Anthropometric and biochemical assessment of nutritional status and dietary intake in school children aged 6-14 years, Province of Buenos Aires, Argentina

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ABSTRACT

Introduction: Childhood obesity is a global epidemic. School age and adolescence are critical stages for the implementation of eating and lifestyle habits.

Objective: To assess anthropometric and biochemical assessment of nutritional status and dietary intake in children, their relationship with socioeconomic factors and georeferencing.

***Methods*:** Cross-sectional study in schoolchildren aged 6-14 years from the District of General Pueyrredón, during August-November 2013. Dietary intake was assessed using a 24-hour dietary recall interview, and georeferencing was done using the gvSIG software.

Results: A total of 1296 children were included for anthropometric and socioeconomic assessment. A sub-sample included 362 children for intake and biochemical parameters. Overweight was observed in 42.97% (95% confidence interval [CI]: 40.3-45.7) and obesity, in 18.5% (95% CI: 16.3-20.5). Breakfast was related to a lower risk for overweight (OR: 0.7, 95% CI: 0.5-0.9) and obesity (OR: 0.7, 95% CI: 0.5-0.9). Attending high school was related to a lower prevalence of weight excess (OR: 0.45, 95% CI: 0.3-0.7); male sex posed a higher risk for obesity (OR: 1.7, 95% CI: 1.3-2.3). Also, 4.44% of participants had anemia; 19.6%, hypercholesterolemia; and 21.3%, hypertriglyceridemia. Lipid and saturated fat intake was high, whereas dietary cholesterol and fiber intake was low. Geographic distribution was homogeneous.

***Conclusions*:** The prevalence of overweight was high. The risk for obesity was higher among boys; breakfast appeared as a protective factor against overweight/obesity. A low-fiber and high-fat intake, and high blood cholesterol and triglyceride levels reveal that overnutrition is a prevalent public health problem.

Key words: *nutritional status, obesity, overweight, child nutrition, adolescent nutrition.*

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INTRODUCTION

In the past three decades, childhood obesity has become a global epidemic.[1-3] School age and adolescence are critical stages for shaping eating and lifestyle habits that will last later in life and have an effect during adulthood and even old age.[4]

Vitamin A deficiency is a health problem worldwide, especially in developing countries. Iron and zinc are relevant nutrients for an adequate growth and development.[5] The most common forms of childhood malnutrition are specific micronutrient deficiencies that may not be diagnosed using an anthropometry.[6] Such deficiencies affect learning, growth, and development in children.[5]

At present, Latin America is going through a nutritional transition and for this reason malnutrition coexists with overweight, obesity, and micronutrient deficiencies.[7] In Argentina, the most recent studies have demonstrated that at least 3/10 children or adolescents are overweight,[8-10] and this prevalence has increased steadily in the past years, as in the rest of the world.[11] Most studies on nutritional status have focused on preschoolers and adolescents, so our objective was to make an anthropometric and biochemical assessment of nutritional status and dietary intake in schoolchildren aged 6-14 years from the District of General Pueyrredón, their relationship with socioeconomic factors and to implement georeferencing based on children's place of residence.

POPULATION AND METHODS

Descriptive, analytical, cross-sectional study conducted between August and November 2013 in the District of General Pueyrredón (Province of Buenos Aires [PBA]), a town of 618 989 inhabitants, of whom 81 911 were aged 6-14 years (13.23%).[12] In 2013, the District of General Pueyrredón had 323 schools. The rate of school enrollment was 94% in 2006.

The sample included schoolchildren aged 6-14 years. Participants selected for the sub-sample were asked to fast for 12 hours. Children with chronic conditions and primary or secondary immunosuppression were excluded.

The sample size estimated for the anthropometric assessment was 1197 students, considering the less prevalent event (wasting: 1.4%),[8] and a 95% confidence level. The District of General Pueyrredón was divided into three areas; the eight divisions of the school district were grouped and 22 schools were randomly selected, respecting the percentage of public and private schools (60%/40%, respectively) and the proportion of each age group. Grades were also randomly sampled.

A sub-sample was selected to assess dietary intake and biochemical parameters. The sub-sample size was estimated at 300 children, considering a 25% event prevalence (anemia), and a 95% confidence level.[13] Five or six children were randomly selected from each grade for this estimation.

Socioeconomic data were collected using a specially designed questionnaire, which was completed by parents under the supervision of trained staff (see *Annex 1*).

Anthropometric data were collected at each school by trained staff (see *Annex 2*). Weight was measured using CAM portable scales, P-1001-PCADOBLE code. Height was measured using a non-extensible tape measure in a vertical plane and on a hard surface as horizontal plane. Measuring techniques were based on the Growth and Development Guidelines of the Argentine Society of Pediatrics.[14] Waist circumference was measured at the upper edge of the iliac crest using the cross-handed technique and a Lufkin-like metal tape. References from J. R. Fernández et al. were used assuming a cut-off point in the 90th percentile.[15] Two measurements were made and the average was estimated.

Lab samples were taken by trained nurses and processed within 3 hours of collection. Ethylenediaminetetraacetic acid (EDTA) tubes were used (hemoglobin and hematocrit) and a tube without anticoagulant for the rest of the lab tests.

Samples were analyzed at the lab of Hospital Interzonal Especializado Materno Infantil (HIEMI). Vitamin A, zinc, and folate were studied at the lab of the Pediatric Research and Development Institute (Instituto de Desarrollo e Investigaciones Pediátricas [IDIP]) "Prof. F. E. Viteri," Hospital de Niños "Sor María Ludovica," La Plata.

For collecting data on intake, 11 nutritionists were trained on standardized methodology and used a 24-hour recall interview, visual aids, and food fact sheets.[16,17] The proportion of week days, weekends or holidays was established to assess intake.

Two teams made up of 10 people were available (nurses, nutritionists, physicians, promoters, and social workers). Two schools were assessed each week, and 3 weekly visits were made to each school. Feedback was provided to each schoolchild. Participants with nutritional alterations were contacted for a referral to the Department of Pediatrics.

The following sociodemographic outcome measures were included: sex, age, maternal level of education, health coverage, private/public school, primary/secondary education, number of daily meals, and breakfast, lunch, and dinner habits ≥ 4 times per week.

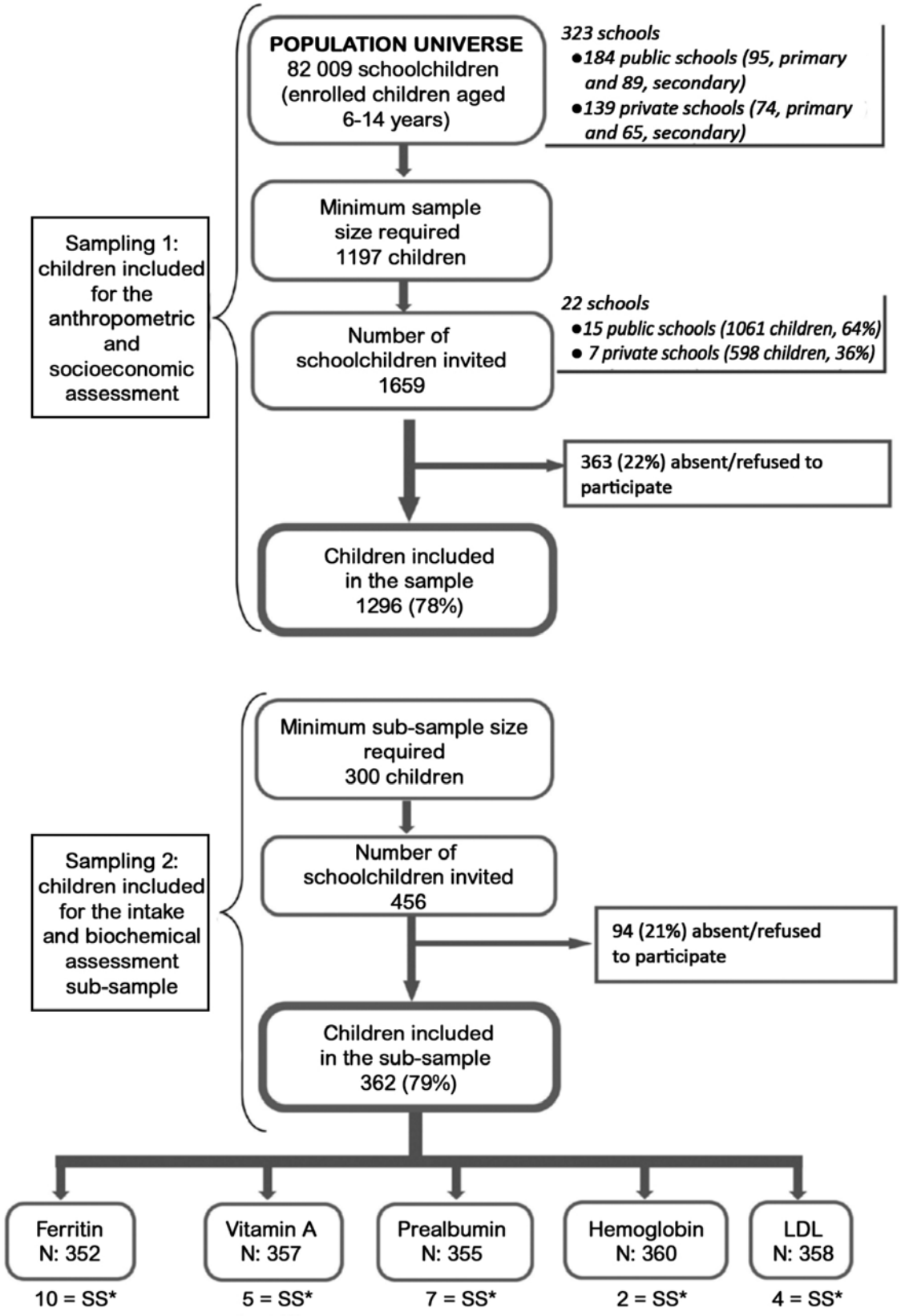
Anthropometric outcome measures: child growth standards and classification published by the World Health Organization (WHO).[18]

Nutritional status (body mass index [BMI])[15,19] was classified into very low weight: ≤ -3 standard deviations (SDs); low weight: ≤ -2 SDs/> -3 SDs; normal weight: > -2 SDs/< +1 SD; overweight: ≥ +1 SD/< +2 SDs; obesity: ≥ +2 SDs/< +3 SDs; severe obesity: ≥ +3 SDs. Overweight, obesity, and severe obesity were considered excess weight. Waist circumference (WC) was considered normal if < 90th percentile and increased if ≥ 90th percentile.

Biochemical outcome measures were estimated: hematocrit and hemoglobin (low: < -2 SDs of the mean for age and sex as an anemia indicator), lipid profile, prealbumin (nephelometry), ferritin (chemiluminescence), vitamin A, zinc (flame atomic absorption spectroscopy, 213.9 nm), and folate.

Calorie, protein, fat, cholesterol, carbohydrate, fiber, vitamin A, calcium, iron, zinc, and folate intake was assessed.

FIGURE 1. *Sample selection. Sampling 1 and 2*



* SS: scant specimen.

Trans fat intake was estimated by difference from total fat as a percentage of the median energy intake.

Ethical considerations: the study was approved by the Bioethics Committee of HIEMI and the Joint Commission of Health Research of the Ministry of Health of the PBA.

A signed informed consent was obtained from parents or guardians, together with schoolchildren's assent.

Statistical analysis

The following software programs were used: the WHO Anthro Plus for the anthropometry, the SARA (analysis system and food registry) for intake, and the Epi Info 7 for the statistical analysis.

Median and interquartile range or mean and standard deviation (SD) were estimated for continuous outcome measures, and proportions were calculated for categorical data with 95% confidence intervals (CI). The t test or the Wilcoxon rank-sum test was used for continuous data, and the χ^2 test, for proportions. A multivariate analysis was done using a multiple logistic regression model and outcome measures associated with overweight and obesity were assessed. The odds ratio (OR) with a 95% CI was used as a measure of association. An alpha error of 5% was considered acceptable.

For intake, the median nutrient value, calorie intake, and percentage of macronutrients from total caloric intake (TCI) were estimated. Results were compared to the dietary reference intake (DRI).[20]

For georeferencing, the gvSIG software was used to manage geographic information with mapping accuracy, which helped to visualize the sample distribution. No statistical tests were used.

RESULTS

The anthropometric assessment and the survey were completed in 1296 schoolchildren from 70 grades of 22 schools; 362 had a blood sample taken (*Figure 1*).

Table 1 describes the characteristics of the population.

Anthropometry

Excess weight was observed in 43% of children (95% CI: 40.3-45.7) (*Figure 2*).

Increased WC was observed in 19.1% (95% CI: 16.91-21.19). The proportion varied by

TABLE 1. *Description of the population, n= 1296*

Outcome measure	Frequency (%)	Overweight percentage	*p*	Obesity percentage	*p*	Excess weight percentage (overweight + obesity)	*p*
Age group							
6-8 years old	387 (29.8)	23	0.4	18.4	0.9	41.3	0.4
9-14 years old	909 (70.1)	25.2		18.5		43.7	
Type of school							
Public	818 (63.1)	23.6	0.3	19.9	0.07	43.5	0.6
Private	478 (35)	26.2		15.9		42.1	
Sex							
Male	627 (48.4)	23	0.2	22.3	0.0004	45.3	0.1
Female	669 (51.6)	26		14.8		40.8	
Level of education							
Primary	998 (77)	25.9	0.03	19.6	0.04	45.6	0.0005
Secondary	298 (23)	19.8		14.3		34.2	
Living with children < 5 years old							
No	1219 (95.5)	24.9	0.2	18.3	0.3	43.2	0.8
Yes	58 (4.5)	17.2		24.1		41.4	
Maternal level of education							
Incomplete secondary education	635 (49)	25	0.6	19.4	0.4	44.4	0.3
Complete secondary or higher education	661 (51)	24.1		17.6		41.6	
Health coverage							
Social insurance or managed care organization	780 (60.8)	24.9	0.2	18.5	0.9	43.3	0.5
Public sector	501 (39.1)	24		19		42.9	
Breakfast							
Yes	1044 (81.6)	24	0.5	17.7	0.06	41.8	0.03
No	235 (18.4)	26.4		23		49.4	

nutritional status and was 78.2% (95% CI: 71.9-83.6) among obese children, 100% (95% CI: 73.54-100) among severely obese children, 15.8% (95% CI: 12.2-20.2) among overweight children, and 0.28% (95% CI: 0.08-1) among those with a normal weight.

As regards eating habits, 76.84% (95% CI: 74.5-79.1) of children had 4 daily meals; 97.7% (95% CI: 96.8-98.4), 2 meals; and 0.39% (95% CI: 0.2-0.9), only 1 meal.

Multivariate analysis

Two multivariate analysis models were developed to assess associated outcome measures due to: a) excess weight (overweight + obesity) and b) obesity. Age, maternal level of education, number of household members, health coverage, type of school or lunch and dinner habits were not associated with excess weight or obesity.

Breakfast was related to a lower risk for overweight (OR: 0.7, 95% CI: 0.5-0.9) and obesity (OR: 0.7, 95% CI: 0.5-0.9). Attending high school was associated with a lower prevalence of excess weight (OR: 0.45, 95% CI: 0.3-0.7). Male sex was related to a higher risk for obesity (OR: 1.7, 95% CI: 1.3-2.3).

Lab tests

The sociodemographic characteristics of the sub-sample showed no significant differences with the overall sample, so it was representative of it. The percentage of obese children was 18.5% (95% CI: 14.9-22.8) and of children with excess weight, 41.2% (95% CI: 36.2-46.3).

Besides, 100% of assessed children had normal zinc and folic acid levels; 2 children had vitamin A deficiency; 3, low ferritin levels; and 2, low prealbumin levels.

Anemia was observed in 16 children (4.4%, 95% CI: 2.7-7.1); 13 boys and 3 girls (OR: 4.6, 95% CI: 1.3-16.4, *p*: 0.01). Ten of these children were in the 12-14-year-old group and 14 had a normal weight for their age.

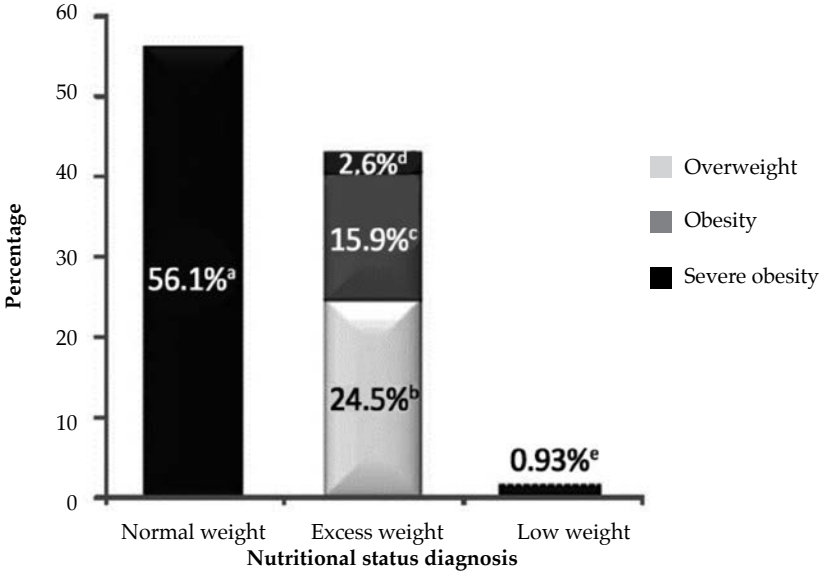
Table 2 shows the results of the biochemical determination of lipid profile.

TABLE 2. *Results of biochemical determinations of lipid profile, n= 362*

Outcome measure		Percentage	95% CI	
Cholesterol	High	3.9	2.2	6.6
	Borderline	15.8	12.2	20.0
	Normal	80.4	75.8	84.3
LDL	High	9.8	7.1	13.3
	Normal	90.2	86.7	92.9
HDL	Low	8.8	6.3	12.2
	Normal	91.2	87.8	93.7
Triglycerides	High	21.3	17.2	25.9
	Low	14.1	10.8	18.2
	Normal	64.6	59.4	69.5

CI: confidence interval; LDL: low density lipoproteins; HDL: high density lipoproteins.

FIGURE 2. *Distribution (%) by final diagnosis of nutritional status, n= 1296*



[a] (95% CI: 53.4-58.8); [b] (95% CI: 22.1-26.8); [c] (95% CI: 13.9-17.9); [d] (95% CI: 1.7-3.5); [e] (95% CI: 0.9-3.9)

High cholesterol levels were detected in 19.6% of children, ranging from 25.5% among obese children to 17.5% among normal weight children. Such difference was not significant.

High triglyceride levels were found in 21.3%. This percentage ranged from 30.2% (95% CI: 23.4-30.7) among children with excess weight to 15.02% (95% CI:10.2-20.1) among those with a normal weight (OR: 2.4; 95% CI: 1.5-4.1, $p < 0.001$).

Among children with excess weight, obese children had a higher prevalence of high triglyceride levels (overweight: 21.95%, obese: 40%, severely obese: 41.67%); when non-obese children were compared to obese ones, the latter had more than a threefold risk for high triglyceride levels than non-obese children (OR: 3.3, 95% CI: 1.86-5.9, $p < 0.001$).

Intake

The median daily intake of energy was 2136 kcal. The median percentage of proteins compared to the TCI was 13.2%; of carbohydrates, 51.6%, and of lipids, 35.5% (*Table 3*). The median percentage of lipids compared to the TCI was higher than recommended (< 10%), as well as the saturated fat intake, whereas dietary cholesterol and fiber intake was lower than recommended. Trans fat intake accounted for approximately 2.69% of the TCI, higher than recommended (1%).

Georeferencing

Children distribution was homogeneous across the District of General Pueyrredón in terms of both biochemical and anthropometric parameters. No predominant areas were observed for none of the studied outcome measures (see *Annex 3*).

DISCUSSION

The results of this study showed a high prevalence of children with excess weight, even higher than that observed in other national studies.[8,9,10] These results were expected and reflect the growing trend of overweight and obesity and the size of the problem in the selected age group.

The WHO technical report "Diet, nutrition and the prevention of chronic diseases: Report of a joint WHO/FAO expert consultation" described this as an increasingly prevalent public health problem that requires to be addressed by means of a comprehensive strategy. For this reason, the recommendation is to prevent obesity in children and adolescents through the promotion of an active lifestyle, fruit and vegetable consumption, a reduction in screen time, and a restriction of sugar-sweetened beverages and salt.[21]

Among the socioeconomic outcome measures included in the multivariate models, male sex

TABLE 3. *Calorie intake by sex and age. Comparison to the dietary reference intake*[**]

	6-8 years old						9-14 years old					
	Girls			Boys			Girls			Boys		
Nutrient	DRI	Percentile		DRI	Percentile		DRI	Percentile		DRI	Percentile	
		50	25-75		50	25-75		50	25-75		50	25-75
Energy 24 h calories/day (kcal)	1519	2024	1722-2315	1614	2075	1548-2404	1856	1945	1844-2790	2082	2394	1582-2532
Proteins (g/day)	38-114	69.9	50-80	40-212	72.5	46-92	46-139	65.4	50-80	52-156	75.6	58-103
Carbohydrates (g/day)	171-247	253.9	202-323	182-262	239.1	198-303	209-302	254	204-329	234-338	307	229-383
Lipids (g/day)	42-59	82.5	47-104	45-63	86.7	50-106	52-72	79.4	54-109	58-81	87.2	63-126
Saturated fatty acids (g/day)	*	25.6	16-38	*	30.2	20-41	*	24.9	16-35	*	29.6	19-44
Polyunsaturated fatty acids (g/day)	9-19	22.3	12-31	10-20	17.6	10-27	12-23	20.3	12-31	13-26	20.1	12-33
Monounsaturated fatty acids (g/day)	----	34.4	18-34	------	30.8	18-37	-----	26.2	18-36	_____	29.6	21-42
Cholesterol (mg/day)	*	233.3	145-385	*	252.9	133-397	*	249.9	146-378	*	292.7	190-432
Fiber (g/day)	25	8.7	5.4-11.9	25	9.6	6-11	26	8.7	6-12	31-38	10.6	8-14
Calcium (mg/day)	800	690.6	468-1006	800	929.4	543-1231	1100	647.7	407-1034	1100	775.5	320-1115
Vitamin A (μg/day)	275	478.6	291-801	275	564.1	332-897	420	411	246-712	445	502.2	281-768
Iron (mg/day)	4.1	12	9.5-17	4.1	13.3	9-17	5.7	12.7	10-16	5.9	15.3	12-21
Zinc (mg/day)	4	9.8	6.5-13	4	9.9	7-14	7	9.2	7-12	7	11.1	8-14
Folate (μg/day)	160	496.5	343-626	160	469.6	302-626	250	509.5	299-706	250	631	381-857

* As low as possible while consuming a nutritionally adequate diet.

** Dietary reference intake by the Food and Nutrition Board. Institute of Medicine. National Academy of Sciences 2002-2005.

DRI: dietary reference intake.

was the only one associated with a higher risk for obesity. Such association has been described in the bibliography.[22]

In addition, breakfast habit (at least 4 times per week) was observed to be a protective factor against both overweight and obesity; this has been demonstrated in different studies.[23,24] In a systematic review, H. Szajewska et al. described that children who did not have breakfast had a higher prevalence of overweight and obesity. Breakfast leads to regular eating habits, an adequate energy intake and a healthier food choice. It has been demonstrated that those who do not have breakfast tend to eat snacks high in fat and/or sugar at mid-morning.[25-27]

Regardless of the mentioned outcome measures, attending high school was also associated with a lower risk for excess weight. This may be explained by the eating habits and physical activity among high school children.[28,29] In the bibliography no association has been established between the level of education and nutritional status; future studies are required to confirm such association and assess potential causes. In this regard, intake was higher than the DRI among children aged 6-8 years, with excess carbohydrate and fat consumption. This, together with the higher overweight and obesity prevalence related to primary school, suggests the influence of an obesogenic environment at this level.

No differences were observed in the prevalence of overweight or obesity in relation to age, sex, type of school (public/private), maternal level of education or health coverage. Besides, no relationship was observed to other factors frequently associated with childhood nutritional status deficiencies, such as maternal age or having siblings younger than 5 years.[6]

A significant percentage of children, who mainly had severe obesity, had a WC > P90. The increase in abdominal fat has been described as a risk factor for cardiovascular disease. The Bogalusa Heart Study, which was conducted in children aged 5-17 years, showed an association between central fat mass distribution measured by WC and abnormal triglyceride, low density lipoprotein (LDL), high density lipoprotein (HDL) and insulin levels.[30]Hirschler et al. described, among Argentine schoolchildren aged 6-13 years, a prevalence of WC > P90 of 0% (normal weight), 28.6% (overweight), and 87.5% (obesity), which was similar to our results that indicated 51% of children with a WC > P90 had at least one risk factor for cardiovascular disease.[31]

Once lab test data are analyzed, it is worth noting that a significant proportion of children had high cholesterol levels, even children with normal weight. Some studies refer that excess weight is associated with higher total cholesterol, LDL, and triglyceride levels and a lower HDL level.[32]

Based on our findings, determining triglyceride levels in obese children may help to detect approximately 40% of those who have an increase in this parameter. However, this excludes children with a normal weight, who probably have a greater representation of the genetic component and may be at risk for cardiovascular disease in the future.

Practically no vitamin or mineral deficiencies were observed.

The prevalence of anemia observed here was very low. This was expected in the studied age group. A lower prevalence of anemia has been described in schoolchildren compared to early childhood and adolescence[8] given the improved adaptation between intake and nutritional requirements. Flour fortification as per Law no. 25630 (2002) may have contributed to a reduction in anemia in Argentina. However, specific studies are required to account for such finding.

The geographic distribution of children with excess weight was homogeneous across the District of General Pueyrredón. This demonstrates that such health problem is not exclusive of a specific sector or geographic area.

For dietary intake analysis, a 24-hour recall interview was used. The disadvantage of this tool is under-recording but it is the recommended instrument for population studies. For this reason, the study included food fact sheets, visual aids, and a standardized recall template with foods that are generally left out. Given the monotonous diet, all foods were included in the SARA software and analyzed.

Calcium intake was insufficient compared to the DRI, especially in the 9-14-year-old group, which may be explained by the increase in energy requirements and an inadequate dairy intake.[33]

Fiber intake was low in all age groups. Total fat intake was high at the expense of saturated fat; trans fat intake was twice the recommended values and dietary cholesterol was lower than recommended.

High blood cholesterol and triglyceride levels are consistent with excessiveintake of total, trans, and saturated fats, which may increase the risk for cardiovascular disease.[21,34]

This study has been conducted based on a reliable methodology for weight, height, waist, and biochemical parameter measurements. Some of the limitations of this study are the lack of data on outcome measures such as physical activity, screen time, and other factors related to excess weight.

CONCLUSION

The prevalence of excess weight was higher than what has been previously reported. The risk for obesity was higher among boys, and breakfast appeared as a protective factor against both overweight and obesity. In turn, a low-fiber and high-fat intake and high blood cholesterol and triglyceride levels have been reported, which altogether reveal that overnutrition is a prevalent public health problem. ■

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ANNEX 1

Socioeconomic data collection sheet

This **survey** is part of the study on the nutritional status of schoolchildren from the District of GeneralPueyrredón. You should know that data **will not be used for any other purposes and that children's names and data will not be disclosed in reports.**
Please take 10 minutes to complete this survey. Thank you!

DATE OF SURVEY _____/_____ /_____ ID ☐

Child's last and first names: _____

ID no.: _____

Date of Birth: __/_____ /_____ Sex: Male ❑ Female ❑

Place of birth: _____

Address: _____

School:_____ Grade: _____

1. What meals does the child usually have? (You may choose more than one) at least 4 times per week

Breakfast❑ Lunch❑ Afternoon snack❑ Dinner ❑

2. How old is the mother or caregiver? Age: __years old.

3. Mother's or caregiver's level of education: (Choose only the highest level attained).

None❑ Incomplete primary education❑ Complete primary education❑

Incomplete secondary education ❑ Complete secondary education❑

Incomplete university education ❑ Complete university education ❑

4. Health coverage. What type(s) of health coverage or insurance does the child currently have?

Social insurance / managed care organization ❑

No coverage, receives care at a public primary health care center or hospital ❑

5. Who else shares the household, including you?

Write down the relationship that each member of the household has with the child (e.g., father or mother's spouse, mother, sibling, uncle, etc.)	AGE

Thank you for your help!

ANNEX 2

Anthropometric and biochemical assessment of nutritional status and dietary intake of children aged 6-14 years, Province of Buenos Aires, Argentina

YEAR 2013

ANTHROPOMETRIC REGISTRY SHEET SCHOOL: ____________ DATE: ___ / ___ / ___ NAME OF PERSON RECORDING DATA: ____________

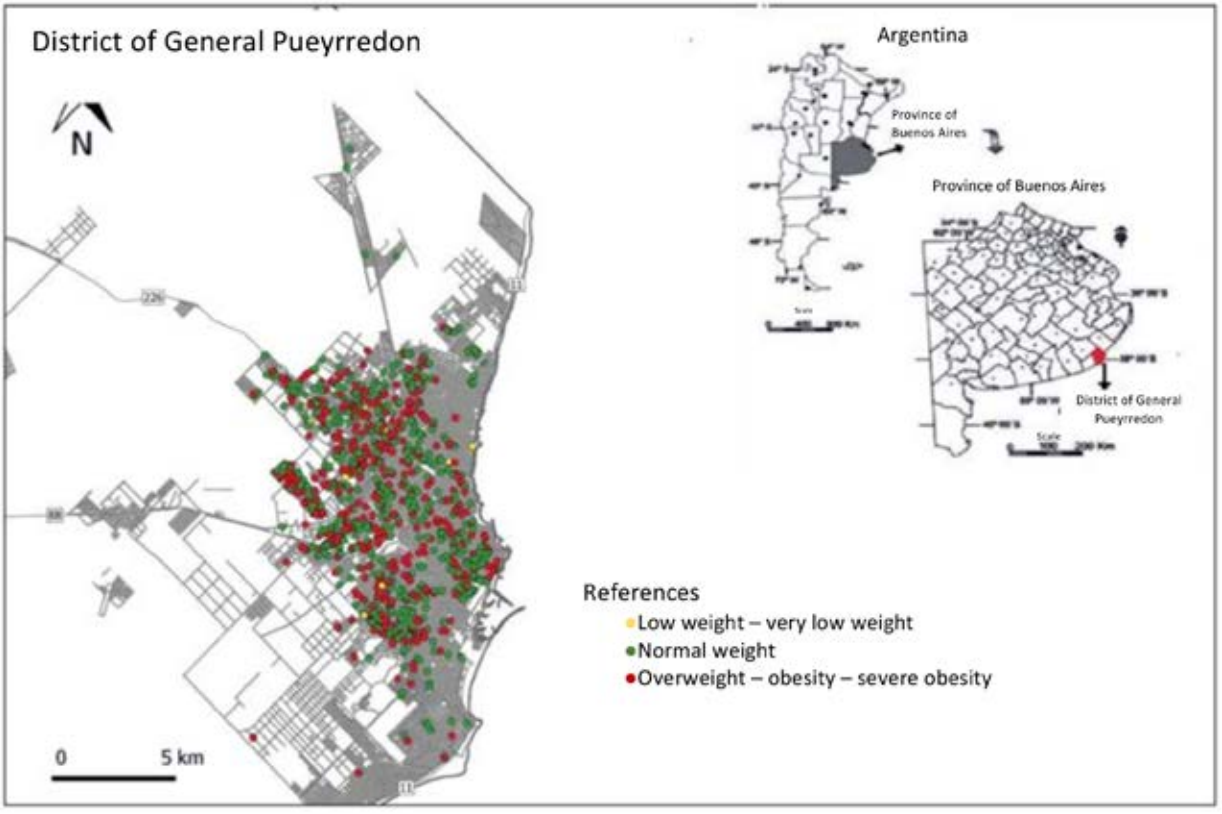
ID	ID no.	LAST AND FIRST NAMES	GRADE	SEX	DATE OF BIRTH	WEIGHT (kg)	HEIGHT (cm)	WAIST CIRCUMFERENCE (cm)	REMARKS
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	
						1 2	1 2 3 *	1 2 3 *	

* A third measurement is made if the two first measurements show a difference of 1 cm or more..

ANNEX 3

Distribution of children by nutritional status.

District of General Pueyrredón, Province of Buenos Aires, Argentina



ANNEX 4

Collaborators

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