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Prevention of childhood obesity and food policies in Latin America: from research to practice

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Summary

Background: Addressing childhood obesity in Latin America requires a package of multisectoral, evidence-based policies that enable environments conducive to healthy lifestyles.

Objective: Identify and examine key elements to translating research into effective obesity policies in Latin America.

Methods: We examined obesity prevention policies through case studies developed with an expert in the specific policy. Policies were selected based on their level of implementation, visibility and potential impact to reduce childhood obesity. They include: (i) excise taxes on sugar sweetened beverages and energy-dense foods; (ii) front-of-package food label legislation; (iii) trans fatty acids removal from processed foods; and (iv) Ciclovías recreativas or 'open streets'. Case studies were coded to identify components that explained successful implementation and sustainability using the Complex Adaptive Health Systems framework.

Results: The analysis identified key elements for effective and sustainable policy, including evidence justifying policy; evidence-based advocacy by civil society; political will; and legislation and skillful negotiations across government, academia, the private sector and civil society. Scientific evidence and evaluation played an important role in achieving tipping points for policies' launch and sustain effective implementation.

Conclusions: Well-coordinated, intersectoral partnerships are needed to successfully implement evidence-based anti-obesity policies. Prospective policy research may be useful for advancing knowledge translation.

Keywords: Childhood obesity, complex adaptive systems, food and nutrition policy, Latin America.

Introduction and objectives

Childhood obesity is an epidemic of major proportions in Latin America, driven by the interaction of environmental and behavioural (nutrition and physical activity) factors operating across different levels of the social–ecological model. High levels of urbanization, limited access to space and time for physical activity and a nutrition transition characterized by ubiquitous access to ultra-processed foods with excessive calories, added sugars, salt, trans fatty acids (TFAs) and saturated fat (1–3) have contributed to a childhood obesity epidemic in Latin America (4). Addressing childhood obesity in Latin America will require a set of multisector, multilevel policies based on the best available evidence. As dietary risk factors track from childhood to adulthood (5), modifying those factors early in life could prevent non-communicable disease related to obesity, such as coronary heart disease (CHD) later on (6). Given the potential impact of preventing childhood obesity, it is surprising that few studies have attempted to understand how countries have effectively translated scientific evidence into policy in the context of child obesity.

To understand how scientific knowledge has supported the decisions to design and implement evidence-based healthy lifestyles policies in Latin America, we examined and identified key Complex Adaptive Health Systems

(CAS) framework elements associated with the translation of evidence into diet- and physical activity-related obesity policies for children in Latin America following a case study methodology.

Methods

The evidence-based food and physical activity policies highlighted in the case studies – sugar sweetened beverages (SSBs) and 'junk' food taxes, front of package (FOP) food labelling, reduction of TFAs in food supply and *Ciclovías* – were chosen based on the availability of evidence on their implementation and interest in them in Latin America and beyond given the urgent need to address unhealthy diets and physical activity patterns (7–9).

The specific case studies selected were: excise taxes on SSBs and energy-dense foods in Mexico; FOP food labelling legislation in Chile and Ecuador; TFA removal from processed foods in Argentina and *Ciclovías* across Latin America. At least two members of the writing team, led by an expert who was actively involved in and/or had an intimate knowledge of the policy adoption process, developed each case study. A sub-team (SV, EEP, LK, RPE) coded the case studies for key elements of successful deployment using the CAS framework. This framework is well suited for understanding the behaviour of diverse, interconnected agents and processes from a systems perspective (10). Analysis focused on CAS constructs of feedback loops, scale-free networks, phase transitions, path dependence and emergent behaviour (Table 1).

Results – case studies

Sugar sweetened beverages and nonessential energy-dense food taxes – Mexico

Worldwide, taxes on unhealthy foods and beverages have been used to dis-incentivize intake and reduce externalities associated with unhealthful diets, rebalance information asymmetry caused by food advertisements and generate revenue to support obesity prevention efforts (11–14). Evidence from high-income countries demonstrates food taxes have increased prices on unhealthy foods and reduced the purchase of processed and foods high in saturated fat, in some cases by up to 15% (15–19). In Mexico, the National Institute of Public Health (INSP) is conducting research that demonstrates support for and the effectiveness of similar legislation aimed at sugar-sweetened beverages and nonessential energy-dense food taxes. Mexico's experience built upon the evidence developed previously in other countries.

In Mexico, approval of SSBs and nonessential energy-dense food taxes was made possible through the cooperation of academia, civil society, and the legislative and executive branches of government. As a result of this science-based advocacy, the Ministry of Finances implemented the SSB and nonessential energy-dense food taxes in January 2014 and made food producers legally responsible for calculating, reporting and paying these taxes.

Research was key in the public debate and decision-making process. Specifically, the INSP was instrumental in setting the stage for the tax approval. Its research revealed not only the alarming trends in obesity and the associated health and economic consequences (20,21) but also the excessive intake of SSB (22–24) and the high energy density of Mexican children's current diets (25). This work clearly demonstrated an urgent need to address SSB intake and provided evidence-based support for the SSB taxes by (i) estimating own- and cross-price elasticities for SSB, which demonstrated that the demand for SSB was elastic in the Mexican population (a 10% increase in price was associated with a 11.6% reduction in the demand) and that the principal substitutes were healthy (water and milk) (26), and (ii) modelling body weight and diabetes projections under different tax scenarios. These studies, along with the existing evidence on the impact of SSB taxes to dis-incentivize intake (27), the reduced costs associated with unhealthful diets (15) and the revenue generated to support obesity prevention efforts (11,12), were disseminated in conferences and

Table 1 Complex Adaptive Health System (CAS) constructs definition

Paina and Peters define five distinct CAS principles that describe facilitators and challenges to implementation and impact (10).
Feedback loops occur when an output of a process within the system is fed back as an input into the same system. Positive feedback loops are those that facilitate, and negative feedback loops are those that represent barriers for the implementation or dissemination of a program.
Scale free networks refers to structures which are dominated by a few focal points or hubs with an unlimited number of links, following a power-law distribution.
Phase transitions occur when radical changes take place in the features of system parameters as they reach certain critical or tipping points.
Path dependence indicates that processes that have similar starting points may end up leading to different outcomes because of bifurcations and choices made along.
Emergent behaviour refers to the spontaneous creation of order, which appears when smaller entities on their own jointly contribute to organized behaviours as a collective.

publications, and presented to the Congress and Ministry of Finance.

To create a stronger, more unified voice with the public and policymakers, 27 non-governmental organizations (NGOs) formed a coalition and partnered with academic and international organizations. This coalition lobbied Congress, promoted science-based advocacy and conducted a mass media campaign of strategically timed policy reports, press conferences, demonstrations, and media campaigns on billboards, TV and radio. This strategic partnership allowed for effective translation of scientific findings to both the general public and policymakers and added credibility to the campaigns. Importantly, partners utilized their existing strengths by having civil society partners with expertise in lobbying analyse the political environment, map positions among congressmen and promote the initiative within Congress. This overall strategy was well organized and utilized partners' existing strengths, which helped to override efforts from the taxes' opponents.

The INSP along with other academic institutions, NGOs and the MOH are currently monitoring and evaluating the effect of the taxes on prices, consumption and the use of fiscal revenues for obesity-related programs. An observational study conducted during the first year of the policy found a significant increase in the price of SSB in urban areas (17); however, this was not the case in rural ones (28). Studies using data from urban households and national sales found a 6% reduction in the consumption of SSB in 2014 (29,30) and a 9% reduction in 2015 (30,31); consumption of nonessential energy-dense foods decreased by 5% in 2014 among urban households (32). These results, which show that the taxes are working, have created public debate about the effect of the tax in Mexico and abroad and are being used by other countries as an argument to implement taxes on SSB (32). An attempt in September 2015 by the SSB industry to repeal the tax measure a year after it took effect was defeated through strong evidence-based advocacy emphasizing the positive public health impact of the policy. The evidence-based advocacy was based on the first year evaluation of the SSB tax, which exemplifies once again, the key role of research, not only in the initial approval, but also for the maintenance of the tax policy in Mexico.

Food labelling – Chile and Ecuador

While it is mandatory to include nutrition labels on packaged foods in most Latin American countries, the vast majority of consumers report a low understanding of the nutrition facts presented (33–35). There is now strong interest from the public health sector and consumer groups in shifting from complex and confusing to easy-to-understand, front-of-package (FOP) labels that include images and clear messaging (36,37). Until recently, FOP messages, voluntarily added by food manufacturers, have focused only on highlighting the positive nutrition attributes of products (i.e. high in fibre, good source of vitamins, etc.). According to a recent IOM report, FOP labels are most effective when they are easily visible using colour coding, large font bold letters and framing the message(s) with borders (38). Although direct evidence of the impact of FOP messages on food intake behaviours is scarce, studies in Finland and Ireland have attributed salt reduction intakes to FOP labelling initiatives that have included social marketing (39–43). Thus, these results suggest that FOP labelling public health initiatives should also be accompanied by social marketing communication strategies to educate consumers and promote their use. The following two case studies focus on the implementation of food label legislation in Chile and a Ministerial decree in Ecuador.

Chile

In July 2012, the Chilean Senate approved the evidence-informed National Law of Food Labelling and Advertising that promoted (i) point-of-food purchase labelling to improve consumer information through easy-to-understand, FOP labels, including specific messaging around sugar, saturated fats, sodium, and calories, and (ii) restrictions on marketing, advertising and sales of unhealthy foods to children. Three years later, regulatory norms to guide implementation of the law were released after intense lobbying on both sides of the issue by government, civil society and industry. The food labelling regulations defined the size and design of FOP warning messages, prohibited the sale or marketing of high energy foods or beverages in schools and banned their marketing to children less than 14 years of age. Implementation of the law was staggered over three years and began in 2016.

In Chile, concern about increasing obesity rates started almost two decades prior to the approval of the Food Labelling Law. In 1998, the National Board for Health Promotion (VIDA Chile) was created with the mandate of implementing a National Health Promotion Plan to decrease obesity rates, especially among preschool, school-age children and pregnant women (44). Unfortunately, after five years of implementation, program coverage was 16%, and obesity rates were increasing relentlessly in all age and sex groups (45). Thus, the academic sector and policymakers identified the need to implement large-scale policies that could modify the environment and make healthier decisions an easier choice for all Chileans.

In 2007, a bill introduced through the Senate Health Committee contained the beginning seeds of the 2012 law, but despite support from the President and the Ministry of Health (MOH), it faced strong opposition from the food industry. As a result, the Chilean Senate convened two

International Health and Nutrition Summits in 2008 and 2011 to bring together national and international experts, researchers and civil society leaders to widen support for the proposed legislation. In order to pass the law, some difficult compromises involving key elements of the original bill had to be accommodated, including those pertaining to using a 'traffic light' food labelling system, banning of infant formula advertising (that had been included by the president) and the prohibition of selling unhealthy foods in universities. From 2012 to 2014, the MOH oversaw a process to develop the regulatory norms to guide implementation.

In order to make an informed decision on how to develop FOP label policy, the MOH requested that researchers across Chilean academic institutions review evidence regarding nutrient profiling and recommend a definition of 'unhealthy' foods based on Chilean dietary patterns. Experts were also convened to provide guidance on how to define 'unhealthy' foods and regulate food marketing to children (46–49). Defining unhealthy foods was particularly problematic, because of a lack of evidence to inform this decision. Indeed, creating a definition of 'unhealthy foods' would require modifying the Chilean Sanitary Regulatory Code, and because creating food label and marketing regulations depended on this definition this represented a major challenge (49). A decision was made to base the definition of unhealthy foods based on the UK's FOP traffic light signpost labelling technical guidance (50). Scientific expert committees found themselves challenged by limited evidence to understand the effectiveness of the different policies, including the link between marketing strategies and nutritional status and the best design and placement of nutritional warning messages, as well as the validity of different nutrient profiling schemes and attributable risks associated to specific food intakes in the local context (46,47). A second challenge was that the MOH and its Nutrition Department were in the midst of restructuring and had limited technical capacity to support the process.

In January 2013, the MOH published a proposed set of food label and marketing regulatory norms to solicit public opinion. Comments were received, mainly from national and international food companies and academia. The World Trade Union, the food industry and some politicians objected to the law on the basis that it violated freedom of expression, was paternalistic and was naive as it ignored the complexities involved with food advertising. At least three new drafts of the regulatory code were developed, and in December 2013 a regulatory code for the Food Labelling Law was approved by the General Accounting Office. The approved regulatory code did not follow the expert recommendations and included some critical errors with respect to definitions and standards; thus, it was intensely opposed by all sectors, academia, consumer's organizations, the senate and the food industry. In March 2014, a new government assumed power in Chile and convened a new group of experts to review the evidence and provide new recommendations to revise the regulatory codes. On July 2014, a new regulatory code was released for public opinion. More than 350 suggestions and nearly 1000 comments were received and considered in the final version that was submitted in October 2014 for approval by the General Accounting Office. Finally, in July 2015, the code, which included most of the recommendations submitted by the MOH, was approved by the government. Implementation of the code began on July 1, 2016, and will become increasingly stringent over a three-year period with regard to cut-points for the nutritional quality of products regulated. The code provides a system for classifying processed foods and beverages according to their energy, added sugar and saturated fat content (Table 2). This phased implementation was the result of lobbying by representatives of the food industry with the Economics and Agriculture Ministries, who interceded on their behalf, arguing that more time was needed for industry to be able to arrive to the full implementation of the law.

Prior to implementation, the authorities from the Nutrition Department of the MOH defined the standards and indicators to monitor and enforce the law. The Chilean MOH has regional departments (SEREMI) that are in charge of monitoring the implementation of public health norms and policies at the local level, as well as carrying on periodic health and food surveillance (51). The surveillance and inspection of the FOP labelling are being implemented by each department following a standard protocol. The SEREMIs will also be responsible for monitoring the compliance with the law with respect to food marketing to children in coordination with an inter-sectoral network conformed by representatives from government, academia, NGOs, consumer associations, food marketing institutions and consumers' rights organizations, among others.

The Chilean FOP case study illustrates the need to anticipate and develop strategies that address the difficulties that are likely to be found when countries try to launch food label legislation. These include having sound policy research and a strategy to negotiate with the forces that try to prevent policy adoption. In Chile, public health researchers and evidence-based civil society advocacy coupled with strong political will were key to passing FOP legislation.

Table 2 Chile's definition of high-energy food or beverages

For food label legislation purposes, Chile defined high-energy foods or beverages as those exceeding 275 kcal/100 g of solid food or 70 kcal/100 mL of beverage. The corresponding cut-off points identify solid foods or beverages that are high in

- added sugar as 10 g/100 g for solids or 5 g/100 mL for beverages;
- saturated fat as 4 g/100 g for solids or 3 g/100 mL for beverages; and
- sodium as 400 mg/100 g for solids or 100 mg/100 mL of beverages.

Likewise, the local agencies from the MOH were instrumental for implementing the federal law.

Ecuador

To alert consumers about levels of fat, sugars and salt in packaged food items, Ecuador became the first country in Latin America to mandate a label in the form of a traffic light (52). The law was motivated by data from a national nutrition survey, conducted in 2011 and 2012, which showed that 30% of children 5 to 11 years of age and 26% of adolescents 12 to 19 years of age were overweight or obese (53). Likewise, 41 and 22% of adults 19 to 59 years of age were overweight or obese, respectively. Ultra-processed foods with excessive levels of added sugars, sodium and saturated fats are ubiquitous in Ecuador (54).

A regulation of the Ministry of Public Health published in November 2013 (55) requires packaged foods to carry a 'traffic light' label in which the levels of total fats, sugars and salt (sodium) are indicated by red (high), yellow (medium) or green (low). The cut-off values for these nutrients and respective colours are described in Table 3.

The objective of the Ministerial decree is to regulate and control the labelling of packaged foods and provide interpretative labels that are clear, precise and non-deceptive and permit the consumer to select foods with a clear understanding of their nutritional content. Consistent with recommendations from a report from the US National Academy of Medicine (formerly the Institute of Medicine) (56), the draft decree stipulated that the label had to be placed on the front of the package; however, the decree which was approved did not carry this stipulation as a result of strong lobbying from the food industry. The regulation applies to all packaged foods and drinks. Large companies were given 6 months (until August 29, 2014), and small companies were given 1 year (until November 29, 2014) to fully comply with the regulation. Although it is too soon to assess the impact of the regulation on purchasing patterns, an evaluation to assess the impact of the regulation is in process.

The MOH and Government of Ecuador demonstrated strong political will to enact the regulation, given opposition by the food industry. Pan American Health Organization (PAHO) also provided political support to Ecuador's efforts; its director participated in a high-level meeting to launch the regulation, which resulted in widespread media attention.

Unlike the tax on SSB and energy-dense foods in Mexico and Chile's National Law of Food Labelling and Advertising, Ecuador's labelling decree was developed and implemented with very little civil society engagement. The leadership was entirely provided by the MOH and academia with support from PAHO. This perhaps explains why in Ecuador the policy ended up being enacted as an MOH regulation and not as a federal law as in the case of Chile.

Trans fatty acids – Argentina

Consumption of industrial TFAs has a significant harmful effect on cardiovascular health; an increase of 2% in energy intake from TFAs may increase the risk for a coronary event by up to 23% (57). In Argentina, CHD is the leading cause of mortality, representing about 10% of total deaths (58).

Legislative strategies to ban TFA from foods have been more successful than labelling or education as shown in some developed countries like Denmark, Iceland, Sweden, Austria, Switzerland and the United States (specifically, New York State) (59–62). In Denmark, the ban on TFA is thought to partially explain the decrease of CHD (63). Although removal of TFAs from the food supply has been identified by the WHO as a 'best-buy' public health intervention for low- and middle-income countries (7), many countries in Latin America have not yet included the removal of TFAs as a global monitoring target because of concerns about the feasibility, achievability and public health effect of removing them from the food supply. Although research on TFA intake during childhood is still limited (6,64), dietary risk factors track from childhood to adulthood (5) so modifying those factors early in life is expected to prevent CHD later on (6). Policies that require removing industrial TFAs and replacing them with polyunsaturated fats exist in Argentina, Chile, Brazil, Costa Rica, India and Mexico (65,66). This case study describes the role of evidence in the decision to significantly reduce TFAs from the food supply in Argentina, a policy that is likely to improve the cardiovascular health of children and adults alike.

Table 3 Cut-off values for total fats, sugars and salt (sodium) in Ecuador's traffic light label (55)

	Low concentration (green)	Medium concentration (yellow)	High concentration (red)
Total fats	≤3 g/100 g	>3 and <20 g/100 g	≥20 g in 100 g
	≤3 1.5 g/100 mL	>1.5 and <10 g/100 mL	≥10 g in 100 mL
Sugars	≤3 5 g/100 g	>5 and <15 g/100 g	≥15 g in 100 g
	< 2.5 g/100 mL	>2.5 and <7.5 g/100 mL	≥7.5 g in 100 mL
Salt (sodium)	≤3120 mg sodium/100 g	>120 and <600 mg sodium/100 g	≥600 mg sodium/100 g
	≤3120 mg sodium/100 mL	>120 and <600 mg sodium/100 mL	≥600 mg sodium/100 mL

The story of TFA policies in Argentina started at the beginning of this century when an academic champion in the fight against industrial TFA, Dr. Marcelo Tavella, launched a demonstration program involving the replacement of TFAs in processed foods (DEMOBAL), in a small city in the province of Buenos Aires (67). At that time, and as part of the baseline food consumption evaluation, the lipid composition of commonly consumed foods was analysed (68) and intake data validated through the analysis of fatty acids of adipose tissue samples (69). Almost all of the processed foods analysed that were sweet or salty, such as cookies and crackers, contained high levels of TFAs. Nearly all cookies, of which Argentina is a major consumer, contained elaidic acid and even apparently healthy choices, such as cereal bars, contained partially hydrogenated vegetable oil (70).

As stated above a lipid composition analysis found that almost all foods commonly consumed in Argentina contained high levels of TFAs, especially sweet or salty solid snack foods, such as cookies, crackers and cereal bars (68). Based on this evidence, the Argentinean MOH began to consider curbing TFA consumption. In Argentina, oils and fats are produced by a handful of large companies, facilitating the government's ability to start a policy dialogue with the key industry stakeholders. In 2004, the government took a first step towards reducing consumption by initiating voluntary food product reformulation program by the food industry. As a result, 70% of the country's food manufacturing companies reduced TFA content in processed foods (67). In the second phase, in 2008, the government initiated mandatory regulations that specify that TFAs in foods should not exceed 2% of total fats in vegetable oils and margarines for direct consumption and 5% of total fats in other foods. Full compliance was mandated by December 2014 (71,72). Since 2015, the National Food Institute of the MOH has been responsible for the surveillance and enforcement of industry compliance with these regulations.

To evaluate this policy, a modelling study was conducted to estimate its health and economic impact after the regulation was fully developed (73). Based on a baseline TFA intake of 1.5% of total energy, it was estimated that the regulation may be able to prevent from 301 to 1,517 deaths, 1,066 to 5,237 fatal and non-fatal CHD events, and 5,237 to 26,394 Disability Adjusted Life Years (DALYs) per year. The model also predicted that these health benefits could be translated into annual savings ranging from 17 to 90 million USD indirect health costs (73).

While this policy development in Argentina is encouraging, most countries in Latin America lag behind in removing the TFAs from their food supply due to concerns about feasibility, achievability and public health effects. Given how recently the regulation was enacted, the actual impact of the TFA regulation on intake in Argentina remains to be determined. However, the successful process followed in the development of this TFA regulation along with the benefits demonstrated through the modelling estimate may help to inform policymakers across Latin America on the development of additional food reformulation policies that can help childhood obesity.

Ciclovías – Latin America

Ciclovías Recreativas (*Ciclovías*) or 'Open Streets' programs temporarily close streets to motorized traffic to transform them into a safe, people-oriented pleasant space for leisure biking, walking, jogging, participating in social, health promotion and cultural events, or simply meeting people (74). Studies of the *Ciclovía* programs conducted in Bogotá and the United States show that users are more likely to meet physical activity guidelines and report higher quality of life, while neighbourhood social capital increases as people replace cars on the streets, and air and noise pollution decrease (75). A cost–benefit study estimated that each dollar invested in Bogota's *Ciclovía* saves $3 USD per person in health care costs, amounting to $13 million USD per year (74). The same study also reported saving the city of Medellin almost $2 million USD annually.

Because of the documented success of *Ciclovías* in Bogota, the initiative has since spread to 461 cities in Latin America (Fig. 1) (76). This phenomenon has been explained as a popular reaction to car-centred urban development and resulting poor quality of life driven by air pollution, stress, lack of public safety and physical inactivity. *Ciclovías* provide a well-deserved respite from these urban maladies and likely contribute to a collective consciousness of healthy physical built environments (77). Although the benefits of *Ciclovías* are diverse and complex, physical activity is the benefit that has received the most attention and scrutiny by public health professionals. The successful spread of *Ciclovías* is due to their popularity among the public at large based on the strong perception that they improve quality of life, resulting in strong political support from city mayors, and scientific advances in understanding the relationship between urban planning and public health (78,79). It is clear that the way *Ciclovías* have been designed has been different across cities according to urban design and political considerations (78–80). The introduction of *Ciclovías* has been met with some resistance from businesses and other sectors including transportation enterprises that were affected by the road closures (78–80). These challenges have been overcome in most instances with strong participation from civil society, highlighting new economic development opportunities for small business owners, and by having evidence-based recommended practices for deploying *Ciclovías* (78,79).

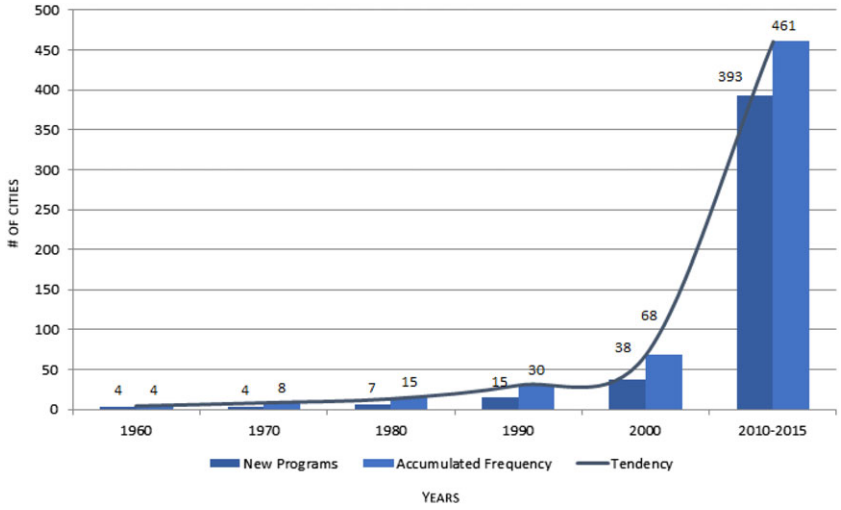

Figure 1 Exponential growth of Ciclovias across time in Latin American cities. Courtesy of Dr. Olga Sarmiento.

Complex Adaptive Health Systems analysis across case studies: Lessons learned

Below, we use the CAS framework to understand the key elements of success and sustainability across the case studies. The qualitative findings discussed below are organized by CAS element and can be used to inform the role of research in future policy interventions.

Feedback loops

Feedback loops occur when an output within the system is fed back as an input into the same system. These feedback loops can be either positive, when aspects drive the changes forward, or negative, when forces oppose approval, implementation or continuation of a policy. Understanding these loops is important for identifying the relationship between various components and how they impact the final outcome. The case study analysis found multiple positive and negative feedback loops (Table 4).

This analysis highlights the positive role that research and evidence play in supporting public health policy development and implementation. This, along with other positive components, such as informed advocates, public outreach and a broad range of supporters, all contributed to the policy reforms. Outside interest groups, misunderstood definitions and negative perceptions hindered the policy development. Future efforts to enact similar childhood obesity prevention policies should consider these facilitating or obstructing forces and foster or address them early on in the policy development.

Table 4 CAS feedback loops

Prominent positive feedback loops:

1. Research and evidence highlighting the need for the policy intervention by outlining obesity trends,[1,2,3,4] assessing food composition,[4] and potential health and economic consequences of enacting policies;[1,4]
2. Political support resulting from the potential generation of government revenue by policy,[1] the belief that access to healthy lifestyles is a constitutional right[2,3] and/or strong popular demand for action;[5]
3. Champions from academia,[1,2,4] government[1,2,3] and civil society organizations[1,2,5] promoted science-based advocacy by translating scientific findings to policymakers and the public;[1]
4. Positive public perception that policy could benefit the population's quality of life;[1,5]
5. Positive prior international experience with policy;[4,5]
6. Positive support from philanthropic[1] and international agencies including PAHO;[4] and
7. Evidence documenting positive impact of policy on healthy lifestyles,[1,5] cost-effectiveness[4,5] or inclusion of a monitoring and evaluation plan of the policy from inception.[2,4]

Notable negative feedback loops:

1. Technical difficulties involving defining 'junk food,' 'ultra processed food' or 'unhealthy foods';[2]
2. Lobbying from entities opposed to the policy changes, such as the food industry;[1,2,3]
3. Interest groups playing to fears of the public of and loss of economic opportunities;[5]
4. Perception from government of high regulatory burden for policy implementation;[2,5] and
5. Lack of funding for policy monitoring and evaluation activities.

1. SSB tax in Mexico; 2. Food labelling in Chile; 3. Food labelling in Ecuador; 4. Trans Fatty Acids in Argentina; 5. Ciclovías throughout Latin America

Scale free networks

When a change in one component of a process results in a relative change in many others, it is considered part of a scale free network. Understanding these networks can help identify how social norms are transformed or new health practices are adopted (10). With respect to the Mexican SSB tax, effective marketing campaigns utilized research findings to alert the general public about the alarming obesity trends and the economic and health benefits of a SSB tax. These campaigns successfully shifted public opinion towards supporting the introduction and sustainability of the policy. Strong popular demand and evidence of successful implementation in other countries or cities helped the rapid dissemination of both the TFAs removal in Argentina and *Ciclovías* throughout Latin America. The initial influences, in this case strong evidence, the marketing campaign and a plan for overcoming expected challenges had a large impact on the support the policies ultimately received. Identifying and addressing these kinds of influences are an important way to reach populations affected by the policy.

Phase transitions

All the case studies went through a phase transition when definable events and processes led to a tipping point that allowed for policy approval or expansion of implementation. The process to reaching this point can be rapid, such as when Ecuador enacted the traffic light FOP, or gradual, such as the slow scale-up of *Ciclovías* across Latin America where it took over three decades to reach the tipping point for rapid dissemination. For the SSB tax, evidence, especially that derived from cost-effectiveness studies, together with strong advocacy and persuasive evidence of the feasibility of policy implementation, played key roles in facilitating the process leading to the tipping point. Highly iterative, multisectoral coalitions have also played a part in reaching the tipping point of adopting an obesity prevention policies. Particularly, as policy interventions are first introduced, it is useful to identify the factors, including evidence and coalition outreach, that will help lead it to adoption and implementation.

Path dependence

Processes that have similar starting points may end up following different implementation pathways and processes; path dependence explains what characteristics influenced those divergent outcomes. The Chilean government introduced obesity prevention interventions in 1998, 2007 and 2012. While each of these proposals was a direct response to the increasing rates of obesity initiated by policymakers, the 2012 proposal was successful in part because of the groundwork laid by research, government and civil society leaders. This group reviewed the evidence to create nutrition profiles and define unhealthy foods and made compromises with stakeholders opposed to the regulations. By contrast the strong political support from the Ecuadorian government and PAHO allowed the MOH to overcome opposition forces when enacting the FOP traffic light regulation. In countries where this is not the case, the path to implementing a similar regulation may be different. Anticipating the factors that will support or divert policy adoption presents advocates with the opportunity to gather evidence and present solutions in advance.

Emergent behaviour

Emergent behaviour happens when smaller entities spontaneously come together as a collective, is usually self-organized, following an iterative process. Almost all of the policies were successfully deployed and implemented following multiple consultations with members of academia, government, advocacy groups and civil society who eventually formed a coalition. Each of these stakeholders brought a different skill set and knowledge base that allowed the coalition to adapt to opposition and encourage public support. For example, with respect to the Mexican SSB tax, researchers supplied evidence and cost-effectiveness analyses that civil society used to sway public opinion through mass media campaigns and that advocates used in lobbying congressmen. This required overcoming major negative feedback loops mostly driven by the food industry. Like most emergent behaviour, the formation process of the coalitions was unique in each case study and therefore hard to transfer to other policy interventions. However, their value to the policies' adoption is undeniable, and there are opportunities to assess lessons learned that may be helpful for future coalition building.

Conclusions

The analysis of the childhood obesity prevention policy case studies demonstrates how evidence-based advocacy, with strong involvement from a variety of stakeholders and skillful negotiations across key actors (including government and the private sector), overcame strong opposition. The CAS analysis also demonstrates the role that evidence plays in supporting policy development, garnering support from both the public and policymakers and proving the effectiveness of the policy after it goes into effect. It also emphasizes the need for leaders and champions to support obesity prevention policies through evidence-based advocacy. The collaborations between academics, policymakers and advocates not only translated research findings for a variety of audiences and identified and overcame potential barriers, they ensured that the policies are evidence-based and directed researchers towards policy-relevant questions.

Table 5 Research recommendation for understanding successful development, implementation and sustainability of anti-obesity policies in Latin America through a Complex Adaptive Systems framework.

• Document the positive and negative feedback loops that emerge once a decision is made to put a policy into place. Place strong emphasis on understanding how highly influential evidence-informed advocacy develops.
• Document the specific processes and strategies by which negative feedback loops are overcome to successfully deploy policy on a large scale.
• Understand the processes and strategies for successful inter-sectoral coordination during policy development and policy implementation phases.
• Identify the lag time and its associated factors in different contexts between implementation and initial detection of healthy lifestyles benefits as a result of policy implementation.
• Apply social networking theory and algorithms to understand the 'contagion' of healthy lifestyles behaviours within and between countries as a result of policy implementation.
• Develop system thinking models and policy tool boxes that can help decision makers to be successful with their anti-obesity policy development and implementation efforts in Latin America.
• Conduct causal thinking multi-level process evaluations to understand the flow of activities and the processes interconnecting their underlying effective policies.
• Conduct cost analyses to understand how much it costs to develop, implement, monitor and sustain effective anti-obesity policies in Latin America.

Research recommendations

Research plays a vital role in both supporting and enacting the policies and in assessing its impact after adoption. A research framework based on CAS principles can be used to prospectively document the prevalence of obesity and physical activity, the evidence for the policy intervention's design and the opposing forces that target healthy nutrition and physical activity behaviours. Once the policies are implemented, research is needed to further understand the systems thinking activities and processes needed for effective implementation and sustainability and evaluate the process and impact of the policies. Sufficient resources to monitor obesity and physical activity trends, generate policy-relevant evidence and evaluate policy outcomes need to be made available. Unfortunately, such resources are often lacking in government budgets.

As the case studies highlight, creating interventions, ideally based on strong evidence, and then translating them into concrete sustainable actions represent another set of challenges. Implementation science can address this gap by understanding existing barriers, identifying effective implementation methods and assessing how best to scale what works. This research can include CAS principles, such as negative and positive feedback loops and phase transitions, that can identify areas of focus for the research. It is particularly important that countries examine lessons learned from across the region and consider how to adapt them to their own contexts. These research perspectives can help countries to soon reach the tipping point that would allow them to successfully implement nutrition and physical activity policies on a large scale (Table 5).

The experience in Latin America of implementing major obesity prevention policies based on SSB taxes, food labelling, TFA regulation leading to product reformulation and physical activity in open spaces has the potential to benefit the rest of the world. Research on the short-term and long-term impact of these policies is needed before they can be disseminated to other countries (37). Indeed, the Latin American experience with anti-obesity policies based on changing the obesogenic environment and promoting healthy lifestyles is already informing similar actions worldwide. Funding the research that supports policy development and assesses policy impact will go a long way to ensuring that these successful childhood obesity prevention efforts continue.

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