr* 2014; **17**: 113–121.
- Monteiro CA, Cannon G. The impact of transnational "Big Food" companies on the south: a view from Brazil. *PLoS Med* 2012; **9**: e1001252.
- Monteiro C. The big issue is ultra-processing. In: *J World Public Health Nutr Assoc* 2010; **1**.
- Brazil Ministry of Health Secretariat of Health Care Primary Health Care Department. Dietary Guidelines for the Brazilian Population, 2nd edn. Brazil Ministry of Health: Brasilia, 2014, p. 152.
- Corvalán C, Reyes M, Garmendia ML, Uauy R. Structural responses to the obesity and non-communicable diseases epidemic: the Chilean Law of Food Labeling and Advertising. *Obes Rev* 2013; **14**: 79–87.
- Colchero MA, Popkin BM, Rivera JA, Ng SW. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. *BMJ* 2016; **352**: h6704.
- Barquera S, Campos I, Rivera JA. Mexico attempts to tackle obesity: the process, results, push backs and future challenges. *Obes Rev* 2013; **14**: 69–78.
- Roodenburg A, Popkin B, Seidell J. Development of international criteria for a front of package nutrient profiling system: international Choices Programme. In: *Eur J Clin Nutr* 2011. <https://doi.org/10.1038/ejcn.2011.101>.
- Roodenburg AJC, Schlatmann A, Dötsch-Klerk M *et al.* Potential effects of nutrient profiles on nutrient intakes in the Netherlands, Greece, Spain, USA, Israel, China and South-Africa. *PLoS ONE* 2011; **6**: e14721.

35. Sacks G, Rayner M, Swinburn B. Impact of front-of-pack 'traffic-light' nutrition labelling on consumer food purchases in the UK. *Health Promot Int* 2009; **24**: 344–352.
36. Sutherland LA, Kaley LA, Fischer L. Guiding stars: the effect of a nutrition navigation program on consumer purchases at the supermarket. *Am J Clin Nutr* 2010; **91**: 1090S–1094S.
37. Temme EH, van der Voet H, Roodenburg AJ, Bulder A, van Donkersgoed G, van Klaveren J. Impact of foods with health logo on saturated fat, sodium and sugar intake of young Dutch adults. *Public Health Nutr* 2011; **14**: 635–644.
38. Cowburn G, Stockley L. Consumer understanding and use of nutrition labelling: a systematic review. *Public Health Nutr* 2005; **8**: 21–28.
39. Vyth EL, Steenhuis IHM, Brandt HE, Roodenburg AJC, Brug J, Seidell JC. Methodological quality of front-of-pack labeling studies: a review plus identification of research challenges. *Nutr Rev* 2012; **70**: 709–720.
40. Vyth EL, Steenhuis IH, Roodenburg AJ, Brug J, Seidell JC. Front-of-pack nutrition label stimulates healthier product development: a quantitative analysis. *Int J Behav Nutr Phys Act* 2010; **7**: 65.
41. Batis C, Rivera JA, Popkin B, Taillie L. First-year evaluation of Mexico's tax on non-essential energy-dense foods: an observational study. *PLoS Med* 2016; **13**: e1002057.
42. Colchero MA, Popkin BM, Rivera JA, Ng SW. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. *BMJ* 2016; **352**: h6704.
43. Poti JM, Mendez MA, Ng SW, Popkin BM. Is the degree of food processing and convenience linked with the nutritional quality of foods purchased by US households? *Am J Clin Nutr* 2015; **99**: 162–171.
44. Coitinho D, Monteiro CA, Popkin BM. What Brazil is doing to promote healthy diets and active lifestyles. *Public Health Nutr* 2002; **5**: 263–267.
45. Stifel D, Alderman H. The "Glass of Milk" subsidy program and malnutrition in Peru. *World Bank Econ Rev* 2006; **20**: 421–448.
46. Carrillo-Larco RM, Miranda JJ, Bernabe-Ortiz A. Impact of food assistance programs on obesity in mothers and children: a prospective cohort study in Peru. *Am J Public Health* 2016; **106**: 1301–1307.
47. Creed-Kanashiro HM, Uribe TG, Bartolini RM *et al*. Improving dietary intake to prevent anemia in adolescent girls through community kitchens in a periurban population of Lima, Peru. *J Nutr* 2000; **130**: 459.
48. Immink MDC. People's community kitchens in Peru: women's activism pro urban food security. *Ecol Food Nutr* 2001; **40**: 699–705.
49. Diaz-Garcés FA, Vargas-Matos I, Bernabe-Ortiz A, Diez-Canseco F, Trujillo AJ, Miranda JJ. Factors associated with consumption of fruits and vegetables among Community Kitchens customers in Lima, Peru. *Prev Med Rep* 2016; **4**: 469–473.
50. Cisneros G, Székely M. La eficiencia de los Subsidios en México: El caso de DICONSA: Tesis de Licenciatura. Instituto Tecnológico Autónomo de México: México, 1990.
51. Cecchini S, Soares FV. Conditional cash transfers and health in Latin America. *Lancet*; **385**: e32–e34.
52. Fernald LC, Gertler PJ, Hou X. Cash component of conditional cash transfer program is associated with higher body mass index and blood pressure in adults. *J Nutr* 2008; **138**: 2250–2257.
53. Fernald LC, Gertler PJ, Neufeld LM. Role of cash in conditional cash transfer programmes for child health, growth, and development: an analysis of Mexico's Oportunidades. *Lancet* 2008; **371**: 828–837.
54. Fernald LC, Gertler PJ, Neufeld LM. 10-year effect of Oportunidades, Mexico's conditional cash transfer programme, on child growth, cognition, language, and behaviour: a longitudinal follow-up study. *Lancet* 2009; **374**: 1997–2005.
55. Pérez-Salgado DR-MJ, Ortiz-Hernández L. Publicidad de alimentos en la programación de la televisión mexicana: ¿los niños están más expuestos? *Salud Publica Mex* 2010; **52**: 119–126.
56. Hernandez B, Gortmaker SL, Colditz GA, Peterson KE, Laird NM, Parra-Cabrera S. Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico city. *Int J Obes Relat Metab Disord* 1999; **23**: 845–854.
57. Théodore FL, Tolentino-Mayo L, Hernández-Zenil E *et al*. Pitfalls of the self-regulation of advertisements directed at children on Mexican television. *Pediatr Obes* 2016, <https://doi.org/10.1111/ijpo.12144>.
58. Jaime PC, da Silva ACF, Gentil PC, Claro RM, Monteiro CA. Brazilian obesity prevention and control initiatives. *Obes Rev* 2013; **14**: 88–95.
59. Hoffman TC, Glasziou PP, Boutron I *et al*. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ* 2014; **348**: g1687.
60. Moore GF, Audrey S, Baker M *et al*. Process evaluation of complex interventions: Medical Research Council guidance. *BMJ* 2015; **350**: h1258.
61. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ* 2008; **337**: a1655.
62. Pratt M, Sarmiento OL, Montes F *et al*. The implications of megatrends in information and communication technology and transportation for changes in global physical activity. *Lancet* 2012; **380**: 282–293.
63. Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. *Obes Rev* 2012; **13**: 659–680.
64. Sallis JF, Cerin E, Conway TL *et al*. Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. *Lancet* 2016, 2207–2217.
65. Reis RS, Kelly CM, Parra DC *et al*. Developing a research agenda for promoting physical activity in Brazil through environmental and policy change. *Rev Panam Salud Publica* 2012; **32**: 93–100.
66. Finck Barboza C, Monteiro SM, Barradas SC *et al*. Physical activity, nutrition and behavior change in Latin America: a systematic review. *Glob Health Promot* 2013; **20**(4 Suppl): 65–81.
67. Sallis JF, Bull F, Burdett R *et al*. Use of science to guide city planning policy and practice: how to achieve healthy and sustainable future cities. *Lancet*; 2936–2947.
68. Survey DH. Demographic & health survey overview. In; N/A.
69. Mialon M, Swinburn B, Sacks G. A proposed approach to systematically identify and monitor the corporate political activity of the food industry with respect to public health using publicly available information. *Obes Rev* 2015; **16**: 519–530.
70. Ng SW, Dunford E. Complexities and opportunities in monitoring and evaluating US and global changes by the food industry. *Obes Rev* 2013; **14**: 29–41.
71. Dunford E, Webster J, Metzler AB *et al*. International collaborative project to compare and monitor the nutritional composition of processed foods. *Eur J Prev Cardiol* 2012; **19**: 1326–1332.
72. Ng SW, Popkin BM. Monitoring foods and nutrients sold and consumed in the United States: dynamics and challenges. *J Acad Nutr Diet* 2012; **112**: 41–45 e4.
73. Dunford E, Trevena H, Goodsell C *et al*. FoodSwitch: a mobile phone app to enable consumers to make healthier food choices and

- crowdsourcing of national food composition data. *JMIR MHealth UHealth* 2014; 2: e37.
74. Mourao DM, Bressan J, Campbell WW, Mattes RD. Effects of food form on appetite and energy intake in lean and obese young adults. *Int J Obes (Lond)* 2007; 31: 1688–1695.
75. Lennerz BS, Alsup DC, Holsen LM *et al.* Effects of dietary glycemic index on brain regions related to reward and craving in men. *Am J Clin Nutr* 2013; 98: 641–647.
76. Galeone C, Pelucchi C, La Vecchia C. Added sugar, glycemic index and load in colon cancer risk. *Curr Opin Clin Nutr Metab Care* 2012; 15: 368–373.
77. Schulze MB, Liu S, Rimm EB, Manson JE, Willett WC, Hu FB. Glycemic index, glycemic load, and dietary fiber intake and incidence of type 2 diabetes in younger and middle-aged women. *Am J Clin Nutr* 2004; 80: 348–356.
78. Ludwig DS. The glycemic index: physiological mechanisms relating to obesity, diabetes, and cardiovascular disease. *JAMA* 2002; 287: 2414–2423.
79. Barquera S, Campirano F, Bonvecchio A, Hernández L, Rivera J, Popkin B. Caloric beverage consumption patterns in Mexican children. *Nutr J* 2010; 9: 47–56.
80. Barquera S, Hernandez-Barrera L, Tolentino M *et al.* Energy intake from beverages is increasing among Mexican adolescents and adults. *J Nutr* 2008; 138: 2454–2461.
81. Popkin BM, Hawkes C. Sweetening of the global diet, particularly beverages: patterns, trends, and policy responses. *Lancet Diabetes Endocrinol* 2016; 4: 174–186.
82. Aburto TC, Pedraza LS, Sánchez-Pimienta TG, Batis C, Rivera JA. Discretionary foods have a high contribution and fruit, vegetables, and legumes have a low contribution to the total energy intake of the Mexican population. *J Nutr* 2016; 146: 1881S–1887S.
83. Rivera JA, Pedraza LS, Aburto TC *et al.* Overview of the dietary intakes of the Mexican population: results from the National Health and Nutrition Survey 2012. *J Nutr* 2016; 146: 1851S–1855S.
84. Sánchez-Pimienta TG, Batis C, Lutter CK, Rivera JA. Sugar-sweetened beverages are the main sources of added sugar intake in the Mexican population. *J Nutr* 2016; 146: 1888S–1896S.
85. González S, Sarmiento OL, Lozano Ó, Ramírez A, Grijalba C. Niveles de actividad física de la población colombiana: desigualdades por sexo y condición socioeconómica. *Biomedica* 2014; 34: 447–459.
86. Sallis JF, Bull F, Guthold R *et al.* Progress in physical activity over the Olympic quadrennium. *Lancet* 2016; 388: 1325–1336.
87. Ng N, Van Minh H, Tesfaye F *et al.* Combining risk factors and demographic surveillance: potentials of WHO STEPS and INDEPTH methodologies for assessing epidemiological transition. *Scand J Public Health* 2006; 34: 199–208.
88. Organization WH. WHO STEPS Surveillance Manual. World Health Organization: Geneva, 2008.
89. Armstrong T, Bull F. Development of the world health organization global physical activity questionnaire (GPAQ). *J Public Health* 2006; 14: 66–70.
90. Hallal PC, Reis RS, Parra DC, Hoehner C, Brownson RC, Simoes EJ. Association between perceived environmental attributes and physical activity among adults in Recife, Brazil. *J Phys Act Health* 2010; 7: S213–S222.
91. Sallis JF, Owen N, Fisher EB. Health Behavior and Health Education: Theory, Research, and Practice, 4th edn. Jossey-Bass: San Francisco, 2008.
92. Pratt M, Charvel Orozco AS, Hernandez-Avila M, Reis RS, Sarmiento OL. Obesity prevention lessons from Latin America. *Prev Med* 2014; 69, Supplement: S120–S122.
93. Popkin BM. An overview on the nutrition transition and its health implications: the Bellagio meeting. *Public Health Nutr* 2002; 5: 93–103.
94. Reis RS, Salvo D, Ogilvie D *et al.* Scaling up physical activity interventions worldwide: stepping up to larger and smarter approaches to get people moving. *Lancet* 2016; 388: 1337–1348.
95. Heath GW, Parra DC, Sarmiento OL *et al.* and Lancet Physical Activity Series Working Group. Evidence-based intervention in physical activity: lessons from around the world. *Lancet* 2012; 380: 272–281.
96. Reis RS, Hino A, da Silva FL *et al.* Promoting physical activity and quality of life in Vitoria, Brazil: evaluation of the Exercise Orientation Service (EOS) Program. *J Phys Act Health* 2014; 11: 38–44.