Contexts of occurrence of child malnutrition in the district of Villaguay, Entre Ríos, Argentina. A multivariate analysis

María Laura Bergel Sanchís1*, María Florencia Cesani1*, Evelia Edith Oyhenart1,2☯

1 IGEVET—Instituto de Genética Veterinaria “Ing. Fernando Noel Dulout” (UNLP-CONICET LA PLATA), Facultad de Ciencias Veterinarias, UNLP, La Plata, Buenos Aires, Argentina, 2 Cátedra de Antropología Biológica IV, Facultad de Ciencias Naturales y Museo, UNLP, La Plata, Buenos Aires, Argentina

☯ These authors contributed equally to this work.

* lbergel@igevet.gob.ar

Abstract

The analysis of nutritional status is anthropologically important to address the complex interaction of biological, social, political, economic and cultural factors. To deepen the knowledge about contexts of occurrence of child malnutrition, we analyzed nutritional status in relation to socio-environmental conditions of residence in children between three and six years from Villaguay, Entre Ríos, Argentina. We performed a cross-sectional study of 1,435 school children of both sexes. Body weight and height were measured and prevalence of low height/age (LH/A), low weight/age (LW/A), low BMI/age (LBMI/A), overweight (Ow) and obesity (Ob) was calculated using World Health Organization reference charts. Socio-environmental information was obtained through a semi-structured survey and processed by Categorical Principal Component Analysis (CatPCA). Anthropometric data showed 1.5% LW/A, 5.2% LH/A; 0.6% LBMI/A, 20.9% Ow and 10.9% Ob. CatPCA allowed us to define four groups (G1-G4) with better (G2), middle (G1) and worst (G4) urban socio-environmental conditions and one with rural characteristics (G3). G4 presented the highest LH/A prevalence and G2 the highest Ow and Ob prevalence (P<0.05). It is concluded that since the distribution of malnutrition was not even it may depend on the context in which children grow up. Thus, the higher the socio-economic level, the higher the incidence of overweight and obesity. Conversely, at the other end of the social scale, undernutrition and increasing weight excess remained major health problems.

Introduction

Anthropometric indicators are widely used to evaluate growth, nutritional status and general health status of individuals and populations [1]. Anthropometric studies compare measurements of a study sample with those of reference populations [2]. Such comparisons are useful to identify cases or populations with or at risk of malnutrition and to implement public health interventions accordingly [3].

Anthropologically, nutritional status represents the complex interaction among different factors, such as biological and socio-environmental factors [4]. The former includes the
specific requirements for each stage of the life cycle, whereas the latter comprises the structural elements related to food availability and access. Together, these factors define the material and symbolic context where the child grows [5].

Malnutrition is the imbalance between inadequate and excessive energy intake, and it comprises deficiency (undernutrition) and excess (overweight and obesity). Both have direct consequences on health and damage may be irreversible during growth [6].

Evidence in the literature suggests that the growth of children up to five years is similar worldwide, regardless of ethnicity [6, 7]. Therefore, changes in growth and body size may be mainly due to differences in dietary intake, socioeconomic status and living conditions [8]. In this context, undernutrition is both a cause and a consequence of poverty since its accumulated effects during childhood will result in low productivity, lower income and health problems during adulthood, thus creating a vicious cycle [9, 10]. Similarly, mothers of these children also present weight and height deficiencies as a result of inadequate dietary intakes during childhood, which may derive in intergenerational undernourishment [11].

On the other hand, excess weight is associated with higher socioeconomic status/welfare [12], despite this relationship may vary depending on whether it occurs in developed or developing countries. In fact, excess weight has long been considered exclusive to developed countries and mainly involved with the poorest populations [13–17]. However, a rapid increase of the incidence of excess weight has been lately reported in developing countries, but associated with higher income populations [18]. Additionally, an increased prevalence of overweight and obesity has also been observed in lower socioeconomic groups [12, 19–22]. In this case, difficulties in accessing adequate food may predispose children living in impoverished environments to manifest such percent excess weight [23, 24], together with iron or muscle tissue deficiency [25, 26]. Finally, Dinsa et al. [27] further explored the association of socioeconomic condition and obesity, suggesting that obesity is a problem of rich people in low income countries, whereas a mixed situation would occur in middle-income countries.

Although food issues involve different sectors, children are the most vulnerable population not only in Argentina but also in the rest of Latin America [7, 28]. Various reports confirm the tendency towards an increasing prevalence of overweight and obesity, with a concomitant decrease in underweight and a persistent height deficit, which is known as nutrition transition [29–31]. This process is characteristic of developing countries and is mainly related to the shift from traditional diets based on fiber-rich/fat-poor starch products to fat-and sugar-rich diets and industrialized foodstuff. This, together with the advances of technology, define the obesogenic environment [32, 33]. In all, changes in the nutritional pattern are due to changes in food consumption, production and marketing accompanied by changes in life style, mainly in peripheral capitalist countries [31].

Beyond this trend, several authors have reported for Argentina the coexistence of child deficiency and excess conditions with marked differences among provinces, regions and socioeconomic conditions [7, 34–38]. Therefore, in order to deepen the knowledge of the contexts of occurrence of child malnutrition, we analyzed the relation between nutritional status and socio-environmental conditions of residence in school-age children between three and six years from the department of Villaguay, Entre Ríos, Argentina.

Materials and methods

Ethics statement

The study aims and procedures were explained during meetings held at each school. Informed consent was signed by the children’s parents or guardians. Children whose parents did not
sign the forms were not measured. In addition, the children themselves were consulted and only those who agreed (orally) were included in the study.

The research was conducted attending the principles proclaimed in the Universal Declaration of Human Rights (1948), ethical standards instituted by the Nuremberg Code (1947), the Declaration of Helsinki (1964) and subsequent amendments and clarifications, and national Law 25.326 and its amendments (Law 26.343/08), regulations and rules for the protection of personal data. This study was approved by the Bioethics Committee of the Latin American School of Bioethics (CELABE, for its acronym in Spanish; Resolution 020, Record 76).

Population

The department of Villaguay is located in the center of the province of Entre Ríos, Argentina (31°51'00" S 59°01'00" W) (Fig 1). It is the fourth largest department of the province (6,753 km²) and the ninth with the largest population (48,965 inhabitants). Rice farming is the main
economic activity, followed by livestock farming, agriculture, poultry farming, beekeeping and horticulture.

**Sample**

Educational institutions were selected by convenience sampling. The total number of kindergartens and elementary public schools was recorded in six out of seven cities of the department of Villaguay (Villaguay, Villa Clara, Villa Domínguez, Jubileo, Ingeniero Sajaroff and Paso de la Laguna) in order to represent urban and rural areas.

A cross-sectional anthropometric study was performed in children aged 3.0–6.9 years. Children having a chronic disease or pathological conditions at the moment of the study were excluded. Children who did not have parental or guardian written informed consent or who refused to participate were also excluded. The final study sample included 1,435 children (722 males and 713 females), representing 47.4% of school enrolment [39] (Table 1). The study was performed during the 2010–2012 school terms.

**Socio-environmental study**

Parents or guardians completed a structured questionnaire evaluating socio-environmental characteristics and measuring housing variables with information regarding structural and physical amenities. These characteristics provided information about indoor (construction, overcrowding, main source of drinking water according to the system of water supply, sewage disposal, fuel used for cooking and heating) and outdoor housing conditions by the degree of coverage and access to public services (pavement, electricity and waste collection). To complement the information on family socioeconomic level, we asked about lodging or housing tenure, level of education and parental employment, health insurance coverage, and supplementary income, including access to national or local programs from governmental agencies, non-governmental organizations or other entities to benefit poor families by supplementing their food budget (nutritional support) and/or by providing cash relief to the heads of households (monetary support). Animal husbandry and orchard were also considered. Other aspects related to family comfort were also taken into account, such as car ownership, internet access, computer and air conditioning [40].

Table 1. Sample composition and mean (M), median (Me) and standard deviation (SD) of the variables measured.

| Age (years) | Sample | Weight (kg) | Height (cm) | Body Mass Index |
|-------------|--------|-------------|-------------|-----------------|
|             | N      | %           | M  Me  SD   | M  Me  SD       | M  Me  SD       |
| **Male**    |        |             |             |                 |                 |
| 3.0–3.99    | 82     | 57.8        | 16.33 15.87 3.86 | 98.18 98.05 5.17 | 16.86 16.56 3.26 |
| 4.0–4.99    | 141    | 45.3        | 18.20 17.91 3.01 | 104.93 105.10 5.06 | 16.46 16.00 1.88 |
| 5.0–5.99    | 264    | 48.9        | 21.16 20.18 4.49 | 112.24 112.40 5.76 | 16.66 16.21 2.31 |
| 6.0–6.99    | 235    | 53.2        | 22.69 21.77 4.09 | 116.73 116.30 5.12 | 16.56 16.11 2.06 |
| **Total**   | 722    | 50.3        |             |                 |                 |
| **Female**  |        |             |             |                 |                 |
| 3.0–3.99    | 60     | 42.2        | 15.08 14.51 3.06 | 96.03 96.00 5.42 | 16.25 15.83 2.08 |
| 4.0–4.99    | 170    | 54.7        | 18.19 17.23 3.88 | 104.43 104.00 4.91 | 16.61 16.08 3.09 |
| 5.0–5.99    | 276    | 51.1        | 19.87 19.36 3.86 | 110.18 110.40 6.43 | 16.54 15.77 5.98 |
| 6.0–6.99    | 207    | 46.8        | 22.38 21.62 4.47 | 115.82 21.62 5.45 | 16.58 15.98 2.40 |
| **Total**   | 713    | 49.7        |             |                 |                 |

Number (N) and percentage (%) of children surveyed and assessed, distributed by sex and age.

https://doi.org/10.1371/journal.pone.0176346.t001
Anthropometric study

Anthropometric measurements were performed by a single technician (MLBS) according to standard protocols [2]. The following variables were recorded: age, obtained from identification cards or school records; body weight (kg), measured on a digital scale (Tanita UM-061, 100 g accuracy) with children lightly clothed (to correct for this clothing, the weight of clothes was subtracted); and height (cm) measured with a portable vertical anthropometer (SECA, 1 mm accuracy).

Intra-observer coefficient error (range, 0–1) was calculated with intraclass correlation. Values greater than 0.75 were considered acceptable [41].

The exact age of each child was calculated as a function of their birth date. Similarly, body mass index (BMI = \( \frac{W}{H^2} \) (kg/m\(^2\)) was determined with weight and height data. Underweight (low weight-for-age, LW/A), stunting (low height-for-age, LH/A), low BMI-for-age (LBMI/A), overweight (Ow) and obesity (Ob) were determined using the World Health Organization (WHO) reference charts [42].

Statistical analyses

Anthropometric variables were calculated as means, medians and standard deviations (Table 1). Categorical Principal Component Analysis (CatPCA) was used to process socio-environmental data. The technique is appropriate for the treatment of multivariate data of heterogeneous nature (numerical, nominal, ordinal and multinomial variables) and reduces the complexity of all socio-environmental observations related to each child without losing information [43]. CatPCA results were used to define groups of observations. The frequency of socio-environmental variables and nutritional indicators was also calculated. The latter were compared between sexes and ages using binary logistic regression and among groups defined by CatPCA by Chi-square test. Statistical processing was performed using SPSS 15.0 software.

Results

After CatPCA analysis, the first two components represented 20.45% of the total variance. The Cronbach’s Alpha values were 0.83 and 0.70 for the first and the second axes, respectively, indicating that the original variables were adequately represented [44].

Table 2 summarizes eigenvectors from CatPCA. The most influential variables in the analysis were parental education, health insurance coverage, material and consumer goods like computer, internet, air conditioning and car, and some physical amenities such as sewer system, waste collection, bottled gas and electricity.

From the order established by the average values of the first two components, four groups of observations were defined (Fig 2), as follows:

Group 1 (G1, dimension-1 positive; dimension-2 positive): Families had access to public services (piped water system, electricity, sewage system, bottled gas, waste collection) and television; houses were built with fired brick masonry and flooring materials; fathers had formal employment.

Group 2 (G2, dimension-1 positive; dimension-2 negative): Families lived in neighborhoods with pavement, piped gas, greater access to material and consumer goods (computer, car, internet, air conditioning), fathers had tertiary/university education, mothers had formal employment and health insurance.

Group 3 (G3, dimension-1 negative; dimension-2 negative): Families practiced orchard agriculture and animal husbandry for personal consumption and used firewood and kerosene
for heating or cooking; drinking water was obtained by protected well and rain-tank storage; excretes were removed by septic tank. Most fathers were unemployed or retired/pensioned.

Group 4 (G4, dimension-1 negative; dimension-2 positive): Both parents had informal work or fathers were laborers and retired/pensioned or mothers were unemployed or housewives.

Table 2. CatPCA eigenvectors for the first two dimensions analyzed.

| Variables                                      | Dimension 1 | Dimension 2 |
|------------------------------------------------|-------------|-------------|
| Computer                                       | 0.689       | -0.238      |
| Mother’s education                             | 0.666       | -0.156      |
| Internet                                       | 0.647       | -0.291      |
| Father’s education                             | 0.638       | -0.165      |
| Air conditioning                               | 0.614       | -0.281      |
| Health insurance                               | 0.609       | -0.112      |
| Car                                            | 0.525       | -0.200      |
| Sewage system                                  | 0.488       | 0.356       |
| Waste collection                               | 0.479       | 0.398       |
| Cable television                               | 0.461       | 0.287       |
| Mother’s work (formal employment)              | 0.423       | -0.120      |
| Electricity                                    | 0.418       | 0.517       |
| Piped water system                             | 0.394       | 0.568       |
| Father’s work (formal employment)              | 0.383       | 0.121       |
| Father’s work (autonomous)                     | 0.381       | -0.254      |
| Pavement                                       | 0.369       | -0.188      |
| House building material                        | 0.269       | 0.544       |
| Mother’s work (autonomous)                     | 0.266       | -0.219      |
| Flooring material                              | 0.254       | 0.297       |
| Piped gas                                      | 0.234       | -0.440      |
| Bottled gas                                    | 0.043       | 0.676       |
| Mother’s work (laborer)                        | -0.040      | -0.082      |
| Monetary support                               | -0.041      | 0.163       |
| Father’s work (retired/pensioned)              | -0.045      | -0.020      |
| Protected well                                 | -0.056      | -0.298      |
| Father’s work (unemployed)                     | -0.088      | -0.005      |
| Rain-tank storage                              | -0.104      | -0.141      |
| Firewood                                        | -0.117      | -0.044      |
| Mother’s work (unemployed)                     | -0.118      | 0.182       |
| Father’s work (laborer)                        | -0.120      | 0.133       |
| Mother’s work (retired/pensioned)              | -0.130      | 0.077       |
| Mother’s work (informal worker)                | -0.150      | 0.012       |
| Orchard                                        | -0.152      | -0.063      |
| Mother’s work (housewife)                      | -0.156      | 0.239       |
| Kerosene                                       | -0.156      | -0.240      |
| Animal husbandry                               | -0.167      | -0.076      |
| Nutritional support                            | -0.248      | 0.092       |
| Critical crowding                              | -0.267      | 0.135       |
| Septic tank                                    | -0.338      | -0.085      |
| Father’s work (informal worker)                | -0.409      | 0.167       |

https://doi.org/10.1371/journal.pone.0176346.t002
More than 45% of these families received public assistance (nutritional and/or monetary support), and 22.19% of them lived under critical crowding conditions.

The frequency of socio-environmental conditions in the total sample and by groups according to CatPCA analysis as well as their comparison by Chi$^2$ is presented in Table 3.

Results of each nutritional status indicator showed that 1.5% of children had LW/A, 5.2% LH/A, 0.6% LBMI/A, 20.9% Ow and 10.9% Ob. Prevalence of LH/A, Ow and Ob were significantly different among groups. G4 presented the highest percentages of LH/A, and G2 those of Ow and Ob (Table 4).

Age, as a factor, did not result in significant differences for all the indicators. On the contrary, boys differed from girls in Ow (boys: 23.0% vs girls: 18.8%) and Ob (boys: 12.7% vs girls: 9.1%) (Table 5).

**Discussion**

The results obtained in the present study allowed us to characterize the nutritional status of the infant population from the Department of Villaguay, Entre Ríos, with reference to material and symbolic contexts where children grow. We observed a high percentage of parents with informal work, low educational level and beneficiaries of money/food aid programs. However,
Table 3. Frequency (%) of socio-environmental variables in the total sample and by groups (G1-G4). Chi-square (Chi^2) comparison among groups.

| Socio-environmental characteristics | Total % | G1 % | G2 % | G3 % | G4 % | Chi^2 | p   |
|-------------------------------------|---------|------|------|------|------|-------|-----|
| **House building materials**        |         |      |      |      |      |       |     |
| Fired-brick masonry                | 79.3    | 90.3 | 85.0 | 46.6 | 83.0 | 191.708 | 0.000 |
| Makeshift material                 | 4.2     | 1.8  | 0.7  | 5.5  | 7.3  | 27.372 | 0.000 |
| Low-quality prefab                 | 3.2     | 2.4  | 2.1  | 6.4  | 3.0  | 9.630  | 0.220 |
| Other materials                    | 5.6     | 5.5  | 5.9  | 2.5  | 6.7  | 5.559  | 0.135 |
| Flooring material                  | 73.7    | 88.4 | 73.8 | 48.3 | 74.4 | 121.125 | 0.000 |
| **Lodging or Home-tenure status**  |         |      |      |      |      |       |     |
| House owner                        | 61.0    | 63.2 | 62.9 | 52.1 | 62.2 | 9.363  | 0.025 |
| Lease holder                       | 18.4    | 23.2 | 25.2 | 11.0 | 14.8 | 27.695 | 0.000 |
| Other (free lodging)               | 16.2    | 13.7 | 10.8 | 18.2 | 20.0 | 14.216 | 0.003 |
| **Critical crowding**              |         |      |      |      |      |       |     |
| Pavement                           | 20.2    | 23.9 | 45.1 | 11.0 | 8.2  | 173.426 | 0.000 |
| Electricity                        | 91.6    | 99.7 | 98.6 | 59.7 | 96.3 | 379.269 | 0.000 |
| Waste collection                   | 82.7    | 98.7 | 93.4 | 42.4 | 83.6 | 359.778 | 0.000 |
| **Drinking water (main source)**   |         |      |      |      |      |       |     |
| Piped water system                 | 93.0    | 100.0| 98.3 | 61.9 | 99.1 | 424.689 | 0.000 |
| Protected well                     | 3.2     | 0.0  | 4.9  | 13.1 | 0.2  | 106.069 | 0.000 |
| Rain-tank storage                  | 1.4     | 0.0  | 0.7  | 5.1  | 1.1  | 30.099  | 0.000 |
| **Wastewater disposal**            |         |      |      |      |      |       |     |
| Sewage system                      | 73.8    | 96.1 | 86.0 | 28.0 | 71.8 | 377.241 | 0.000 |
| Septic tank                        | 17.0    | 2.1  | 8.7  | 37.3 | 23.2 | 156.523 | 0.000 |
| **Fuel (cooking/heating)**         |         |      |      |      |      |       |     |
| Piped gas                          | 9.0     | 0.0  | 32.2 | 14.4 | 0.6  | 280.611 | 0.000 |
| Bottled gas (cylinder)             | 85.0    | 99.2 | 65.7 | 56.4 | 97.8 | 632.976 | 0.000 |
| Firewood                           | 10.4    | 5.3  | 10.1 | 16.1 | 11.6 | 19.877  | 0.000 |
| Kerosene                           | 1.3     | 0.0  | 0.3  | 6.8  | 0.4  | 64.727  | 0.000 |
| **Father’s Education**             |         |      |      |      |      |       |     |
| Elementary                         | 44.2    | 37.6 | 14.3 | 44.9 | 64.5 | 199.396 | 0.000 |
| High School                        | 31.3    | 48.9 | 54.9 | 16.5 | 12.7 | 238.957 | 0.000 |
| Tertiary/University                | 6.9     | 5.8  | 25.9 | 0.4  | 0.4  | 212.196 | 0.000 |
| **Mother’s Education**             |         |      |      |      |      |       |     |
| Elementary                         | 44.2    | 33.4 | 10.5 | 51.7 | 66.5 | 263.345 | 0.000 |
| High school                        | 33.5    | 53.7 | 40.9 | 21.2 | 20.7 | 131.754 | 0.000 |
| Tertiary/University                | 12.3    | 10.3 | 44.4 | 1.7  | 1.3  | 358.841 | 0.000 |
| **Father’s Work**                  |         |      |      |      |      |       |     |
| Formal Employed                    | 47.7    | 80.5 | 53.5 | 26.7 | 30.5 | 273.429 | 0.000 |
| Laborer                            | 7.1     | 2.9  | 1.7  | 5.1  | 13.8 | 60.832  | 0.000 |
| Self-employed worker               | 9.0     | 2.4  | 1.0  | 26.7 | 34.4 | 227.838 | 0.000 |
| Informal worker                    | 18.0    | 4.7  | 35.7 | 1.7  | 1.1  | 311.182 | 0.000 |
| Unemployed                         | 2.0     | 1.1  | 0.7  | 4.2  | 2.4  | 10.643  | 0.014 |
| Retired/Pensioned                  | 1.5     | 1.1  | 1.0  | 1.7  | 1.9  | 1.486   | 0.686 |
| **Mother’s Work**                  |         |      |      |      |      |       |     |
| Formal Employed                    | 24.8    | 31.1 | 51.4 | 16.5 | 9.7  | 190.500 | 0.000 |
| Laborer                            | 0.7     | 0.3  | 0.3  | 1.3  | 0.9  | 3.097   | 0.377 |
| Self-employed worker               | 3.8     | 0.8  | 1.0  | 7.2  | 6.0  | 29.576  | 0.000 |
| Informal worker                    | 3.8     | 1.6  | 15.7 | 0.8  | 0.4  | 138.403 | 0.000 |

(Continued)
most families lived in their own houses made of brick with mosaic tile or concrete floors, and access to piped water system, sewage system, electricity, waste collection and cable television. In this context, more than 35% of children presented some type of malnutrition.

In our study, the prevalence of acute and chronic undernutrition was low compared with that reported for the provinces of Jujuy and Catamarca, Argentina, where poverty, unhealthy environments and poor health care were among the main underlying determinants of such condition [35]. On the other hand, according to the Argentine National Nutrition and Health Survey [28], 8.0% of children aged 6–60 months presented stunting, being Entre Ríos one of the provinces with the highest percentage. Although in our study the number of low height values recorded was lower, the prevalence of stunting in children (5.2%) shows that this form of malnutrition remains an unresolved issue.

According to UNICEF [45], higher prevalence of nutritional stunting is observed in areas with indicators associated with vulnerability, such as populations living below the poverty line and with low educational level. Consistent with the above mentioned, and despite many families received food aid or money programs, most undernourished children from Villaguay (G4) lived in overcrowded households and their parents had low educational level, informal or low-skilled works, or were unemployed.

### Table 3. (Continued)

| Socio-environmental characteristics | Total | G1   | G2   | G3   | G4   | Chi² | p    |
|-------------------------------------|-------|------|------|------|------|------|------|
| %                                   | %     | %    | %    | %    | %    |      |      |
| Unemployed                          | 8.8   | 7.9  | 2.1  | 3.4  | 15.3 | 53.575 | 0.000 |
| Retired/Pensioned                   | 4.2   | 55.8 | 26.9 | 47.5 | 57.2 | 77.362 | 0.000 |
| Housewife                           | 49.2  | 1.8  | 0.7  | 3.4  | 8.2  | 35.510 | 0.000 |
| Health Insurance                    | 48.2  | 71.8 | 85.3 | 24.6 | 21.9 | 444.201 | 0.000 |
| Public Assistance                   |       |      |      |      |      |      |      |
| Monetary support                    | 23.0  | 24.5 | 13.3 | 14.8 | 30.7 | 42.339 | 0.000 |
| Nutritional support                 | 8.8   | 3.4  | 0.3  | 11.0 | 16.1 | 76.117 | 0.000 |
| Farming Practice                    |       |      |      |      |      |      |      |
| Orchard (agriculture)               | 6.6   | 3.2  | 4.5  | 14.0 | 6.9  | 30.170 | 0.000 |
| Animal husbandry                    | 7.8   | 2.9  | 6.3  | 13.6 | 9.5  | 26.754 | 0.000 |
| Others                              |       |      |      |      |      |      |      |
| Internet                            | 24.2  | 30.5 | 74.5 | 4.2  | 1.7  | 601.244 | 0.000 |
| Cable television                    | 84.4  | 98.4 | 95.1 | 53.4 | 82.4 | 255.734 | 0.000 |
| Computer                            | 34.4  | 52.6 | 85.7 | 8.9  | 5.2  | 658.938 | 0.000 |
| Air conditioning                    | 20.5  | 22.1 | 68.5 | 4.2  | 0.9  | 568.820 | 0.000 |
| Car                                 | 33.9  | 43.4 | 75.5 | 17.4 | 12.1 | 378.283 | 0.000 |

https://doi.org/10.1371/journal.pone.0176346.t003

### Table 4. Prevalence (%) of nutritional status indicators in the total sample and by-group. Comparison among groups (Chi²).

| Indicators               | Total | G1   | G2   | G3   | G4   | Chi² | p    |
|-------------------------|-------|------|------|------|------|------|------|
| %                       | %     | %    | %    | %    | %    |      |      |
| Low weight-for-age      | 1.5   | 1.8  | 1.4  | 2.1  | 1.1  | 1.397 | 0.706 |
| Low height-for-age      | 5.2   | 3.7  | 3.5  | 5.1  | 7.3  | 8.265 | 0.041 |
| Low BMI-for-age         | 0.6   | 0.8  | 0.3  | 1.7  | 0.2  | 6.483 | 0.090 |
| Overweight              | 20.9  | 17.9 | 26.2 | 17.4 | 21.8 | 8.994 | 0.029 |
| Obesity                 | 10.9  | 12.9 | 13.6 | 10.6 | 8.3  | 7.596 | 0.050 |

https://doi.org/10.1371/journal.pone.0176346.t004
Paradoxically, undernutrition is concomitant with excess weight, a frequent condition in various Latin American countries, including Argentina [34, 46–49]. Thus, Peña and Bacallao [50] and Monteiro et al. [17] suggest that excess weight—the other side of malnutrition—competes with global hunger. Worldwide, more than 1,600 million people have excess weight, of which 400 million become obese [6]. In this regard, the WHO recognized the global epidemic of obesity, also called globesity, in 2002. Changes in dietary habits as a result of increased refined carbohydrate and saturated fats intake are responsible for such increase [51]. Similarly, changes in physical activity patterns leading to increased sedentary lifestyles would be another cause of body weight increases [52]. Although overweight and obesity is multifactorial in origin, food intake and physical activity, known as “the big two”, would be the determinant factors [53].

In Argentina, overweight and obesity have increased markedly [28, 54, 55]. Results of a multicentric study performed by Oyhenart et al. [40] in infant populations from six Argentinian provinces showed excess weight rates (Ow and Ob) in Chubut (26%), Buenos Aires (22%), Mendoza and La Pampa (15%), Jujuy (14%) and Catamarca (11%). Thus, the excess infant weight recorded in Villaguay (31.8%) would place this population among the provinces with the higher excess weight rates, in agreement with that reported by Durán et al. [7].

Different authors have analyzed the complex relationship between excess weight and socio-economic level [13, 15, 17]. Our results show that the socio-environmental characteristics of G2 (the group with the highest rate of children with excess weight) were more favorable than those of G4 (the group with the highest rate of malnourished children), since most parents had a high educational level, formal employment, health insurance coverage and material and consumer goods (computer, car, internet, air conditioning), all indicators of greater purchasing power. Nevertheless, high Ow and Ob prevalence in the other groups evidence the magnitude of the nutritional transition in this population.

Finally, boys had higher Ow and Ob prevalence, probably in line with that stated by Aguirre [56] concerning inter-gender relationship. This author observed that food distribution among family members may be unequal: in case of food shortage, boys are given priority in terms of quantity and quality of food, since they represent the workforce both in the present (adults) and in the future (children).

**Conclusion**

In summary, at least three out of ten children from Villaguay presented either deficit or excess malnutrition, disclosing the process of nutrition transition underway. However, the distribution was not homogeneous; rather, it depended on the material and symbolic context where

---

**Table 5. Logistic regression analysis of nutritional status by age and sex.**

| Indicators            | Covariables | Beta  | Standard error | Wald coefficient | p    |
|-----------------------|-------------|-------|----------------|------------------|------|
| Low weight-for-age    | Sex         | 0.385 | 0.436          | 0.776            | 0.378|
|                       | Age         | -0.038| 0.208          | 0.034            | 0.852|
| Low height-for-age    | Sex         | -0.243| 0.238          | 1.040            | 0.307|
|                       | Age         | -0.105| 0.112          | 0.871            | 0.350|
| Low BMI-for-age       | Sex         | -0.688| 0.709          | 0.941            | 0.331|
|                       | Age         | -0.218| 0.308          | 0.501            | 0.479|
| Overweight            | Sex         | -0.257| 0.131          | 3.892            | 0.049|
|                       | Age         | -0.096| 0.062          | 2.369            | 0.123|
| Obesity               | Sex         | -0.376| 0.171          | 4.831            | 0.027|
|                       | Age         | -0.044| 0.081          | 0.303            | 0.581|

https://doi.org/10.1371/journal.pone.0176346.t005
children grew up. Thus, the higher the family socio-economic level, the higher the incidence of
overweight and obesity, whereas at the other end of the social scale, undernutrition and
increasing weight excess remain serious health issues.

Acknowledgments
The authors greatly acknowledge school authorities, teachers, parents and students from the
Department of Villaguay for their generous participation and collaboration. Thanks are also
due to Omar Okada and Lucia Featherston for figures design, Maria Cristina Munoz for careful
reading of the manuscript, and translator Adriana Di Maggio for copyediting the manuscript
language usage, spelling, and grammar.

Author Contributions
Conceptualization: MLBS MFC EEO.

Formal analysis: MLBS MFC EEO.

Funding acquisition: EEO.

Investigation: MLBS MFC EEO.

Methodology: MLBS MFC EEO.

Project administration: EEO.

Writing – original draft: MLBS.

Writing – review & editing: MLBS MFC EEO.

References
1. Cole TJ. The secular trend in human physical growth: a biological view. Econ Hum Biol. 2003; 1(2):161–
8. https://doi.org/10.1016/S1570-677X(02)00033-3 PMID: 15463971
2. Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual. Champaign,
IL: Human Kinetics Books; 1988.
3. OMS. Informe sobre la salud en el mundo 1995—Reducir las desigualdades. Organización Mundial de
la Salud; 1995.
4. Tanner JM. Growth as a mirror of the condition of society: secular trends and class distinctions. Acta
Paediatr Jpn. 1987; 29(1):96–103. PMID: 3144856
5. Bergel Sanchis ML. Malnutricio con socio-ambientales y alimentacion familiar. Un estudio
bio-socio-antropológico en poblacion escolar de Villaguay (Provincia de Entre Rios, Argentina). Unpub-
lished Doctoral Thesis, Facultad de Ciencias Naturales y Museo de la Universidad Nacional de
La Plata. 2014.
6. WHO. World Health Organization. Obesity and overweight. Genova: WHO; 2008.
7. Durán P, Mangialavori G, Biglieri A, Kogan L, Abeyá Gilardon E. Estudio descriptivo de la situación
nutricional en niños de 6–72 meses de la República Argentina. Resultados de la Encuesta Nacional de
Nutrición y Salud (ENNyS). Arch argent pediatr. 2009; 107(5):397–404. https://doi.org/10.1590/S0325-
00752009000500005 PMID: 19809759
8. Ortale S. Prácticas y representaciones sobre desnutricion infantil de causa primaria en familias pobres
urbanas del Gran La Plata. Unpublished Doctoral Thesis. Facultad de Ciencias Naturales y Museo de
la Universidad Nacional de La Plata; 2002.
9. Paraje G. Evolución de la desnutrición crónica infantil y su distribución socioeconómica en siete países
de América Latina y el Caribe. Cepal—Serie Políticas sociales Nro. 140. Publicación de las Naciones
Unidas. ISSN versión impresa 1564–4162 ISSN versión electrónica 1680–8983 ISBN: 978-92-1-
323179-1; 2008.
10. OPS. Malnutrition in infants and young children in Latin America and the Caribbean: achieving the Mil-
leennium Development Goals. 2008 Available from: http://www1.paho.org/hq/dmdocuments/2009/
MalnutritionEng.pdf
11. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and child undernutrition: consequences for adult health and human capital. Lancet. 2008; 371(9609):340–357. https://doi.org/10.1016/S0140-6736(07)61692-4 PMID: 18206223
12. McLaren L. Socioeconomic status and obesity. Epidemiol Rev. 2007; 29:29–48. https://doi.org/10.1093/epirev/mxm001 PMID: 17478442
13. Popkin BM. Population, development and nutrition. In: Sadler MJ, Strain JJ, Caballero B, editors. Encyclopedia of human nutrition. London: Academic Press; 1998. pp. 1562–73.
14. Martorell R, Khan LK, Hughes ML, Grummer-Strawn LM. Obesity in Latin American women and children. J Nutr. 1998; 128(9):1464–73. PMID: 9732306
15. Peña M, Bacallao J. Obesity among the poor: an emerging problem in Latin America and the Caribbean. In: Peña M, Bacallao J, editors. Obesity and poverty: a new public health challenge. Washington, D.C.: Pan American Health Organization; 2000. pp. 3–12.
16. Motta MAFA, da Silva GAP. Malnutrition and obesity in children: describing the profile of a low-income community. J Pediatr (Rio). 2001; 77(4):288–93.
17. Monteiro CA, Conde WL, Popkin BM. Is obesity replacing or adding to undernutrition? Evidence from different social classes in Brazil. Public Health Nutr. 2002; 5(1A):105–12. https://doi.org/10.1079/PHN2001128 PMID: 12027272
18. Rodríguez Caro A, González López-Valcárcel B. El trasfondo económico de las intervenciones sanitarias en la prevención de la obesidad. Rev Esp Salud Pública. 2009; 83(1):25–41.
19. Peña M, Bacallao J. La obesidad en la pobreza: un problema emergente en las Américas. Revista Futuros. 2005; 3(10). Available from: http://www.revistafuturos.info/futuros_10/obesidad1.htm
20. Ferreira VA, Magalhães R. Obesidade no Brasil: tendências atuais. Revista Portuguesa de Saúde Pública. 2006; 4(2):71–81.
21. Pedraza DF. Obesidad y pobreza: marco conceptual para su análisis en Latinoamérica. Saúde Soc. 2009; 18(1):103–17.
22. Álvarez-Castaño LS, Goez-Rueda JD, Carreño-Aguirre C. Factores sociales y económicos asociados a la obesidad: los efectos de la inequidad y de la pobreza. Rev Gerenc Polit Salud (Colombia). 2012; 11(23):98–110.
23. Stunkard AJ. Factores determinantes de la obesidad: opinión actual. In: Peña M, Bacallao J, editors. La obesidad en la pobreza: un nuevo reto para la salud pública. Washington DC: Organización Panamericana de la Salud; 2000. pp. 27–32.
24. Alves Ferreira V. Obesidade & pobreza: o aparente paradoxo [dissertação de mestre]. Rio de Janeiro, Brasil: Ministério da Saúde. Fundação Oswaldo Cruz. Escola Nacional de Saúde Pública; 2003.
25. Adjemian D, Bustos P, Amigo H. Nivel socioeconómico y estado nutricional. Un estudio en escolares. Archivos Latinoamericanos de Nutrición. 2007; 57(2):125–29. PMID: 17992975
26. Ohyenart EE, Dahinten SL, Alba JA, Alfaro EL, Bejarano IF, Cabrera GE, et al. Estado nutricional de niñas y niños de las familias más pobres residentes en barrios periféricos de La Plata, Argentina. Rev Panam Salud Pública. 2007; 22(3):194–201. PMID: 18062854
27. Dinsa GD, Goryakin Y, Fumagalli E, Suh르cke M. Obesity and socioeconomic status in developing countries: a systematic review. Obes Rev. 2012; 13(11):1067–79. https://doi.org/10.1111/j.1467-78X.2012.01017.x PMID: 22764734
28. ENNyS. Encuesta Nacional de Nutrición y Salud. Argentina. Ministerio de Salud de la Nación. 2007. Available from: http://www.msal.gov.ar/hmr/Site/ennys/site
29. Bejarano I, Dippijer J, Alfaro E, Quispe Y, Cabrera G. Evolución de la prevalencia de sobrepeso, obesidad y desnutrición en escolares de San Salvador de Jujuy. Arch argent pediatr. 2005; 103(2):101–9.
30. Bolzón A, Mercer R, Ruiz V, Brawerman J, Marx J, Adrogué G, et al. Evaluación nutricional antropométrica de la niñez pobre del norte argentino: Proyecto encuNa. Arch argent pediatr. 2005; 103(6):545–55.
31. Carvalho AT, Almeida ER, Nilson EAF, Ubarana JA, Coutinho JG, Toledo Vianna RP, et al. Situación nutricional de niños menores de cinco años en municipios de nordeste brasileiro. Journal of Human Growth and Development. 2014; 24(2):221–27.
32. Laurentin A, Schnell M, Tovar J, Domínguez Z, Pérez BM, López de Blanco M. Transición alimentaria y nutricional. Entre la desnutrición y la obesidad. An Venez Nutr. 2007; 20(1):47–52.
33. Popkin BM. Global changes in diet and activity patterns as drives of the nutritional transition. In: Kalhan SC, Prentice AM, Yajnik CS, editors. Emerging societies- coexistence of childhood malnutrition and obesity. Nestle Nutr Workshop Ser Pediatr Program. 2009;63:1–10; discussion 10–4. pp. 259–68.
34. Ohyenart EE, Dahinten SL, Alba JA, Alfaro EL, Bejarano IF, Cabrera GE, et al. Estado nutricional infanto juvenil en Argentina: variación regional. Rev Arg Antrop Biol. 2008; 10(1):1–62.
35. Lomaglio DB. Transición nutricional y el impacto sobre el crecimiento y la composición corporal en el noroeste argentino (NOA). Nutr clin diet hosp. 2012; 32(3):30–5.

36. Zonta ML, Garraza M, Castro L, Navone GT, Oyhenart EE. 2011. Poverty, nutritional status and child enteropatases: a cross-sectional study in Aristóbulo del Valle, Misiones, Argentina. Revista de Nutrición Clínica y Dietética Hospitalaria 31(2):48–57. Sociedad Española de Dietética y Ciencias de la Alimentación. Madrid, España. ISSN 1989-208X.

37. Garraza M, Cesani MF, Navone GT, Oyhenart EE. 2016. Malnutrición y body composition in urban and rural schoolchildren: A cross-sectional study in San Rafael, Mendoza (Argentina). American Journal of Human Biology 28:796–803. ISSN 1520-6300. https://doi.org/10.1002/ajhb.22869 PMID: 27238213

38. Bergel Sanchís ML, Quintero FA, Navazo B, Torres MF, Luna ME, Luis MA, Castro L, Oyhenart EE. 2016. Caracterización del estado nutricional en relación a factores socio-ambientales de la población escolar del partido de Punta Indio (provincia de Buenos Aires, Argentina). Revista Argentina de Antropología Biológica 18: 1–13. Asociación de Antropología Biológica Argentina. La Plata, Buenos Aires, Argentina. ISSN 1514-7991.

39. DiNIECE. Dirección Nacional de Información y Estadística de la Calidad Educativa del Ministerio Nacional de Educación. Buenos Aires; 2008.

40. Oyhenart EE, Castro LE, Forte LM, Sicre ML, Quintero FA, Luis MA, et al. Socioenvironmental conditions and nutritional status in urban and rural schoolchildren. Am J Hum Biol. 2008; 20(4):399–405. https://doi.org/10.1002/ajhb.20738 PMID: 18257061

41. Prieto L, Lamarca R, Casado A. La evaluación de la fiabilidad en las observaciones clínicas: el coeficiente de correlación intraclase. Med Clin (Barc). 1998; 110(4):142–5.

42. de Onis M, Onyango AW, Borghi E, Siyam A, Siekmann J. Elaboración de un patrón OMS de crecimiento de escolares y adolescentes. Bulletin of the World Health Organization. 2007; 85(9):660–7.

43. Cesani MF, Luis MA, Torres MF, Castro LE, Quintero FA, Luna ME, et al. Sobrepeso y obesidad en escolares de Brandsen en relación a las condiciones socioambientales de residencia. Arch argent pediatr. 2010; 108(4):294–302. https://doi.org/10.1590/S0325-00752010000400002 PMID: 20672186

44. Peterson RA. A meta-analysis of Cronbach’s coefficient alpha. J Consum Res. 1994; 21(2):381–91.

45. UNICEF. Estado mundial de la infancia. Niñas y niños en un mundo urbano. Resumen Ejecutivo. Fondo de las Naciones Unidas para la Infancia. 2011. Available from: http://www.unicef.org/spanish/sowc2012/pdfs/SOWC%202012%20Executive%20Summary%20LoRes%20PDF_SP_03132012.pdf

46. Monteiro CA, Conde WL, Popkin BM. The burden of disease from undernutrition and overnutrition in countries undergoing rapid nutrition transition: a view from Brazil. Am J Public Health. 2004; 94(3):433–4. PMID: 14998807

47. Caballero B. A nutrition paradox-underweight and obesity in developing countries. N Engl J Med. 2005; 352(15):1514–6. https://doi.org/10.1056/NEJMpp048301 PMID: 15829531

48. Doak CM, Adair LS, Bentley M, Monteiro C, Popkin BM. The dual burden household and the nutrition transition paradox. Int J Obes (Lond). 2005; 29(1):129–36.

49. Oyhenart EE, Orden AB, Forte LM, Torres MF, Luis MA, Quintero FA, et al. Transición nutricional en tres ciudades con diferente complejidad urbano ambiental. Rev Arg Antrop Biol. 2005; 7(2):35–46.

50. Peña M, Bacallao J. La obesidad y sus tendencias en la región. Rev Panam Salud Pública. 2001; 10(2):75–8.

51. Gardner G, Halweil B. Nourishing the underfed and overfed. State of the world, New York: Norton. Worldwatch Institute; 2000.

52. Caballero B, Popkin BM. The nutrition transition: diet and disease in the developing world. London, England: Academic Press; 2002.

53. Wanderley EN, Ferreira VA. Obesidade: uma perspectiva plural. Ciência saúde coletiva Rio de Janeiro. 2010; 15(1):185–94.

54. Poletti OH, Barrios L. Obesidad e hipertensión arterial en escolares de la ciudad de Corrientes, Argentina. Arch argent pediatr. 2007; 105(4):293–98.

55. CESNI/SAOTA. Hacia el mapa de la obesidad en Argentina. Buenos Aires; 2012. Available from: http://www.fundacionpepsico.com.ar/files/mapa-obesidad-cesni-saota.pdf

56. Aguirre P. Estrategias de consumo ¿Qué comen los argentinos que comen? Buenos Aires: CIEPP-Mirón y Dávila Editores; 2005.