Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 93, No. 1
doi:10.1007/s11524-015-9997-5

Socio-Urban Spatial Patterns Associated with Dyslipidemia among Schoolchildren in the City of San Luis Potosi, Mexico

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ABSTRACT *The places where a child lives and attends to school are both major environmental and social determinants of its present and future health status. Noncommunicable diseases (NCDs) and some of their risk factors among child and adolescent populations are obesity and dyslipidemia, so finding the patterns of distribution of these risk factors by gender, type of school, area, and margination level is important to do health intervention focusing in their necessities to prevent diseases at younger ages. Because of that, a cross-sectional study was performed among elementary and junior high school students from public and private schools in six of the seven areas of the metropolitan zone of San Luis Potosi, Mexico. Biochemical dyslipidemia indicators (triglycerides, total cholesterol, and high-density lipoprotein) and anthropometric data (weight and height) were obtained. Seventeen public schools and five private schools with a total of 383 students were included. More than half of the studied population (53.0 %) had elevated triglyceride levels. A total of 330 students (86.2 %) had normal levels of total cholesterol with a mean value of 141.7 mg/dl, and 202 schoolchildren (52.8 %) had lower than acceptable levels of high-density lipoprotein (HDL) with a mean value of 43.9 mg/dl. There were differences in the levels of high-density protein between the areas and the type of school where they had been studied. Finally, a total of 150 students (39.4 %) had at least one altered lipid value and 103 participants (26.9 %) had two altered values. Several students, despite their young age, showed a high prevalence of risk factors, so it is important to design programs according to their necessities.*

KEYWORDS *Dyslipidemia, Schoolchildren, Health geography, Mexico, Chronic disease, Risk factors*

INTRODUCTION

In the year 2008, for the first time ever, more than half of the world population lived in urban areas. It is expected that by the year 2050, this percentage will increase to

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70 %. Furthermore, this new urban growth will occur mainly in small towns which have fewer resources to respond to the magnitude of the consequent health change.[1]

The lifestyle among urban populations is one of the main features that have led to major transitions in morbidity and mortality.[2] An individual's exposure to cardiovascular disease (CVD) risk factors, which include physical inactivity, tobacco use, obesity, and unhealthy diets that lead inadequate nutrition, is highly influenced by their socioeconomic status and the environment in which they live. Poverty, unplanned urbanization, and lack of education could increase exposure to risk factors and have an influence on noncommunicable diseases (NCDs). With this, children are particularly impacted due to their unique vulnerabilities.[3]

Cities in developing countries are urbanizing at a rapid rate without much foresight. This has led to the creation of cities with unequal distribution of goods with some areas having insubstantial housing conditions and low access to the following: safe and healthy foods, health care services, and green places for outdoor activity that are free of environmental toxins and pollutants.[3]

At the same time, social inequality as a result of economic insecurity and a failing economic environment is considered as one of the probable causes of obesity. Inequitable access to healthy foods as determined by socioeconomic factors could influence the diet and population health. It has evidenced that when the stroke mortality and the risk factors to suffer it are analyzed according to the socioeconomic level, the individuals with the lowest socioeconomic level are more vulnerable to suffer a stroke than the others who have a higher socioeconomic level.[4]

In the case of schoolchildren, the major risk factors and NCDs among this population are physical inactivity, obesity, dyslipidemia, and high blood pressure. Dyslipidemia is influenced by genetics and lifestyle.[5]

It is known that hypertriglyceridemia is rare as an isolated disorder and usually is associated with hyperinsulinemia. Subjects with hyperinsulinemia could eventually develop metabolic disorders and have an increased risk for CVD. Indeed, having low high-density lipoprotein (HDL) values places a sufficient risk for CVD.[6]

In relation to children with a family history of premature CVD, it is suggested a review of the lipid profile at very early age (2 years old), as it can be effective and result in positive changes in the medical management of the child and family. Children with conditions predisposing to dyslipidemia such as overweight and obesity, hypertension, HDL <40 mg/dl, and exposure to cigarette smoke should be monitored with rapid lipid profile tests. If dyslipidemia has already being diagnosed, it is suggested to conduct a medical and lipid profile reviews every 5 years or less.[7]

However, recent research indicates that the environment also plays a major role on it. The atmosphere is composed of microenvironments and macroenvironments. Microenvironments among schoolchildren would be, for example, the neighborhood, household characteristics, school that they attend to, and type of transport; macroenvironments would be, for instance, the level of urbanization, media, food production and distribution, and health system. Both microenvironments and macroenvironments can be potentially positive or negative when it comes to the individual health behaviors.[8]

According to the World Health Organization (WHO), the population and individual health status are both critically determined by the place of residence. In the case of child and adolescent populations, a major determinant is where they study.[9]

In consequence, two theoretical and methodological positions are evident: (a) *the demographic and epidemiological transition,* which explains that socio-economic changes and transition in diseases are related to modernization with a significant impact in children and young women health [9] and (b) the position of *the cultural ecology* from the medical and health geography perspective, which establish that the environment and structure of the cities shape the individual behaviors and health. The structure of the cities is further classified in concentric, central, sectorial, and multi-core space models.[10] It is important to note that both positions are complementary since the holistic and integrated approach persists about the nature-society relationship.

In Mexico, the city of San Luis Potosi is classified as a medium-sized city with a shift of its economic activity from extractive mining in the decade of the 1960s to an unprecedented industrial boom in the early 1990s.[11] This industrial shift is characterized by the region called "New Industrial Triangle" of Toyota model (highly specialized maquiladoras and automobile assembly plants with lower production costs, outsourcing, no unions, and minimum health benefits).[12] In result, San Luis Potosi is a new urban center with 2,585,518 inhabitants and exponential growth, where 42.31 % of the population is concentrated in the City of San Luis Potosi and its suburbs (including the municipalities of Soledad de Graciano Sanchez and Mexquitic).[13] However, the urban growth has outpaced the ability and strategic planning process on urban spaces and equipment, housing, health, and education that are necessary to ensure a good quality of life for the population. Actually, the prevalence in San Luis Potosi of NCDs has increased up to 15 % in the last 6 years along with an augmentation in the associated risk factors.[14]

About the schools, they are classified into public and private. The public ones are characterized because the costs are paid by the government; it gives them the physical space, materials, and teachers who apply the study programs and, at the same time, are secular. A private school is the one that works without the government support, their mission and philosophy are made by an independent education council, and the students pay for their studies.

San Luis Potosi City is divided into seven zones according to a geographical division: Soledad 1-Saucito, Soledad 2, Soledad 3, Satélite-Zona Industrial, Lomas-Tangamanga, Centro, and Morales zone.

- Soledad 1-Saucito. It is the zone with the highest marginalization in San Luis Potosí and metropolitan area, the only zone where more than 2 % of the population is laborers (29.0 %), and the zone with the lower coverage of potable water (80.0 %) and drainage (91.0 %).[15] It has becoming a zone with high population increase without planning. Although the scholarity has increased, the 4.0 % of them have not had any kind of instruction.
- Soledad 2-San Pedro. It is a zone with one of the higher marginalization levels in San Luis Potosí.
- Soledad 3-B. Anaya. It is a zone with a medium margination level in S.L.P.
- Satélite-Zona industrial. It is the zone with the highest number of habitants and one of the zones with higher level of marginalization in the metropolitan area, with higher population growing up and densely populated.
- Lomas-Tangamanga. It is the zone with lowest number of habitants and with the lowest marginalization level.[16]
- C>entro zone. It has had a negative growth; however, it is the zone with the highest population. It is characterized by a medium marginalization level.

- Morales-Industrial Aviación. It is a zone with a medium marginalization level and with a high population density.

The main economic activities developed in the city zones are the second and third productive sectors. Around 72.0 % of the economic active populations are employees or laborers and the 17.0 % work by their own.

Due to the above, the development and use of a geographical reference system would allow examining spatial variations related to dyslipidemia, assess the magnitude of the problem, and determine the impact of possible health interventions among children and adolescents. It is essential to use instruments focused on heath geography in order to understand the relationship between environment and health and describe and solve specific diseases in a given population.

The objective of this study was to estimate the body mass index distribution and the triglyceride concentration, total cholesterol and HDL cholesterol by sex, kind of school, geographic area, and level of marginalization. A novel approach is offered by adopting a holistic approach in relation to spatial patterns associated with dyslipidemia among schoolchildren; hence, preventive, quick decisions and concrete models can be implemented within the city of San Luis Potosi, Mexico.

MATERIALS AND METHODS

A cross-sectional study was performed among elementary and junior high school students from public and private schools in the metropolitan area of San Luis Potosi, Mexico. The schools were selected by a randomization of the total schools that the secretary of public education given to the researchers.

Biochemical dyslipidemia indicators (triglycerides, total cholesterol, and HDL) and anthropometric data (weight and height) were obtained. To acquire the blood sample for the dyslipidemia indicators, the kids were cited in the morning in their schools with 8 h of fasting, and to obtain the anthropometric data, they were cited with light clothes and they were weighed and measured without shoes.

Verbal and written informed consent was obtained from the legal guardians or parents; they were informed about the purpose, benefits, and risks of this research project. The project was approved by the Ethics Committee of the Faculty of Medicine of the Autonomous University of San Luis Potosi.

The levels used for biochemical parameters were based on the guidelines for cardiovascular health in children and adolescents issued by the American Academy of Pediatrics (Table 1).[11]

TABLE 1 Guidelines for cardiovascular health in children and adolescents issued by the American Academy of Pediatrics

Category	Less than acceptable (mg/dl)	Acceptable (mg/dl)	Higher than acceptable (mg/dl)
Triglycerides			
1–9 years old		<75	≥75
10–19 years old		<90	≥90
Total cholesterol		<170	≥170
HDL cholesterol	≤45	>45	

To integrate the information, each school was placed according to their address (as they lacked of georeference) along with a link to the corresponding database. Marginalization, political division, zoning, and georeferenced database through streets and neighborhoods were obtained from the spatial databases and digital coverages from the National Institute of Statistics and Geography (INEGI) in the Area of Basic Geostatistic and Urban Block (AGEB).[12] As a result, the city was divided into seven areas: Lomas-Tangamanga, Morales-Industrial Aviación, Centro, Soledad 1-Saucito, Soledad 2-San Pedro, Soledad 3-B. Anaya, and Satélite-Zona Industrial (Fig. 1).

As for the location of parks and recreational areas, we worked on QuickBird satellite image (2001) to 0.65-cm spatial resolution using a visual interpretation and false 432 color composite. The working platforms were

FIG. 1 Location of schools.

ArcGIS 9.0 (for all processes of spatial analysis) and ENVI 4.7 for the interpretation of the satellite image.

Risk factors were established for each school based according to the sampled students and triglycerides, total cholesterol, and HDL levels. The risk index was a result of the proportion of children who have all or some of the factors associated with dyslipidemia.

STATA v.13 program was used to do the statistical analysis. Depending of the type of variable, we used chi-square, Student's t, Wilcoxon, or ANOVA tests.

The areas were divided by marginalization level, and the higher level was Soledad 2-San Pedro and Satélite-Zona Industrial, the medium level was Soledad 3-B. Anaya, Centro, and Morales-Industrial Aviación, and the area with less marginalization level was Lomas-Tangamanga.

TABLE 2 Number of students per school and area

	Men		Women		
	N	%	*n*	%	Total
	School				
1	0	0	1	100.0	1
2	2	66.7	1	33.3	3
3	7	41.2	10	58.8	17
4	18	46.2	21	53.9	39
5	0	0.0	1	100.0	1
6	1	100.0	0	0.0	1
7	0	0.0	1	100.0	1
8	3	75.0	1	25.0	4
9	20	48.8	21	51.2	41
10	18	48.7	19	51.4	37
11	8	44.4	10	55.6	18
12	11	61.1	7	38.9	18
13	1	100.0	0	0.0	1
14	3	100.0	0	0.0	3
15	1	50.0	1	50.0	2
16	25	58.1	18	41.9	43
17	18	51.4	17	48.6	35
18	14	58.3	10	41.7	24
19	14	50.0	14	50.0	28
20	1	100.0	0	0.0	1
21	31	48.4	33	51.6	64
22	0	0.0	1	100.0	1
Type of school					
Private	37	46.3	43	53.8	80
Public	159	52.5	144	47.5	303
Area					
Soledad 2-San Pedro	39	54.9	32	45.1	71
Soledad 3-B. Anaya	40	51.3	38	48.7	78
Satélite-Zona Industrial	32	49.2	33	50.8	65
Lomas-Tangamanga	9	45.0	11	55.0	20
Centro	65	49.6	66	50.4	131
Morales-Industrial Aviación	11	61.1	7	38.9	18
Total	196	51.2	187	48.8	383

TABLE 3 Distribution of indicators by gender

	Men		Women		Total		
	(*n*=196)		(*n*=187)		(*n*=383)		
Indicator	*n*	%	*n*	%	*n*	%	*p* value
Body mass index							
Desnutrition	15	7.7	11	5.9	26	6.8	0.666
Normal weight	92	46.9	95	50.8	187	48.8	
Overweight	40	20.4	44	23.5	84	21.9	
Obesity	45	23.0	37	19.8	82	21.4	
Unknown	4	2.0	0	0.0	4	1.0	
Triglycerides							
Mean, 6–9 years (mg/dl)	99.2 (SD 58.5)	95.2 (SD 51.0)	97.1 (SD 54.6)	0.2952			
Mean, 10–15 years (mg/dl)	99.3 (SD 52.6)	104.9 (SD 47.5)	101.8 (SD 50.3)	0.2375			
Acceptable	89	45.4	89	47.6	178	46.5	0.362
High	105	53.6	98	52.4	203	53.0	
Unknown	2	1.0	0	0.0	2	0.5	
Total cholesterol							
Mean (mg/dl)	142.5 (SD 25.5)	140.7 (SD 25.7)	141.7 (SD 25.6)	0.254			
Acceptable	164	83.7	166	88.8	330	86.2	0.184
High	30	15.3	21	11.2	51	13.3	
Unknown	2	1.0	0	0.0	2	0.5	
High-density lipoprotein[a]							
Mean (mg/dl)	45.2 (SD 12.7)	42.7 (SD 13.1)	43.9 (SD 12.9)	0.0673			
Low	63	49.6	69	56.1	132	52.8	0.354
Acceptable	64	50.4	54	43.9	118	47.2	

TABLE 3 *(continued)*

	Men		Women		Total		
	(*n*=196)		(*n*=187)		(*n*=383)		
Indicator	*n*	%	*n*	%	*n*	%	*p* value
Risk factors							
None	61	31.1	57	30.5	118	30.8	0.354
One	72	36.7	79	42.2	151	39.4	
Two	59	30.1	44	23.5	103	26.9	
Three	4	2.0	7	3.7	11	2.9	

SD standard deviation

[a] *n*=H 127, M 123

The body mass index (BMI) was made in categories in accordance to the WHO categories.[17]

RESULTS

A total of 22 schools in the metropolitan area of the state capital participated. Public schools (schools=17, students=303) and private schools (schools=5, students=80) were included (Fig. 1). A total of 383 students were included, of which 51.2 % were male and 48.8 % female, and the 34.2 % had studied in the Centro area, 20.4 % in Soledad 3-B. Anaya, and 18.5 % in Soledad 2-San Pedro. There were no schools in Soledad 1-Saucito area that had participated (Table 2). The mean age was 9.2 years (6–15) old. The mean age for female group (9.0 years) was statistical significantly lower compared to male group (9.4 years) (p=0.0204). The 35.5 % of the students and six schools were in the highest marginalization level, 59.3 % of the students and 14 schools were in the medium marginalization level, and 5.2 % of the students and two schools were in the lowest marginalization level.

TABLE 4 Distribution of indicators per type of school

	Private		Public		Total		
	(*n*=80)		(*n*=303)		(*n*=383)		
Indicator	*n*	%	*n*	%	*n*	%	*p* value
Body mass index							
Desnutrition	4	5.0	22	7.3	26	6.8	0.31
Normal weight	35	43.8	52	17.2	87	22.7	
Overweight	17	21.2	67	22.1	84	21.9	
Obesity	23	28.8	59	19.5	82	21.4	
Unknown	1	1.2	3	1.0	4	1.0	
Triglycerides							
Mean, 6–9 years (mg/dl)	91.9 (SD 43.6)		98.3 (SD 56.9)		97.1 (SD 54.6)		0.251
Mean, 10–15 years (mg/dl)	94.0 (SD 41.6)		104.2 (SD 52.6)		101.8 (SD 50.3)		0.135
Acceptable	39	48.8	139	45.9	178	46.5	0.705
High	41	51.2	162	53.5	203	53.0	
Unknown	0	0.0	2	0.7	2	0.5	
Total cholesterol							
Mean (mg/dl)	140.0 (SD 24.4)		142.1 (SD 25.9)		141.7 (SD 25.6)		0.2613
Acceptable	70	87.5	260	85.8	330	86.2	0.741
High	10	12.5	41	13.5	51	13.3	
Unknown	0	0.0	2	0.7	2	0.5	
High-density lipoprotein[a]							
Mean (mg/dl)	38.2 (SD 12.5)		45.1 (SD 12.7)		44.0 (SD 12.9)		*0.0008*
Low	31	75.6	101	48.3	132	34.5	*0.001*
Acceptable	10	24.4	108	51.7	118	30.8	
Risk factors							
None	22	27.5	96	31.7	118	30.8	0.354
One	36	45.0	115	38.0	151	39.4	
Two	20	25.0	83	27.4	103	26.9	
Three	2	2.5	9	3.0	11	2.9	

SD standard deviation

[a] *n*=private 41, public 209

TABLE 5 Distribution of indicators per area

Indicator	Soledad 2-San Pedro		Soledad 3-B. Anaya		Satélite-Zona Industrial		Lomas-Tangamanga		Centro		Morales-Industrial Aviación		*p* value
	(*n*=71)		(*n*=78)		(*n*=65)		(*n*=20)		(*n*=131)		(*n*=18)		
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
Body mass index													
Desnutrition	7	9.9	5	6.4	7	10.8	0	0.0	6	4.6	1	5.6	0.55
Normal weight	37	52.1	36	46.2	31	47.7	12	60.0	59	45.0	12	66.7	
Overweight	11	15.5	18	23.1	12	18.5	3	15.0	36	27.5	4	22.2	
Obesity	15	21.1	19	24.4	14	21.5	4	20.0	9	6.9	1	5.6	
Unknown	1	1.4	0	0.0	1	1.5	1	5.0	1	0.8	0	0.0	
Triglycerides													
Mean, 6–9 years (mg/dl)	113.2 (SD 71.0)		85.0 (SD 51.4)		93.9 (SD 45.8)		104.4 (SD 49.6)		96.2 (SD 49.7)		96.3 (SD 61.4)		0.33
Mean, 10–15 years (mg/dl)	114.7 (SD 63.3)		87.7 (SD 32.1)		96.3 (SD 47.8)		97.0 (SD 36.0)		106.8 (SD 51.9)		110.5 (SD 68.8)		0.4
Acceptable	31	43.7	41	52.6	32	49.2	8	40.0	57	43.5	9	50.0	0.93
High	39	54.9	37	47.4	33	50.8	12	60.0	73	55.7	9	50.0	
Unknown	1	1.4	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0	
Total cholesterol													
Mean (mg/dl)	144.0 (SD 27.1)		135.3 (SD 24.3)		144.8 (SD 23.5)		129.6 (SD 20.8)		143.2 (SD 27.1)		151.3 (SD 17.7)		*0.02*
Acceptable	57	80.3	71	91.0	54	83.1	19	95.0	113	86.3	16	88.9	0.72
High	13	18.3	7	9.0	11	16.9	1	5.0	17	13.0	2	11.1	
Unknown	1	1.4	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0	
High-density lipoprotein[a]													
Mean (mg/dl)	42.6 (SD 10.7)		48.2 (SD 11.7)		48.7 (SD 9.5)		32.8 (SD 9.7)		41.4 (SD 14.2)		50.3 (SD 10.6)		*<0.0001*
Low	21	65.6	22	39.3	9	30.0	17	100.0	57	58.2	6	35.3	*<0.001*
Acceptable	11	34.4	34	60.7	21	70.0	0	0.0	41	41.8	11	64.7	
Risk factors													
None	19	26.8	31	39.7	25	38.5	0	0.0	36	27.5	7	38.9	0.06
One	31	43.7	29	37.2	29	44.6	11	55.0	46	35.1	5	27.8	

Two	19	26.8	17	21.8	9	13.8	8	40.0	44	33.6	6	33.3
Three	2	2.8	1	1.3	2	3.1	1	5.0	5	3.8	0	0.0

SD standard deviation

[a] *n*=Soledad 2-San Pedro, 32; Soledad 3-B. Anaya, 56; Satélite-Zona Industrial, 30; Lomas-Tangamanga, 17; Centro, 98; Morales-Industrial Aviación, 17

Body Mass Index

According to the results of BMI categories, it was found that 6.8 % were in malnutrition, 48.8 % were in a normal nutritional status, 21.9 % were overweight, and 21.4 % were obese with no statistically significant difference by gender (*p*=0666) (Table 3), type of school (*p*=0.31) (Table 4), areas (*p*=0.55) (Table 5), and marginalization level (*p*=0.192) (Table 6).

Triglycerides

The mean triglyceride level for children between 6 and 9 years old was 97.1 mg/dl and for those between 10 and 15 years old was 101.8 mg/dl; there was no statistically significant difference (*p*>0.05) between these mean values by gender (Table 3), type of school (Table 4), area (Table 5), and marginalization level (Table 6).

A total of 8 schools (36.36 %) had high mean triglyceride levels, and 20 schools (90.90 %) had triglycerides higher than the acceptable levels (Fig. 2). One school in the Satélite area had the female group with the higher mean triglyceride value

TABLE 6 Distribution of indicators per margination level

	High		Medium		Low		
	(*n*=136)		(*n*=227)		(*n*=20)		
Indicator	*n*	%	*n*	%	*n*	%	*p* value
Body mass index							
Desnutrition	14	10.3	12	5.3	0	0.0	0.192
Normal weight	68	50.0	107	47.1	12	60.0	
Overweight	23	16.9	58	25.6	3	15.0	
Obesity	29	21.3	49	21.6	4	20.0	
Unknown	2	1.5	1	0.4	1	5.0	
Triglycerides							
Mean, 6–9 years (mg/dl)	104.5 (SD 61.3)		92.6 (SD 51.0)		104.4 (49.6)		0.3044
Mean, 10–15 years (mg/dl)	105.3 (SD 56.14)		99.9 (SD 47.6)		97 (SD 36.0)		0.7724
Acceptable	63	46.3	107	47.1	8	40.0	0.957
High	72	52.9	119	52.4	12	60.0	
Unknown	1	0.7	1	0.4	0	0.0	
Total cholesterol							
Mean (mg/dl)	144.4 (SD 25.4)		141.1 (SD 25.9)		129.6 (20.8)		*0.0461*
Acceptable	111	81.6	200	88.1	19	95.0	0.354
High	24	17.6	26	11.5	1	5.0	
Unknown	1	0.7	1	0.4	0	0.0	
High-density lipoprotein[a]							
Mean (mg/dl)	45.5 (SD 10.5)		44.5 (13.5)		32.7 (9.7)		*0.0008*
Low	30	22.1	85	37.4	17	85.0	*<0.0001*
Acceptable	32	23.5	86	37.9	0	0.0	
Risk factors							
None	44	32.4	74	32.6	0	0.0	*0.033*
One	60	44.1	80	35.2	11	55.0	
Two	28	20.6	67	29.5	8	40.0	
Three	4	2.9	6	2.6	1	5.0	

SD standard deviation

[a] *n*=high, 64; medium, 92; low, 10

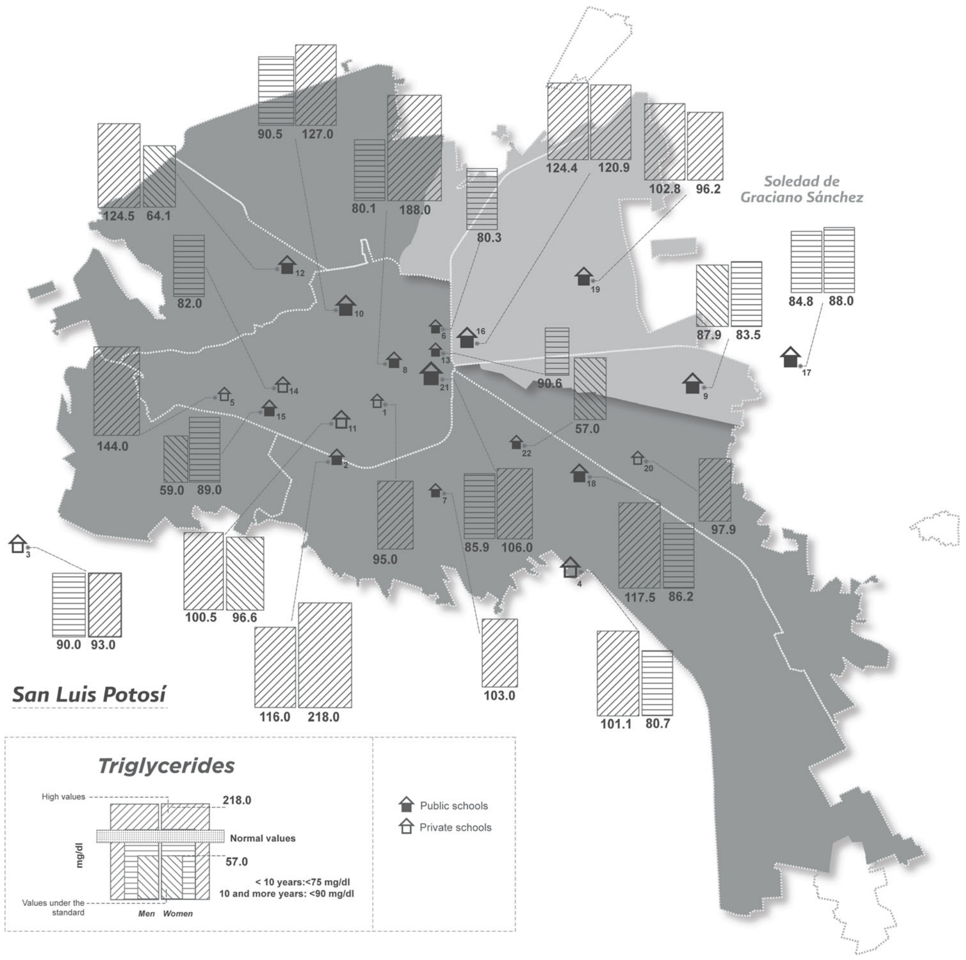

FIG. 2 Distribution of triglyceride per school.

(218 mg/dl), whereas two schools in the Morales and Soledad 2 areas had the higher mean values for the male group. A mean triglyceride value in both male (84 mg/dl) and female groups (88 mg/dl) was found in a school belonging to the Soledad 3 area. The school with the lower mean value (57 mg/dl) was in the Centro area and was among the female group.

A total of 172 schoolchildren (53.28 %) had triglycerides values above the acceptable value; there was no statistically significant difference ($p>0.05$) between the proportions by gender (Table 3), type of school (Table 4), area (Table 5), and marginalization level (Table 6).

Total Cholesterol

The total cholesterol mean in schoolchildren was 141.7 mg/dl. There was no statistically significant difference in the mean of total cholesterol by gender ($p=0.254$) (Table 3) and type of schools ($p=0.2613$) (Table 4). Although, there were statistically significant differences in the total cholesterol concentration mean by area ($p=0.02$) (Table 5) and by marginalization level ($p=0.0461$) (Table 6).

None of the schools had total cholesterol mean values higher than 170 mg/dl (Fig. 3). The highest mean value was identified among women from a school in the Centro area (158.4 mg/dl) and in men from a school in the Satélite-Zona Industrial area (158.7 mg/dl). The lowest mean level for both men (109.0 mg/dl) and women (99.0 mg/dl) was found in two schools in the Centro area (Fig. 3).

A total of 278 students (86.0 %) had acceptable total cholesterol levels, while 15.3 % of men and 11.2 % of women had high cholesterol levels; there was no statistically significant difference by gender (*p*=0.184) (Table 3) and type of school (*p*=0.741) (Table 4), area (Table 5), and marginalization level (*p*=0.72) (Table 6).

High-Density Lipoproteins

A total of 250 students and 11 schools were included for the HDL analysis. The mean HDL value was 43.9 mg/dl; there was no statistically significant difference by gender (*p*=0.0673) (Table 3). When public and private school values were compared, a statistical significant difference (0.0008) was obtained and the public schools had a higher mean level of HDL than the private schools (Table 4). Further, statistically significant differences in the HDL mean by areas (*p*<0.001) were found:

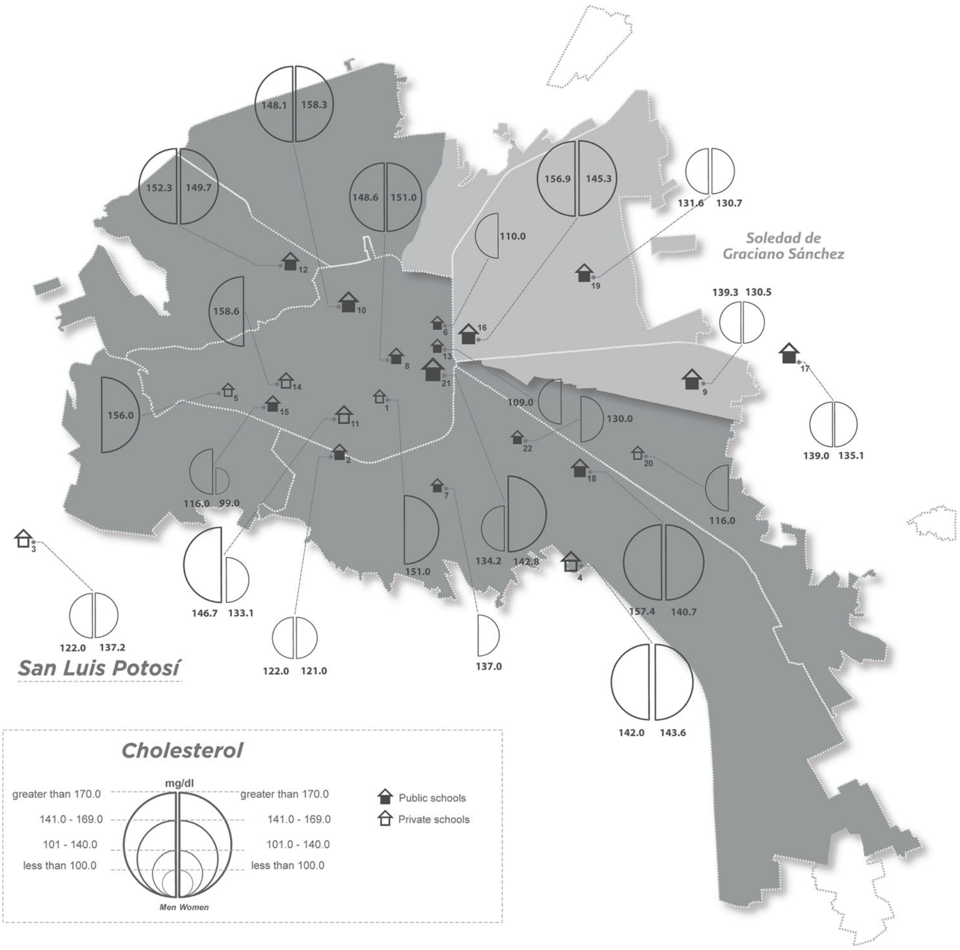

FIG. 3 Distribution of cholesterol per school.

Morales-Aviation Industrial area had the highest value, and Lomas-Tangamanga had the lowest value (Table 5). Likewise, in Lomas-Tangamanga, all the students had low HDL values and the area of schoolwith the highest percentage of students with acceptable levels of HDL was Satélite-Zona Industrial ($p<0.001$) (Table 5). There were statistically significant differences in the HDL cholesterol concentration mean ($p=0.008$) by marginalization level, where the lowest concentration was in the lowest marginalization area (Lomas-Tangamanga, 32.7 mg/dl) (Table 6).

Two schools had the higher mean values: one located in the Morales area (46.3 mg/dl for men and 56 mg/dl for women) and the other one in the Satélite area (52.1 mg/dl for men and 46.5 mg/dl for women) (Fig. 4).

The 52.8 % of the students had HDL lower than the acceptable levels. The 45.5 % of the schools had a mean HDL level lower than the acceptable in both women and men groups. These schools were located in the Soledad 2, Centro, and Lomas areas (Fig. 4).

There was no statistically significant difference in the acceptable total cholesterol values by gender (Table 3). There were more students in public schools that had

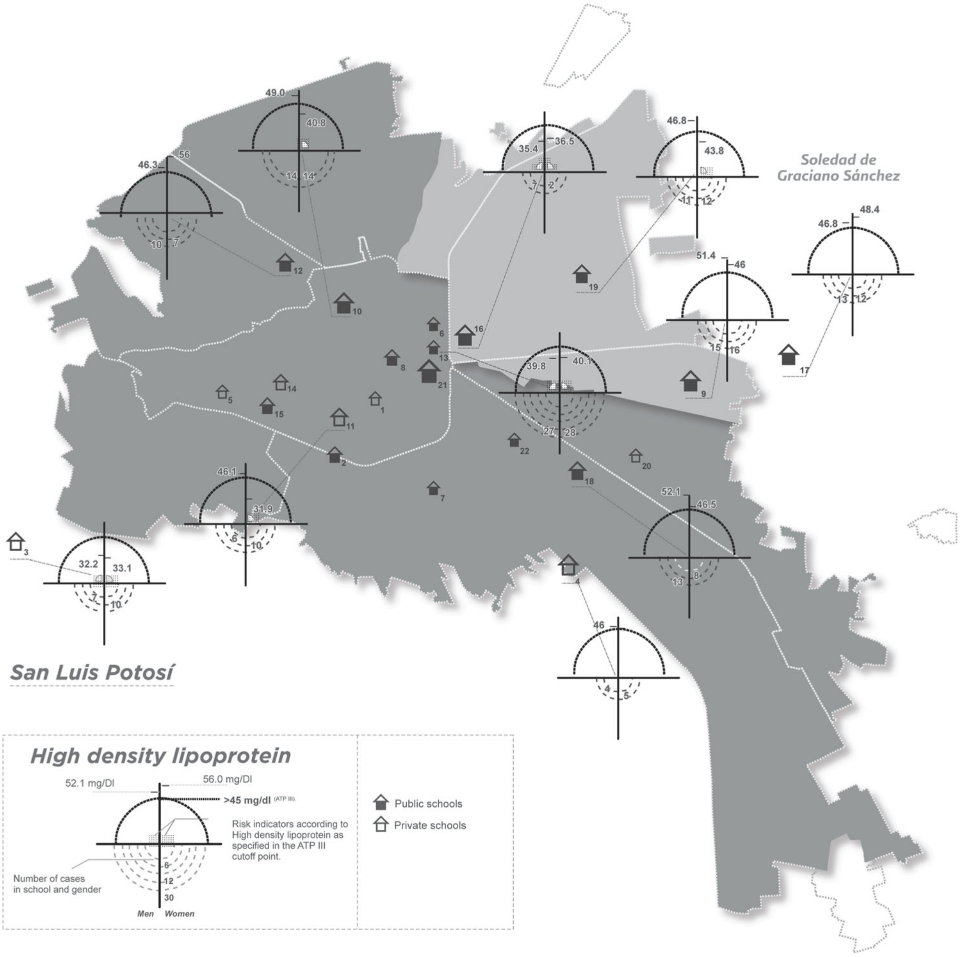

FIG. 4 Distribution of high-density lipoprotein per school.

acceptable levels of HDL (p=0.001) (Table 4). There were statistically significant differences in the acceptable total cholesterol values by area (Table 5) and the marginalization level (p<0.0001) (Table 6), and the total number of students of Lomas-Tangamanga was in low levels for HDL cholesterol.

Other Findings

It is emphasized that 2.9 % of the schoolchildren had the three lipid parameters altered, 26.9 % had two lipid parameters altered, and 39.4 % had one abnormal lipid parameter. Only 31.33 % of the schoolchildren had the three parameters within acceptable values. There was no statistically significant difference by gender (p=0.354) (Table 3), type of schools (p=0.354) (Table 4), area (p=0.06) (Table 5), and marginalization (0.033). According to the analysis by school, 13.6 % of schools had their complete population of students within acceptable lipid values, 34.8 % had their students with none or just one altered value, 4.3 % had all their students with one altered lipid value, and the rest of the schools had their students with up to two altered values (Fig. 5). A risk scale was developed, and it was found that

FIG. 5 Distribution of risk factors per school.

TABLE 7 Degree of risk factors associated with dyslipidemia

School	Sampled students	WRF	% WRF	RF1	%RF1	RF2	%RF2	RF3	%RF3	RI	DR
10	37	11	29.7	9	24.3	14	37.8	3	8.1	1.0	0.88
18	24	7	29.2	11	45.8	4	16.7	2	8.3	0.9	
21	64	16	25.0	24	37.5	23	35.9	1	1.6	0.8	
17	35	14	40.0	11	31.4	9	25.7	1	2.8	0.8	
11	18	4	22.2	7	38.9	6	33.3	1	5.6	0.8	
16	43	11	25.6	19	44.2	12	27.9	1	2.3	0.8	
19	28	8	28.6	12	42.9	7	25.0	1	3.6	0.8	
9	41	17	41.5	16	39.0	8	19.5	0	0.0	0.7	0.55
12	18	7	38.9	5	27.8	6	33.3	0	0.0	0.6	
4	39	17	43.6	17	43.6	5	12.8	0	0.0	0.5	
3	17	0	0.0	8	47.0	8	47.0	1	5.8	0.5	
14	3	1	33.3	1	33.3	1	33.3	0	0.0	0.4	
8	4	1	25.0	3	75.0	0	0.0	0	0.0	0.3	0.25
2	3	0	0.0	3	100.0	0	0.0	0	0.0	0.2	
7	1	0	0.0	1	100.0	0	0.0	0	0.0	0.1	0.10
5	1	0	0.0	1	100.0	0	0.0	0	0.0	0.1	
1	1	0	0.0	1	100.0	0	0.0	0	0.0	0.1	
13	1	0	0.0	1	100.0	0	0.0	0	0.0	0.1	
20	1	0	0.0	1	100.0	0	0.0	0	0.0	0.1	
6	1	1	100.0	0	0.0	0	0.0	0	0.0	0.1	
22	1	1	100.0	0	0.0	0	0.0	0	0.0	0.1	
15	2	2	100.0	0	0.0	0	0.0	0	0.0	0.1	

WRF without risk factor, *RF1* risk factor 1(HDL), *RF2* risk factor 2 (cholesterol), *RF3* risk factor 3 (triglycerides), *RI* risk index, *DR* degree of risk

31.81 % of schools had a risk value of 0.88, while 36.36 % of them had a risk value of 0.10 for dyslipidemia (Table 7).

CONCLUSIONS AND DISCUSSION

This research is the first to explore the association between dyslipidemia among children and adolescents and the geographical location of various schools in the city of San Luis Potosí.

The results suggest that schoolchildren have dyslipidemia in relation to elevated triglyceride levels and low HDL levels. This is consistent with a study by Aradillas et al., in which it was found that 4.00 % of the population between 16 and 18 years old from the city of San Luis Potosi had hypertriglyceridemia and 40.00 % had an increased risk for microvascular disease due HDL levels below 39 mg/dl (according to the reference guide established by the International Diabetes Federation European Region in 1999).[18]

This study gives a relation between certain biochemical parameters and the level of marginalization of the geographic zones studied. The lower concentrations specifically those of total cholesterol were found in the lowest marginalization areas (Lomas-Tangamanga). However, we looked a lower HDL concentration in that area in comparison with the higher marginalization areas.

Analyzing the chemical parameter media and the geographic area by school, we found that the higher values specifically those of triglycerides and total cholesterolwere identified in the zones with the higher growth and number of population.

The results are consistent with some studies that show that the geographic area distribution and the higher urbanization are associated with the increase of obesity, decrease of physical activity, and a poor health.[19]

Environmental determinants of health are receiving growing attention in the literature, although there is little empirical research in this area. The Study on Environmental and Individual Determinants of Physical Activity (known as the SEID project) was a social ecological project that examined the relative influence of individual, social environmental, and physical environmental determinants of recreational physical activity. It involved a community survey of 1803 healthy workers and home makers aged 18–59 years living in a 408-km^2 area of metropolitan Perth, Western Australia. Physical environmental determinants were mainly conceptualized as spatial access to popular recreational facilities. Overall, 59 % of respondents exercised as recommended. Recreational facilities located near home were used by more respondents than facilities located elsewhere. The most frequently used facilities were informal: the streets (45.6 %), public open space (28.8 %), and the beach (22.7 %). The physical environment's directs the influence on exercising as recommended was found to be secondary to individual and social environmental determinants. Nevertheless, accessible facilities determined whether or not they were used and, in this way, support and enhance the achievement of recommended levels of physical activity behavior by providing opportunities. The results suggest that access to a supportive physical environment is necessary but may be insufficient to increase recommended levels of physical activity in the community. Complementary strategies are required that aim to influence individual and social environmental factors. Given the popularity of walking in the community, it is recommended that greater emphasis be placed on creating streetscapes that enhance walking for recreation and transport.[20] In relation to the marginalization level, it has been observed that, usually, it is allied with the poverty, barriers to get resources, and little health services, which increases the susceptibility to get a poor health. In the study, despite we found some higher parameters in this area, the fact that we presented higher HDL in comparison with lower marginalization areas is an object for study. The above could suggest that the students in the lower marginalization areas could be more active than the higher marginalization areas; however, both groups show no acceptable averages.

Current evidence to treat hyperinsulinemia and hypertriglyceridemia suggests that one of the objectives should be lifestyle changes by combining a proper diet and aerobic and resistance exercise. In terms of diet, interventions that promote increased availability, accessibility, and consumption of drinking water are suggested, in addition to daily consumption of vegetables, legumes, whole grains, and fiber grains; decreased consumption of sugars by increasing the availability and accessibility of food reduced or with no added caloric sweeteners; decreased consumption of saturated fats in the diet; and minimization of trans fat from industrial sources. On the other hand, improve the current models of physical activity in schools with at least 30 min of moderate to vigorous activity along with proper spaces and materials for students to play freely, which may allow the practice of individual and group sports during leisure time and physical education class. In turn, limiting the time spent in sedentary activities such as watching television is necessary.

The location of overlapping parks and schools reveals that parks are in areas with high and middle incomes (mainly the Lomas, Morales, and Soledad 1 areas). Whereas, areas with high levels of marginalization are associated with poor green spaces and have higher crime rates. The Centro area of the City of San Luis Potosi is a clear example of this reality.[21]

This study had some limitations; it is recommended a further analysis including other variables of environmental impact such as neighborhoods located in the vicinity of toxic waste dumps, sewage waste, and industry, in order to further explain and understand the health profiles of minority populations compared to the dominant social groups. The characteristics of an impassable neighborhood disproportionately affect communities with minority populations or residents with low incomes.[16] In consequence, a focus on environmental justice for risk factors in children is necessary, as it provides a more explicit turn on potential intergenerational inequities and physical and emotional problems that are related to rising rates of obesity, dyslipidemia, and other NC among children.[20]

The results of this analysis determine our understanding on the dynamics of certain children's risk factors and may be beneficial for the development of specific interventions and policies aimed at addressing childhood obesity in the state of San Luis Potosi. Lifestyle interventions that incorporate better eating habits, increased physical activity, and decreased sedentary activities should be the first-line approach for students.

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