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Impact of a school-based intervention program on obesity risk factors in Mexican children*

Margarita Safdie, PhD,^(1,2) Nancy Jennings-Aburto, PhD,⁽¹⁾ Lucie Lévesque, PhD,⁽²⁾ Ian Janssen, PhD,⁽²⁾ Fabricio Campirano-Núñez, MS,⁽¹⁾ Nancy López-Olmedo, MS,⁽¹⁾ Tania Aburto, BS,⁽¹⁾ Juan A Rivera, PhD.⁽¹⁾

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Abstract

Objective. To evaluate the impact of an 18-month school obesity prevention intervention on the health behaviors of 4th and 5th grade students based on ecological principles and formative research conducted in Mexico. **Materials and methods.** A Randomized Control Trial (RCT), design was used to assign 27 schools to one of three conditions: basic or plus interventions and control. School environment measures, children's eating and physical activity behaviors, and body mass index were assessed four times over a 2-year period in a sample of 830 students. **Results.** In the intervention schools, the availability of healthy foods increased with a concomitant decrease in unhealthy food availability. Food intake showed the same trend. In the intervention schools, children did not engage in more moderate to vigorous physical activity (MVPA) in physical education (PE) class or recess but increased steps taken. Obesity prevalence did not change. **Conclusion.** The intervention improved the school food environment and child healthy behaviors.

Key words: obesity /prevention; nutrition; physical activity; evaluation of the effectiveness of interventions; child nutrition; Mexico

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Resumen

Objetivo. Evaluar el impacto de una intervención de 18 meses para la prevención de obesidad en escolares de 4° y 5° grados basada en el modelo ecológico en conductas saludables en México. **Material y métodos.** Diseño experimental para asignar 27 escuelas a uno de los tres tratamientos: intervenciones básicas, intervenciones plus y control. Se midió el impacto en el ambiente escolar, la alimentación y la actividad física e índice de masa corporal en niños. La evaluación se llevó a cabo en dos años en 830 estudiantes. **Resultados.** En las escuelas de intervención, la disponibilidad de alimentos sanos aumentó y la disponibilidad de alimentos poco saludables disminuyó. La ingesta de alimentos en niños no mostraron las mismas tendencias. En las escuelas de intervención, los niños no participaron más en actividad física moderada y vigorosa. La prevalencia de obesidad no se modificó. **Conclusión.** La intervención mejoró el entorno alimentario escolar y las conductas saludables de alimentación y actividad física.

Palabras clave: obesidad/prevenición; nutrición; actividad física; evaluación de la efectividad de la intervención; nutrición infantil; México

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(1) Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública. Cuernavaca, Morelos, México.

(2) School of Kinesiology and Health Studies, Queen's University. Ontario, Canada.

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Corresponding author: Dr. Juan A Rivera. Centro de Investigaciones en Nutrición y Salud, Instituto Nacional de Salud Pública. Av. Universidad 655, Col. Santa María Ahuacatitlán. 62100 Cuernavaca Morelos, México.

E-mail: jrivera@insp.mx

Schools are ideal settings for delivering health promotion services and strategies because they provide access to a large number of children in a contained environment.¹ Schools can contribute to obesity prevention by offering an optimal environment and opportunities for healthy behaviors.^{2,3}

The global childhood obesity epidemic has created a situation wherein the current generation of children may live shorter and less healthy lives than their parents.^{4,5} In Mexico, the prevalence of overweight and obesity in children increased from 18.4% in 1999, to 26.2% in 2006, to 30.3% in 2008.⁶⁻⁸ Because Mexican children spend approximately 22 hours per week in school for 10 months of the year, the school environment has likely contributed to the increase in these conditions, which is consistent with evidence showing that the environment of elementary schools in Mexico promotes energy-dense food and sugar sweetened beverage (SSB) intake and restricts opportunities for physical activity (PA).⁹⁻¹³

The World Health Organization (WHO) recommends multifactor, multilevel intervention approaches to prevent obesity in the population, including school-aged children. Such interventions should include strategies to enhance both healthy eating and PA and should be based on theories and models that consider psychosocial and environmental influences on behavior.^{2,3}

Since obesity is the result of sustained positive energy balance, which is the consequence of higher energy intake relative to energy expenditure in multiple settings and environments where children live, it is not surprising that few interventions reported in the literature have been successful at impacting BMI in participating children.¹³⁻¹⁹ This is likely because many of these interventions were exclusively implemented in the school environment, where children spend only part of their time, and did not influence energy intake and expenditure in other settings. Moreover, BMI is limited in terms of its sensitivity to capture changes in adiposity in children.

Despite their limited potential to impact BMI, school interventions have demonstrated effects on behaviors that lead to energy balance (PA and healthy eating) especially when parents are also engaged through the school.¹⁵ Programs that complement PA and healthy eating intervention activities at school with healthy lifestyle education to children and parents have been found to be successful in positively impacting PA and healthy eating behaviors.^{16,19}

Few studies have examined the impact of multifactor, multilevel, school-based interventions in developing countries such as Mexico and the evidence from these studies is weak and inconsistent.^{17,18,20,21} More data are thus needed on the effectiveness of ecologically-driven school-based interventions for the improvement of health

behaviors and conditions in developing countries.^{20,22} Thus, the National Institute of Public Health in Mexico (*Instituto Nacional de Salud Pública*, INSP) launched a comprehensive study to evaluate the effectiveness of an ecologically-based program aimed at promoting healthy eating and physical activity in selected Mexico-City schools to optimize to overall energy balance in childhood as a strategy for obesity prevention.

Materials and methods

The Research, Ethics and Biosecurity Commissions of the INSP reviewed and approved the study protocol. Parents provided written informed consent allowing their children to participate in the study. In addition, children were asked to provide oral assent to participate. The intervention and research were carried out over the 2006-07 and 2007-08 school years.

School recruitment: Only public elementary schools meeting the following criteria were considered for study inclusion: 1) located in the south of Mexico City; 2) classified by the Ministry of Education (*Secretaría de Educación Pública*, SEP) as having students of low socioeconomic status; 3) receiving benefits from the Federal School Breakfast Program (*Programa Federal de Desayunos Escolares*, PFDE) served at schools; 4) possessing the minimum facilities necessary for intervention implementation; 5) possessing the standard SEP-issued set of sports equipment; 6) having an enrollment of at least 350 students; 7) having two or more classrooms per grade; and 8) being a part-time school (i.e., 4.5 hrs/day). Of a preliminary list of 1 283 schools located in the urban area of Mexico City, provided by the Federal Administration of Educational Services (*Administración Federal de Servicios Educativos del Distrito Federal*, AFSEDF), 274 schools located in the four "delegaciones" (administrative zones that comprise Mexico City) of interest (Xochimilco, Tlalpan, Magdalena Contreras and Coyoacán) were identified. From the schools located in the delegaciones, 84 schools partially met the inclusion criteria (i.e. were not in the correct *delegación*, were not considered urban or didn't have facilities for the implementation), and the school list shrank to 40 eligible schools. From the 40 eligible schools that met the inclusion criteria and agreed to participate in the study by committing to accomplish the study needs (i.e. change food and PA school environment, permit evaluation and implementation activities during school day), 27 schools were randomly selected and assigned to one of three conditions: Basic intervention (n=8), Plus intervention (n=8) and Control (n=11). Thus, intervention strategies were implemented in 16 school intervention schools and were targeted to children in

4th and 5th grades in the first year and 5th and 6th grades in the second year.

Student recruitment: A total of 886 students from 4th and 5th grades (approximately 32 students per school) from these 27 schools were randomly selected for outcome evaluation from 1 712 students who agreed to participate and whose parents had provided informed consent; the refusal rate was lower than 20%. A flow chart of the sample from recruitment to the end of the 18-month intervention period is shown in figure 1.

Context of the study

In order to understand the intervention program logic, it is important to understand the context and dynamics of food availability in the Mexican school system. The overall context of the schools has been described in the methods paper.²³ In brief, the children enrolled in the public Mexican schools system attend school for only 4.5 hours a day, either during a morning or afternoon shift; our study was conducted during the school morning shift. Schools have no cafeteria facilities and only few schools have a canteen. Food availability in schools mostly depends on external food vendors who are chosen by school authorities, based on hygienic standards, to sell foods to students during recess. The intent is to provide students with snack options rather than a full meal, given that children have breakfast and lunch at home and many are beneficiaries of the PFDE.

In regards to the PA environment at schools we identify that there were no opportunities to engage in PA at schools but the weekly 50-minute PE class through the physical education program (PEP). However, the PEP in schools had several shortcomings that limited the quality and the quantity PE classes; these include lack of incentives to motivate physical education teachers, shortage of materials, a lack of appropriate areas for delivering PE classes, and PE class structure that delivers only 9 to 11 minutes of moderate to vigorous physical activity (MVPA).⁹

Intervention description

Intervention content was informed by formative research findings showing that the school setting promotes the intake of unhealthy food and beverages (energy dense foods and SSB, has limited access to vegetables, fruits and water, offers several opportunities to eat and drink throughout the school period, and does not offer enough opportunities for physical activity.^{11,12} Taken together with recommendations from the literature,²¹ ecological principles,²⁴ the theory of planned behavior (TPB),²⁵ social cognitive theory (SCT),²⁶ health belief

model (HBM)²⁷ and formative research findings² were used to guide the development of two program intensities: basic and plus.

The basic program focused on improving norms related to nutrition and physical activity at the schools and was limited to using existing school infrastructure and resources. The plus program implemented all the components incorporated in the basic program and included additional financial investment and human resources. No changes were made to existing nutrition or physical activity practices in control schools.

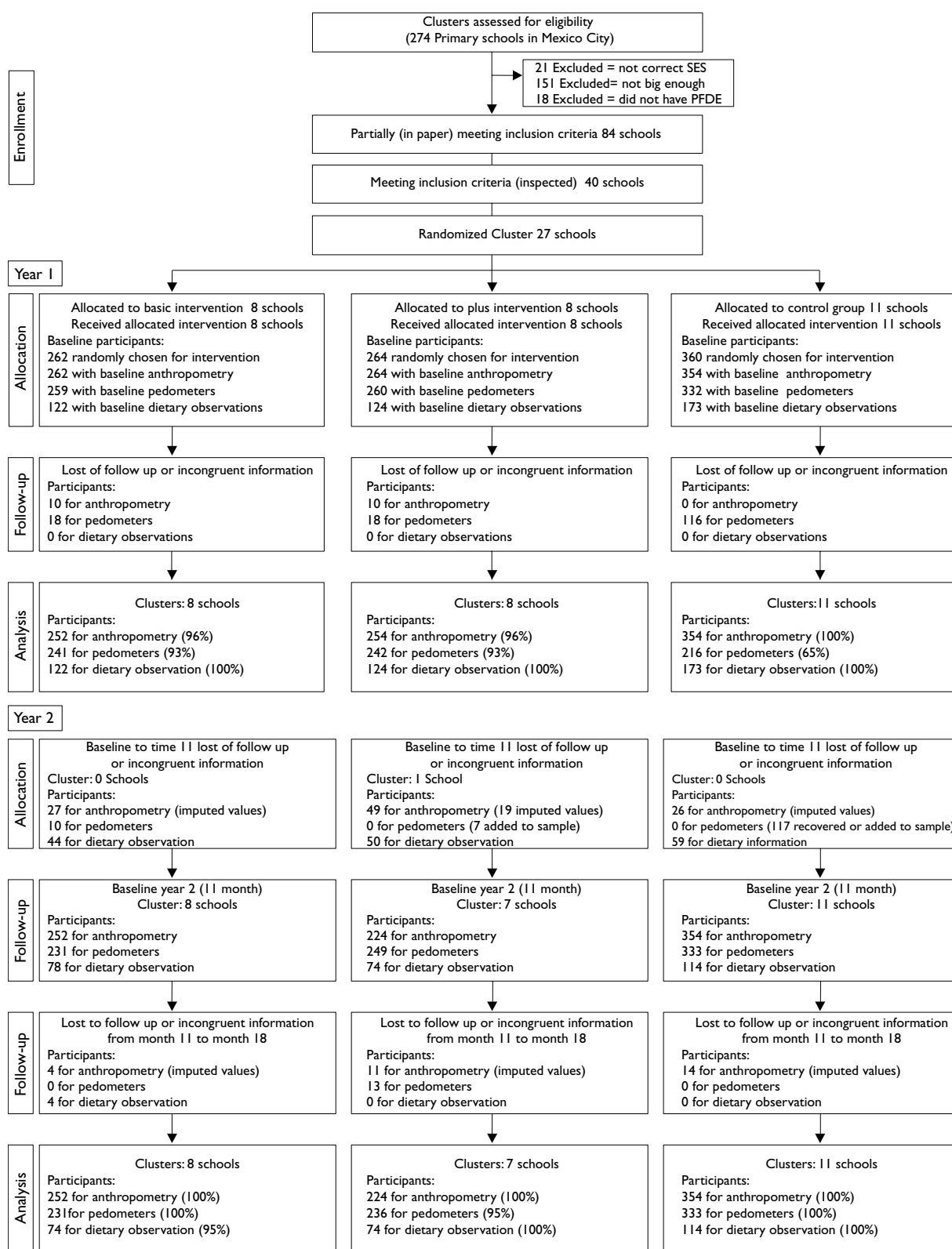
Implementation of both program intensities depended largely on the willingness of principals, teachers and school staff. The aim of the nutrition intervention component was to improve the prevailing food environment by increasing availability of healthy food (fruits, vegetables, and non-fried dishes) and beverages (particularly water), by reducing the availability of energy-dense foods and SSB, and reducing the number of eating opportunities during the school day. The aim of the PA intervention component was to enhance the prevailing physical activity environment by increasing the availability of physical activity resources, by improving infrastructure and enhancing aesthetics. In plus schools only, specialized PE teachers were hired to teach one additional PE class per week for 4th and 5th grade students and to offer 15 to 20 minutes of moderate physical activity (calisthenics) referred to as "activation period" after the morning civics ceremony four days of each week.

Nutrition and PA interventions were supported by a communication/educational component based on SCT,²⁶ TPB²⁵ and HBM²⁷ to increase student and school staff awareness of program activities and to develop positive attitudes towards physical activity and healthy eating at schools.

In the second intervention year the same activities were repeated in both the basic and plus schools with the addition of the morning activation periods in the basic schools. Detailed intervention components are summarized in table I.

Intervention implementation

This project was a collaborative effort between the INSP, the AFSEDF, and the Physical Education General Direction (*Dirección General de Educación Física*, DGEF). A team of 12 INSP implementers (two per school) was assigned to visit each intervention school equally (2/3 per week) to make sure implementation was carried out properly by school staff. Compliance with the intervention activities was assessed through a comprehensive weekly observational monitoring system, which identified the degree of adherence to each strategy.



PFDE: Programa Federal de Desayunos Escolares, Federal School Breakfast Program

FIGURE 1. CONSORT DIAGRAM OF IMPACT OF A SCHOOL-BASED INTERVENTION PROGRAM ON OBESITY RISK FACTORS IN MEXICAN CHILDREN

Table I
DESCRIPTION OF INTERVENTION IMPLEMENTED BY TYPE OF PROGRAM, TARGET GROUP AND SCHOOL YEAR

	Year 1				Year 2			
	Intervention		Target group		Intervention		Target group	
	Basic	Plus	Schools	Personnel	Basic	Plus	Schools	Personnel
Nutrition								
Promotion to increase the availability of healthier food choices	X	X	X		X	X	X	
Promotion to reduce the availability of candy and sweets					X	X	X	
Promotion to modify culinary techniques and ingredients of preparations sold during recess	X	X	X	V, SA	X	X	X	V, SA
Ensure water availability	X	X		SC	X	X		SC
Limit the availability of sugared beverages in the school					X	X	X	
Promotion of a Fruit and Vegetable Day		X	X					
Limit the sale of certain densely energetic foods		X	X		X	X	X	
Reduce exposure to eating opportunities	X			SC	X	X		SC
Prohibition of eating during lesson time and limit school breakfast time to 20 minutes					X	X		5 th and 6 th
Physical activity								
Promotion of PA during recess and free time: Using an activity box	X	X		S				
Improve the quality of PE: One lesson 50 minutes/week	X			4 th and 5 th	X			5 th and 6 th
Improve the school premises and provide sports equipment.	X	X	X		X	X	X	
Organized activation: 15 to 20 minutes of activation to all children from Tuesday to Friday.		X	X	SC		X	X	SC
Improve quantity and quality of the PE class and MVPA time to 100 minutes/week.		X		4 th and 5 th		X		5 th and 6 th
Communication and education								
Supportive resources such as pamphlets for PE teachers were provided to improve the quality of PE classes.	X			PET				
Supportive resources such as workshops were provided to PE teachers to improve the quality of PE classes		X		PET	X	X		PET
Distribution of booklets: How to prepare a healthy lunch (for parents). Booklets for vendors on how to improve culinary techniques and sell healthy food	X			P,V				
Educational and skills-based workshops with vendors aimed to teach the use of healthier culinary techniques and the preparation of healthier food		X		V		X		V
School authorities sensitizing on healthy lifestyles and the benefits of healthy eating and PA (workshop)					X	X		SA
Educational and skills-based workshops with children aimed to achieve energy balance at school, promote fruit and vegetable intake and teach how to pack a healthy lunch		X		4 th and 5 th	X	X		5 th and 6 th
Mass communication and marketing strategy targeted to children to promote four basic behaviors, through messages and concepts: Fruit and vegetable consumption, water consumption, engage in PA and pack a healthy lunch.	X	X	X	4 th and 5 th	X	X	X	SC

PE: Physical education

PA: Physical activity

MVPA: Moderate to vigorous physical activity

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Measurement of study outcomes

Measurements were obtained over approximately seven weeks each time at the beginning (baseline) and end (seven months) of the 2006-07 school year and at the beginning (11 months) and end (18 months) of the 2007-08 school year. Measures were either developed or adapted for this study; all measures were pilot tested in 9 to 11 year-old children from public schools in Mexico City.²⁸ This paper reports on the impact of the intervention on the environment (food and beverage availability and physical activity opportunities) and student health behaviors at school (food intake and number of steps taken). We also examined changes in obesity prevalence.

Food and beverage availability at school: This information was assessed using food inventories, which determined the quantity and quality of food and beverages at schools' during recess time. The food and beverage inventories were completed at each school by trained nutritionists during the data collection phase. Foods were classified into one of the following three categories: highly recommended foods (fresh fruits and vegetables, boiled corn with lemon, non fried low-fat tacos (beans, mushroom, nopales and sorbets). Foods recommended for consumption no more than two times a week (non-fried tacos, meat, potatoes with sausage, chili pepper with cream), ham sandwich, popcorn, rice with milk "arroz con leche", salted peanuts); and non-recommended foods (candies, ice cream, fried foods, pizzas, hot dogs, doughnuts, milk based gelatin desserts, cookies, SSB). For each school, the overall availability for each of these categories of food and beverages was calculated by adding the total number of available portions of a given food and dividing by the total number of portions sold.

Potable drinking water availability in schools was assessed by direct observations (i.e., counting water containers) and reporting the number of liters available within each 4th, 5th, and 6th (only for the second year) classrooms at school.

Food intake at recess: A direct observation protocol complemented by a close-ended survey was used to assess child food intake and purchasing patterns²⁸ in a subsample of 8 children per school (4 per grade; n=216 across 27 schools). Field personnel were trained to observe and record the foods and beverages consumed by the children at recess, including estimated quantities. Overall intake was expressed according to above-described food categories for changes across time (i.e., baseline to 7, 11, and 18 months) within intervention

groups (i.e. basic, plus, and control) and expressed in percent of change relative to baseline.

Physical activity opportunities during PE classes and recess: Trained observers assessed the quality of PE lessons by recording students' levels of physical activity using SOFIT (System for Observing Fitness Instruction Time) a standardized direct observation instrument. This methodology has been described elsewhere.²⁹ Briefly, the observers recorded the intensity of physical activity and class context using a time-sampling system of 10-second intervals. Observers coded intensity of physical activity as: 1) lying, 2) sitting, 3) standing, 4) walking, or 5) more active (e.g., requiring more energy than ordinary walking). In addition to PE classes, PA during recess time was also assessed using an adapted version of SOFIT described elsewhere.⁹ One PE class and one recess were observed at each school.^{9, 29} Time spent in MVPA during PE classes and recess at school was obtained by adding the time spent in the two most intense categories of the SOFIT (walking and more active).

Children's physical activity (steps taken) at school. Steps were measured by NL-1000 pedometers.³⁰ Participants wore the pedometers for five consecutive days starting on Monday morning upon arrival at school. Each pedometer was programmed to restart every day at 08:00 hours when the school day began. Based on our baseline data⁹ we estimate that this total represents approximately 30% of total daily physical activity. We thus created a cut-off for steps accumulated during the school day at 30% of the all-day cut-off proposed by Tudor-Locke and colleagues,³¹ which equated to 3 600 steps for girls and 4 500 steps for boys. We then calculated the percentage of participants who reached these cutoffs during school hours at each data collection period and categorized participants as: 1) improved (i.e., participants who improved progressing from not reaching to reaching cutoffs); 2) declined (i.e., participants who regressed from reaching to not reaching cut offs); and 3) stagnant (i.e., participants who neither improved nor declined). These measurements have been reported previously and were sufficiently sensitive to detect differences in intervention groups after the first year of intervention.³²

Overweight and obesity: Body mass index (BMI) was calculated as weight (kg) / height (m²). Height was measured to the nearest 1 mm using a Dynatop stadiometer and weight was measured to the nearest 0.1 kg using a portable electronic scale (Tanita).³³ The age- and sex-specific International Obesity Task Force (IOM) BMI cut-points were used to classify participants as non-overweight or overweight/obese.³⁴

Statistical analyses

Sample sizes

Environmental outcomes were measured at the school level, while behavioral outcomes and BMI were measured at the individual level.

Sample size calculation was based on the 40% prevalence of overweight and obesity observed during previous formative evaluation phase in Mexico City schools, and the expected change between groups. Thus, sample size required to detect a 10% difference between groups was calculated to attain a power of 0.8 and a type I error (α) <0.05 (two-tailed), using an intra-class correlation coefficient (ICC) of 0.08.³⁵ This calculation yielded a minimum sample size of eight schools, in each of the two intervention groups (described below) and eight schools in the control group, with 240 children per group for anthropometric measurements. The number of children selected to assess opportunities to engage in moderate to vigorous physical activity in physical education classes and recess, and the number of children selected for the evaluation of food intake were based on the largest possible number given logistic and financial restrictions of direct observation methodologies. Given that we had additional funding for evaluation three schools were added to the control group. The consort diagram and sample sizes obtained for the different outcomes are shown in figure 1.

Data Analysis. The analyses examined changes in both individual-level variables (overweight/obesity, food intake, number of steps taken) and school-level variables (food availability and MVPA in PE classes and recess). At the individual-level, we employed an intent-to-treat analysis and thus included all participants in the analysis for all time points. For those participants with missing data (i.e., 20 %), data imputations were performed by imputing the mean change score for the other children of that school who were of the same sex.³⁶ General linear models (GLM)³⁷ were used to examine within and across group differences in mean BMI values and number of steps taken from baseline to month 7, month 7 to month 11, month 11 to month 18, and baseline to month 18. We used logistic regression to test the effect of intervention on reaching step cut-offs at baseline and follow-up. These analyses controlled for sex and were conducted in SPSS Statistics Software, (version 19).

For the analysis of food intake we determined the children's intake in percentage for the three food categories previously described and calculated the average effect by difference-in-difference, considering the

interaction of treatment variables with every time point using a random effects regression model. In the model we considered analytical weights for the total number of foods eaten by each individual to avoid giving excessive weight to the children who only consumed a small number of foods, and the correlation within the schools. These analyses were also adjusted for sex and age.

The prevalence of overweight and obesity at the school-level was calculated using the BMI (kg/m^2) index. Children were categorized as non-obese, overweight, or obese using the age and gender specific BMI cut points suggested by the IOM.

At the school-level, because the interventions and the sample size varied from year one to year two, we examined changes in food availability and the unit of analysis where schools. General mixed models were used to examine within and across group differences in food availability from baseline to month 7, and from month 11 to month 18.

To determine minutes of MVPA in PE classes at the schools, we estimated the mean differences using a linear regression model from baseline to month 7 and from month 11 to month 18, adjusting for sex, age and design study. These analyses were carried out using STATA software version 9.0.*

Results

Baseline characteristics

During the first year, the study was conducted in 27 schools. These schools had between 316-755 students, 11-20 school teachers, and 1-2 PE teachers, each. School characteristics did not vary across the three intervention groups (data not shown). During the second year of intervention, one of the plus schools became a full-time school (longer duration of school period with a formal main meal included and changes in curricula) and was thus no longer eligible for inclusion in the study.

The baseline sample of 886 children was reduced to 830 students due to concerns about inconsistent information from 56 children. At baseline, the children were 9.7 years old ± 0.7 years and had a BMI of $19.8 \pm 3.7 \text{ kg}/\text{m}^2$. The combined prevalence of overweight and obesity was 43%, with no differences across Basic, Plus, and Control groups. Table II describes the characteristics of children for the intervention and the control groups at baseline.³⁴

* Stata Corporation. Stata Statistical Software. Release 9.0 ed: College Station; 2005.

Table II
DESCRIPTIVE CHARACTERISTICS OF STUDY GROUPS AT BASELINE

	Total (n = 860)		Intervention group					
	Mean	SD	Control (n=354)	SD	Basic (n=252)	SD	Plus (n=254)	SD
Boys (%)	50		51.4		51.6		46.0	
Age (y)	9.7	0.7	9.8	0.8	9.7	0.7	9.7	0.7
Weight (kg)	38.6	9.8	39.1	9.6	37.5	9.8	38.9	10.0
Height (cm)	138.8	7.1	139.3	7.1	137.9	7.1	139.0	6.8
BMI Kg/m ²	19.8	3.7	19.9	3.6	19.4	3.7	19.9	3.7

* S standard deviation or as specified

‡ Mean and percentage comparison adjusted for study design. No difference among groups ($p>0.05$)

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Changes in food and beverage availability at schools

There were significant changes in the distribution of food available among the three categories of food over the two years of intervention. These changes were characterized by an increase in the percentage of highly recommended food and by a reduction in the percentage of non-recommended food items in both intervention schools relative to control schools from baseline to 18 ($p<0.05$) months. The availability of recommended foods increased significantly ($p<0.05$) in plus schools from baseline (18%) to 7 (31%), 11 (35%) and 18 (52%) months. In basic schools, substantial changes were also documented across the assessment periods from baseline (24%) to 7 (32.9%), 11 (42%) and 18 (55%). Non recommended food availability decreased significantly in plus schools from baseline (50.7%) to 7 (24.4%) months, and from 11 (27.3%) to 18 (15.7%) months. In basic schools a reduction was also observed from baseline (44.4%) to 7 (22.55) months and from 11 (25.6%) to 18 (15.7%) months. Changes in food availability in all categories at the intervention and control schools are shown in table III.

Changes in potable water availability at schools

Another change in the environment in intervention schools was the availability of potable drinking water, which increased significantly ($p<0.05$) relative to control during both years. At the beginning of the intervention none of the schools had potable drinking water available, however by the end of year one (7 month), 63.4% of the classroom on 4th and 5th grade of basic schools and 73.2% of the classrooms in plus schools had potable drinking water available in contrast to control schools.

Table III
FOOD AVAILABILITY BY TYPE INTERVENTION GROUP

		Intervention group		
		Control schools (n=11) %	Basic schools (n=8) %	Plus schools (n=8) %
Foods highly recommended				
	Baseline	21.2	24.3	18.2
Year 1	7 months	20.6	32.9	31.1
	Change	-0.6	8.6	12.9*
	11 months	27.8	42.0	35.0
Year 2	18 months	26.2	55.1	52.0
	Change	-1.6	13.1*	17.0*
Foods recommended for consumption twice a week				
	Baseline	23.9	31.6	31.1
Year 1	7 months	31.3	44.5	44.5
	Change	7.4	12.9	13.4
	11 months	27.8	32.4	37.8
Year 2	18 months	23.2	24.3	32.2
	Change	-4.6	-8.1	-5.6
Foods not recommended				
	Baseline	54.9	44.0	50.7
Year 1	7 months	48.1	22.5	24.4
	Change	-6.8	-21.5*	-26.3*
	11 months	44.4	25.6	27.3
Year 2	18 months	50.5	20.5	15.7
	Change	4.4	-5.1	-11.6*

Generalized linear latent and mixed models

* Reference: control group, $p<0.05$

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For the second year of intervention (11 month) 19.5% of classrooms in basic and 8.8% of control schools had water available, whereas the plus schools did not. By the end of year two (18 month) the water availability in basic schools improved to 92% and 62.2% in plus schools whereas the control schools improved to 11.1% (data not shown).

Changes in time spent in MVPA in PE classes and recess at schools

The changes in MVPA in children during PE classes and recess were not significant. Between baseline and 7, 11 and 18 months assessments, the number of MVPA minutes of PE varied only slightly by intervention group, ranging from 2.9 to 4.0 minutes between groups and assessment periods. Similarly, at recess the differences in MVPA minutes did not vary significantly (MVPA minutes ranged from 2.8 to 3.9 minutes) between groups and assessment periods. The mean differences in MVPA in children across two years of intervention by PE classes and recess are presented in table IV.

Changes in children's food intake during recess

The quality in food intake changed considerably over the two years of intervention. Children's intake of highly recommended and recommended for consump-

tion twice a week food items increased in intervention schools when compared to the control group at each of the assessment periods (7, 11, 18 months). The increase in highly recommended food intake was notable even though not all the differences were statistically significant. The intake of highly recommended foods increased in plus treatment schools from baseline (16 %) to 7 months (30 %), 11 months (25.5 %) and 18 months (33.9%) months. In basic treatment schools, meaningful changes were also documented across the three assessment periods. However, not all the changes were statistically significant in basic schools relative to changes in the control group.

Moreover, a significant decrease in the intake of non-recommended foods was documented in intervention schools relative to control schools in three out of four assessment periods. Overall the children's food intake changes were notable across the majority of the assessment periods and decreased from 59 to 24.6% in plus and from 58 to 36% in basic. Changes in the quality of children's food intake by group are presented in table V.

Changes in children's physical activity (steps taken)

Year one intervention impact on steps taken have been previously published³² in brief, the number of steps

Table IV
MODERATE-TO-VIGOROUS PHYSICAL ACTIVITY MINUTES IN CHILDREN DURING PHYSICAL EDUCATION AND RECESS TIME BY INTERVENTION GROUP

		Intervention group					
		Control schools		Basic schools		Plus schools	
		Mean*	95% CI	Mean*	95% CI	Mean*	95% CI
Physical education class							
Year 1	Baseline	16.1	14.5-17.7	16.0	14.4-17.7	16.0	14.8-17.7
	7 months	19.9	18.4-21.4	20.0	18.4-21.6	19.8	18.3-21.4
	Difference [‡]	3.8	1.6-6.0	4.0	1.7-6.3	3.8	1.5-6.1
Year 2	11 months	18.7	17.2-20.3	19.2	17.6-20.8	19.2	17.6-20.7
	18 months	21.9	20.4-23.4	22.3	20.6-24.0	22.1	20.6-23.7
	Difference [‡]	3.2	1.0-5.3	3.1	0.8-5.5	2.9	0.7-5.3
Recess							
Year 1	Baseline	9.1	7.5-10.5	9.4	7.8-11.0	9.3	7.7-10.9
	7 months	13.0	11.6-14.5	13.0	11.5-14.6	13.0	11.5-14.6
	Difference [‡]	3.9	1.8-6.1	3.6	1.4-5.8	3.7	1.5-6.0
Year 2	11 months	12.0	10.5-13.5	12.3	10.7-13.9	12.4	10.8-14.0
	18 months	15.0	13.5-16.5	15.6	13.9-17.2	15.2	13.6-16.8
	Difference [‡]	3.0	0.9-5.1	3.3	1.0-5.5	2.8	0.6-5.1

* Confidence Intervals estimates by xtgee, adjusted by baseline measurement, sex, age and design study

[‡] Mean of the difference within year estimated by simple linear regression model adjusted by sex and age

All mean differences within year p value >0.05

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taken during school decreased in control schools (from 4490; 95%CI=4274-4706 to 3850 95%CI=3617-4084) and increased in basic (from 3323; 95%CI=3127-3520 to 3964 95%CI=3776-4153) and plus (from 3724; 95%CI=3505-3943 to 4410 95%CI=4197-4624) schools from the baseline to the final year (7 months).

Thus, only detailed information of year 2 impact results are presented here. Steps taken increased in a significant manner only in the basic (491; 95%CI=123-860) group; however, the plus group showed an increasing tendency (145; 95%CI=-459-748) and the control group decreased (-630; 95%CI=-1231,-28). The increase in steps taken in the basic group was significantly higher relative to the control group ($p<0.05$) after controlling for baseline steps. Furthermore in year 1, in the basic group 25% of children improved from not reaching to reaching the cut off point ($p<0.001$), and in plus group 36.4% improved from not reaching to reaching the cut off point ($p<0.001$); detailed information about the impact of year 1 has been published elsewhere.³² For year 2, in the basic group, significantly ($p=0.003$) fewer children (5.12%) decreased their activity from reaching the in-school cut-off (already defined) for activity to not reaching the cut-off from baseline to follow-up relative to that of the control group (12.16%). In contrast, 4.65% ($p=0.06$) children in basic schools and 2.15% ($p=0.03$) in plus schools maintained a status of reaching cut off for steps in school relative to students in the control group (12.16%).

The percentages of the children who improved from not reaching the cut-off point to reaching the cut off point were not significant but were higher in the intervention groups (11.6 % for basic, 21.09 % for plus) when compared to control (8.11 %) group.

Changes in overweight/obesity

Table VI presents obesity prevalence and BMI means by group across the four assessment periods. The prevalence of overweight and obesity in children changed across the evaluation period (measured at the 7, 11, 18 month assessments) by type of intervention group. During year one the prevalence of overweight and obesity decreased in all three groups relative to baseline. During year two, the prevalence decreased similarly from 11 to 18 months. However, the highest reduction in prevalence of overweight and obesity was observed in children from basic schools (from 12.1 to 10.9 %), whereas children from both the plus (10.7 to 10.0%) and the control groups (17.9 to 17.1%) had a smaller reduction and these changes were not statistically significant.

Although BMI changed significantly across intervention groups from baseline compared to the 7, 11, and 18 months assessments, changes were not in the anti-

Table V
CHANGE IN CLASSIFICATION FOOD CONSUMPTION
(PURCHASE AT SCHOOL) BY INTERVENTION GROUP
IN MEXICO CITY'S PUBLIC SCHOOL (PANEL ANALYSIS)

		Intervention group		
		Control (n=383)	Basic (n=261)	Plus (n=234)
Foods highly recommended				
Year 1	Baseline	17.6	17.4	16.0
	7 months	25.3	32.6	30.0
Year 2	11 months	14.4	23.9	25.2
	18 months	28.5	34.8	33.9
Change by treatment group and period [§]				
Baseline to 7 months		-	6.7	6.4
11 months to 18 months		-	-3.2	-5.5
Baseline to 11 months		-	10.0	12.6*
Baseline to 18 months		-	6.8	7.0
Foods recommended for consumption twice a week				
Year 1	Baseline	21.4	24.8	25.1
	7 months	25.0	43.5	45.5
Year 2	11 months	28.4	33.3	39.5
	18 months	26.2	28.9	40.4
Change by treatment group and period [§]				
Baseline to 7 months		-	15.1 [‡]	16.7 [‡]
11 months to 18 months		-	-2.3	3.2
Baseline to 11 months		-	1.5	7.3
Baseline to 18 months		-	-0.7	10.5
Foods not recommended				
Year 1	Baseline	61.3	58.0	59.0
	7 months	49.2	24.1	24.3
Year 2	11 months	57.4	42.8	34.0
	18 months	45.3	36.1	24.6
Change by treatment group and period [§]				
Baseline to 7 months		-	-21.0 [‡]	-22.8 [‡]
11 months to 18 months		-	5.3	2.9
Baseline to 11 months		-	-11.6	-21.4 [‡]
Baseline to 18 months		-	-6.3	-18.5 [‡]

Random effects regression model

* $p<0.1$

[‡] $p<0.05$

[§] Reference: control group

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Table VI
BODY MASS INDEX (BMI) BY TYPE OF INTERVENTIONS ACROSS FOUR TIME MEASUREMENTS ADJUSTED BY SEX

		Intervention group							
		Control (n=354)		Basic (n=252)		Plus* (n=224)		Plus* (n=254)	
Prevalence of overweight and obesity									
Year 1	Baseline	19.5		11.9		12.0		12.7	
	7 months	17.0		11.3		11.2		12.2	
Year 2	11 months	17.9		12.1		10.7		-	
	18 months	17.1		10.9		10.0		-	
BMI, kg/m ²		Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Year 1	Baseline	19.9	19.5-20.3	19.4	19.0-19.9	20.0	19.5-20.5	19.9	19.4-20.4
	7 months	18.4	17.8-19.1	19.8	19.0-20.5	18.5	17.2-19.3	18.5	17.7-19.2
Year 2	11 months	18.9	18.3-19.6	20.1	19.3-20.8	18.7	17.9-19.5	-	-
	18 months	19.1	18.4-19.8	20.4	19.6-21.1	19.0	18.2-19.9	-	-

*The difference between the N in plus schools at time 0 and 7 vs. time 11 and 18 is due to a loss of a plus school at the second year of intervention
 Differences within year $p < 0.05$
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pated direction. There was a BMI reduction in children in control schools from baseline to month 7, 11 and 18 and an increase in BMI in Basic schools from baseline to 7, 11 and 18 month. Overall, the interaction between intervention duration and type for BMI was significant ($F, 10.34, p < 0.001$). There was a significant difference in BMI between baseline and 7 months ($F, 11.48, p < 0.001$); between 7 months and 11 months ($F, 10.46, p < 0.001$); and between baseline vs. 18 months ($F, 11.92, p < 0.001$).

Discussion

This school-based intervention was effective in improving the food environment and healthy behaviours in children, including healthy eating and PA, through a set of regulations, without the need for large investments. This is one of the first studies to examine the impact of a multifactor, multilevel, school-based intervention in Mexico. These findings are consistent with previous research showing that environmental interventions in schools can impact food availability.³⁸⁻⁴⁰ Moreover, at the individual level the intervention also found improvements in individual health behaviors such as food intake. Statistically significant reductions were documented in the intake of non-recommended food and beverages in the plus intervention schools during both study years and in the basic intervention schools during the first study year. This suggests that improvements in the school food environment translated into

reductions in the overall intake of unhealthy foods. This change in intake is particularly remarkable given that children were free to bring food from home in addition to purchasing food at school. It may be that the school intervention, which was promoted to parents through school-bag correspondence, served to enhance parental awareness about providing healthy snacks to their children. This pattern further strengthens the evidence linking the school environment (i.e., food availability) to individual-level behavior (i.e., food intake) and is consistent with previous evidence from developed countries.^{19,21,41} Furthermore, the deterioration of the food environment noted in schools where no intervention was occurring, attests to the risk of increasing the obesogenic environment when nothing is done.⁴⁰

In contrast to the findings for the nutrition component of the intervention, the physical activity component of the intervention appears to have been less successful. The most likely explanation for the lack of change in children's MVPA during PE class may be related to implementation integrity.⁴² Unlike the nutrition intervention, which was not subject to interruptions and was implemented as planned, over 30% of the scheduled PE classes were canceled during the intervention period³¹ reducing the variability in PE class opportunities between intervention and control schools. This finding is not unusual as schools have limited space and must often make room for other activities occurring in the school (e.g., school assemblies, picture day, etc). The

prioritization of other activities over PE has been reported elsewhere^{3,43,44} and remains a constant challenge for schools. This may be especially true in the Mexican context where the double school-shift is necessary because of a lack of human resources (including PE teachers) and school infrastructure.⁹

The positive increase in steps taken found in children from intervention schools should not be considered contradictory to the findings for MVPA during PE classes because of the greater variability in treatment conditions conducive to step taking. The intervention schools offered morning activation sessions on most school days whereas control schools did not offer these sessions. It is conceivable that these opportunities translated into more steps taken. These results are comparable to findings from other studies where the PA in schools increased despite the PE class quality.⁴⁵⁻⁴⁷

In terms of steps taken, the effects were higher in year one, some of those effects have been published elsewhere.³¹ Nevertheless, the effects observed in year two were more moderated probably because there was not much room for improvement, if we had analysed and reported the two year intervention results together, the findings would have had more coherence with the rest of the results presented in this paper. Nonetheless these findings suggest that the PA and PE environment in Mexico can be improved and children can engage in more PA at schools through comprehensive interventions that address school environmental and individual needs.

The intervention had no significant effect on the prevalence of overweight and obesity or children's BMI. The BMI changes were not associated to the study intervention as they showed a non-significant BMI reduction in control schools (similar to plus schools); and a non-significant BMI increase in basic schools. A potential reason is that basic schools didn't have a strict control over food availability, the children had access to SSB and other energy-dense food items during year one and two (food and beverages recommended for consumption only twice a week), which could affect children's intake and thus BMI. Moreover, the intervention did not control for serving (serving sizes or number of servings per day) so it could be possible that children increased their energy intake through the consumption of highly recommended foods and the food recommended for consumption only twice a week. Thus, even when the intervention managed to change the quality of the food available at basic schools it didn't restrict the energy intake in children, especially; in year one and this could have influenced the BMI increase. In addition, in basic schools there were no education workshops targeted to food vendors and children to support the changes in food availability in school and to promote healthy intake. The

BMI reduction in control school could have happened because these schools had higher BMI at the beginning of the intervention and had a bigger sample size, relative to basic and plus schools, thus, any biological or environmental change in children would affect BMI and this could have been more evident in control schools.

Moreover, our study didn't control for the intake of the PFDE, which included a sweet snack (i.e., cookies, sweet peanut-based snacks or sweet rolls) and sugar sweetened whole milk, by intervention group; therefore children who eat the PFDE could have increase their energy intake and have a higher BMI.

Overall the intervention didn't impact the BMI, since control and plus schools changed in a very similar way. This is not an odd case since extensive literature on childhood obesity prevention reveals same tendencies in these types of interventions specifically when the intervention length and the exposure are low.^{21,48,49} Our intervention did not have an extended length (two to four years) or pursue family or community changes. The time the children spend in school is not even the 25% of the day and this length is not substantial to impact the overall children's intake during the day. These results are comparable to results from interventions implemented in developed and developing countries that haven't achieve impact in BMI even when intervened for longer periods,^{45,50} or been more comprehensive and included family and community environments.²¹

Overall we were able to implement a formative ecological multifactor multilevel intervention that was designed to tackle the specific obesogenic situation in the Mexican schools system as the literature recommends.^{2,3} Our school based intervention successfully improved the environment and modified practices among students and in school communities. The result document a successful intervention aimed at improving health behaviors towards the battling of childhood obesity in the Latin America Region using the ecological approach, which is a contribution to the literature given the lack of evidence in the childhood obesity prevention area.^{51,52}

The evidence derived from this study have already impacted the Mexican Health System since several policy strategies that have been derived from this study, and other studies, such as the Mexican National Guidelines for Healthy Eating in Schools. These guidelines include a series of regulations and recommendations related to the sale and distribution of foods inside the schools to promote healthy eating, including the control of portion sizes, and activities and curriculum change to promote physical activity in these settings. The Guidelines are being implemented in all schools in Mexico and have influenced the availability and accessibility of healthier foods and opportunities

for physical activity both at schools, at national level. Thus, the results of this project have already impacted policy development in schools and children and promote health on a population wide scale.

To summarize, statistically significant impacts were documented in environmental and behavioral outcomes towards the prevention of obesity. The knowledge and the experience generated in this project added to the design and implementation of the Mexican national guidelines would likely attain larger impacts on healthy behaviors and body composition in the Mexican school system to prevent childhood obesity.

Limitations of the study

During year 2 we lost a plus school due to changes in the school curriculum policy; therefore, this school became a full time school where children spend a half day there rather than 4.5 hours. This fact was out of our control since municipal and federal authorities were not fully involved in the intervention and becoming a full time school resulted in bigger budget for the school. In addition, we lost to follow up approximately 20% of our sample across the two years of intervention in time 7, 11 and 18. In order to compensate this lost we applied intent to treat analysis by imputing missing variables as suggested (by age and sex) by the literature in RCTs.³⁵

The PFDE increase the food intake in children and we were unable to control or make recommendations about the intake, therefore, it was difficult to assess and control the food intake in children. Our trial did not control for serving (total calories for per serving or number of servings during the day), so it could be possible that children increased their energy intake through the consumption of healthier food.

Strengths of the study

To our knowledge, this is among the firsts randomized institutional multilevel, multifactorial project carried out in Mexico City to prevent childhood obesity in schools. The implications of the results reported are extremely important since this ecological approach school based project is reporting positive findings in health behaviors that lead to prevention of childhood obesity in developing countries where there is not enough evidence to guide the obesity prevention effort.^{14,46,50,51} We intervened in two levels (organization and individual) and the environmental and behavioural outcomes are of great proportion for Mexico since we diagnosed, intervene and evaluate a project at different levels of influence and created evidence to guide the National Obesity Prevention effort. Our aim as a National Institute of Public Health is to develop effective

interventions that promote healthy eating and physical activity in different settings, to achieve energy balance. Results of interventions should be the basis for designing public policies in different settings to prevent childhood obesity. The implications of these finding substantiate a conclusion that establishing a healthy food and PA environment at schools can promote healthy lifestyles in children and, as the literature states, it's the first step towards the obesity prevention.^{2,3,20,46,48,50}

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