Measures of schoolchild height and weight as indicators of community nutrition, lessons from Brazil

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Measures of schoolchild height and weight as indicators of community nutrition, lessons from Brazil

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Abstract

Many countries measure the heights and weights of children in primary and secondary school, including Egypt. Individual children are usually monitored at school against growth charts, with appropriate referrals. Schoolchild data aggregated to the community, state or nation, and validated against population surveys, led to interventions such as school-based dietary supplementation and feeding, and community or national dietary education. Nutritional programs rarely target dietary needs of children 5-19. Influences on anthropometric nutritional status for children 0- 5 are widely examined in population surveys; but similar data are lacking for children 5-19, undesirably, as differences in growth and development from 5-19 are strongly associated with health in later life. Nutritional status of older children requires study in the context of household, community and national economic conditions. Many such details were surveyed by the Pesquisa de Orcamentos Familiares (POF), across the 27 provinces of Brazil, 2002-2003, conducted by the Instituto Brasileiro de Geografia e Estatistica (IBGE), a national agency publishing industrial activity, agricultural production, employment, prices, and GDP series. The POF sampled 48,470 households, and 178,375 persons, for household and social characteristics, anthropometrics, economic activity, sources of income, and detailed expenditures (for example 3,256 foods). Here, nutritional status of 50,237 persons aged 5-19 is estimated using WHO 2007 Reference Standards for age, sex, height, weight and BMI. Characteristics of students (public or private, age in grade) and children not enrolled in school, part and full-time employment, personal income and expenditure on food, entertainment and stimulants, were related to relative and seasonal differences in nutritional status. Child nutritional status also responded to household education, income, employment, spending (particularly on food), food consumption, adult and cohort anthropometrics, and community factors, such as urbanization and location. Outcomes and explanatory factors were mapped for spatial autocorrelation and tested for Granger causation over the survey period. Child nutritional status varied seasonally; annual school censuses do not model average nutritional status. Nutritional status of enrolled children incompletely modeled children not in school. Accordingly, continuing population surveys are necessary to monitor the nutritional status of all children 5-19. Variations in nutritional status of enrolled children were sensitive to economic data available at monthly or quarterly intervals in most places, such as local prices, economic activity and employment, suggesting these as factors in active policy. Despite its size, the POF sample was insufficient to very significantly model the responses of child nutritional status to local economic conditions. These are strong reasons to support the annual collection of height and weight for all schoolchildren, and to expand monitoring of the influence of community economic conditions on child nutritional status.

Keywords: Nutrition, z-scores, school status, growth monitoring

Brazil is well served by institutions concerned with child welfare, and by a vibrant community of artists, scholars, scientists that has vividly and compellingly portrayed children's living conditions in many locations at many times. The need for improvement has long been visible, but knowledge of how to obtain improvement has been somewhat laggard. Almost all developed countries maintain some form of growth monitoring among school children; but rarely are results compared with likely causative factors. It is the purpose of this paper to examine a large sample of child heights and weights obtained during a recent population survey in comparison with ample data on family, school, cultural, and economic dimensions whose effects can be seen to separately influence growth and development.

The 7/2002-6/2003 Pesquisa de Orcamentos Familiares (POF) surveyed 27 provinces, with populations from 313,716 to 35,881,393, ranging across 29 degrees of latitude and 34 degrees of longitude.[1] Differences in climactic and soil conditions, cultural patterns and the concentration of economic segments have established regional contexts for discussion of population analyses in Brazil, though the number and extent of regions analyzed has depended on context.[2] Spatial analysis of child nutritional status used longitudes and latitudes for POF provincial locations.

The POF 2002/3 sampling frame drew upon Brazil's 2000 Census, whose data were used by UNICEF, "Report on the situation of children and adolescents in Brazil," (2003), covering many of the issues discussed here in significant detail.[3] The 2000 Census did not collect nutritional consumption, anthropometrics or levels of schooling for students surveyed by the POF, (in addition to all items surveyed by the Census). Pending further reconstruction of the POF data from its 14 source files, comparison with Census details is not reported here.

In order to examine the nutritional status of children 5-19, the sample data frame aggregates out of 182,333 persons surveyed, the 169,355 for whom BMI could be calculated. Weighted by the POF "Domestic expansion factor for estimates," this subsample represents 164,303,300 persons, or 93.4 percent of 175,846,000 represented by the full survey. Observations are located by province and four levels of urbanization. Our study is based on the individual data containing sex, anthropometrics, birth dates, educational status and attainment, benefits, race, religion and other characteristics. Data were merged from the household characteristics file, containing nominal household income, family size, a number of housing characteristics ordinarily used to proxy for wealth in less than fully monetized societies, location and interview week. A household condition of living file with categorical response variables was also merged.[4] The POF had each respondent keep running tallies of daily household and individual expenditures, and of individual sources of income. Data were aggregated from these detail

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[1] See, Instituto Brasileiro de Geografia e Estatística – IBGE, "Pesquisa de Orçamentos Familiares 2002-2003, Primeiros resultados, Brasil e Grandes Regiões," Rio de Janeiro, 2004, for description of the sampling methodology and scope of inquiry. Longitude and Latitude here uses Google Earth markers.

[2] See, Calitri, R., "Regional variations in the relationship of diet and income in the United States and Brazil, 1996," New School for Social Research, PhD, 2002, chapter 1, for a brief discussion of regional divisions.

[3] At, http://www.unicef.org/brazil/english/siab_english.pdf. The UNICEF report cites household income (in minimum wage ranges) and mother's schooling levels as important factors in child school attendance, and used years of schooling to discuss educational disparities. Here, food spending per capita exceeded income as an influence on nutritional status, and level of instruction was used to report on the nutritional consequences of age in grade.

[4] Not analyzed: durable goods inventory, 90 day and annual spending, spending on vehicles and medicine.

files to the household level for total food spending, real income and expenditures adjusted for inflation and average food price deflators.[5] Deflated income from employment and spending were also totaled for individual children and their households. We focus on school enrolment, household and individual level income and expenditure, age in grade and race, in addition to season, location and household and community variables often studied, as they impact nutritional outcomes for persons 5-19.

Table 1 displays a few overall characteristics of the survey, and serves to distinguish the economic situations of families with children from those of "average" families.

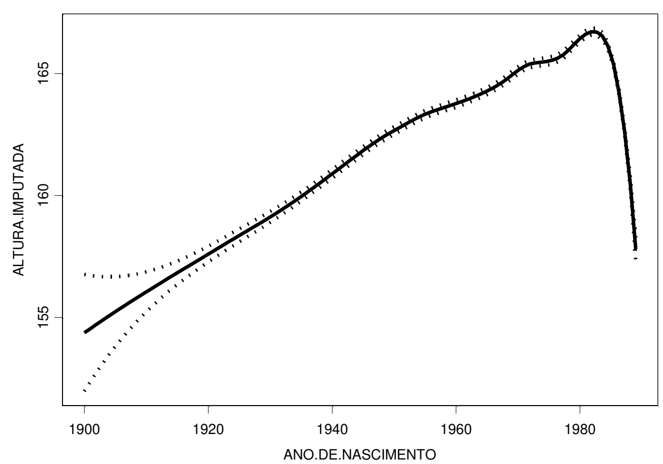
Table1. Household characteristics with and without Children *(and with children 5-19)*, POF, Brazil, 2002/3

HH Type	Persons		HH Size	HH Inc./Mo.	Daily Per Capita	
	Adults	Children			Income	Food Spd.
Households w/o Children	28,128,700		3.1	$2,379	$33.40	$3.43
All Children's' Households	70,826,214	65,348,386	5.0	1,734	12.91	1.83
H.H. with Children 5-19	*50,849,514*	*46,704,496*	*5.2*	*1,747*	*12.57*	*1.79*
Total	164,303,300		4.5	$1,897	$16.42	$2.11

Households without children were smaller and wealthier than those with children. Households with children 5-19 received 77 percent of the average daily income per capita. Children's households spent 62 percent less on food per capita than households without children.

Despite the relative poverty of their families in the current economy, Brazilian children are notably taller than their older relatives. Figure 1 displays the average stature of POF respondents by their year of birth, weighted for population. It shows a secular increase of adult stature across the 20th century; and two episodes of rapid increase (evident plasticity in population nutritional status) during what were also periods of economic growth in the early 1970s and late 1980s.[6] Children aged 14 in 2002/3 were taller than adults born in the 1920s, on average.

Average Stature (cm), by Year of Birth, Ages 14 +, POF, Brazil, 2002/3



Relative heights are not reliable indicators of nutritional status, especially for children. The growth charts in common use reflect the distributions of height and weight in "well nourished" populations (plus BMI, and developmental milestones in WHO 2006 version for ages 0-5). Growth monitoring using the distribution of average z-scores by age in given populations is long-

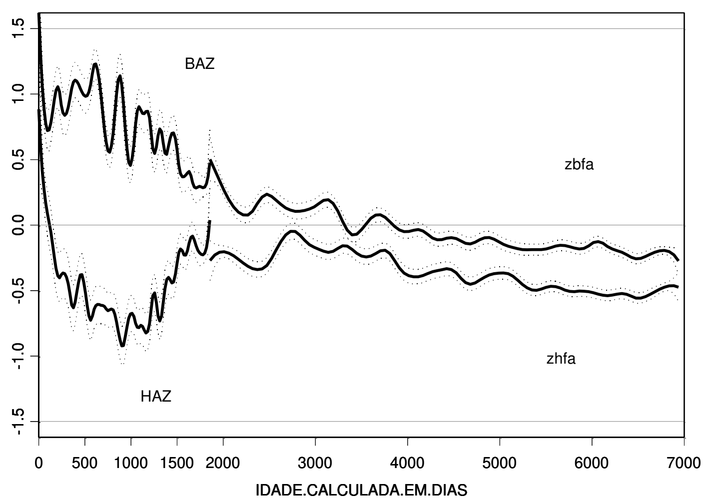
[5] National consumer price inflation was 12.53 and 9.3 percent 2002, 2003, Nunes de Almeida, A., Freitas, R.E., "RENDA E DESPESA FAMILIAR NO BRASIL SEGUNDO A PESQUISA DE ORÇAMENTOS FAMILIARES (POF) 2002-2003, IPEA (Instituto dePesquisa Economica Aplicada, Ministeroo de Planejamento, Orcamento e Gestao), 11/2006.

[6] See, Theil, H., "The geographic distribution of gross world product, 1950-1990," in Thiel., H, "Studies in Global Econometrics," Kluwer, Dordrecht, 1996, for a statistical review of post 1950 growth in Brazilian GDP per capita.

established practice.[7] It is also necessary to diagnose malnutrition incidence. The WHO Child Growth Reference, 5-19 Years (2007), was used to generate z-scores for this paper. It uses the NCHS sample, productive until replaced by the WHO multi-center growth reference study for the Child Growth Standards, 0-5 Years (2006).[8]

All statistical calculations here were population weighted. All figures, except 16, were generated using local 3rd degree polynomial regression, in Locfit for S-Plus[9] Bandwidths were adjusted to minimize residuals. Error bands represent local 95 percent likelihood. POF imputed heights and weights and WHO 2006 and WHO 2007 programs were used to obtain height, weight, and BMI for age z-scores.[10] Weight for age averaged +0.5 standard deviations for the first 24 months, then fell to 0.0 and ranged (-0.1, 0.1) through age 10. Mean BMI and height for age z-scores are displayed across ages 0-5 and 5-19 in Figure 2. BMI for age averaged around +1 standard deviations among children aged 0-3, but declined consistently across ages 3-19, falling below the WHO reference average above age 10. Average height for age z-scores remained below 0.0 for all ages above 4 months, ranging from -1.0 to <0.0 across ages 3-5 and declining steadily after age 10.[11] Mean z-scores for boys and girls were similar, with differences in extremes to be discussed.

BMI and Height for Age, Ages 0-5 and 5-19, POF, Brazil, 2002/3



It is necessary to point out that a child's z-score at a given age is the result of its nutrition, activity and other influences during its entire lifetime. Figure 3 represents the rate of change in height across age, (1st deriv.) for 2002/3 POF children aged 0-19, n=70,263. In this sample, linear growth

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[7] See, Waterlow, J, Schurch, B., Eds, "Causes and Mechanisms of Linear Growth Retardation," European Journal of Clinical Nutrition, Vol. 48, Supplement 1, 1994, http://www.unu.edu/unupress/food2/UID06E/UID06E00.HTM

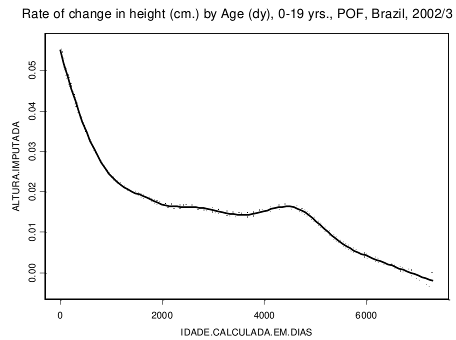
[8] See, http://www.who.int/childgrowth/en/.

[9] Loader, C., (1999). Local Regression and Likelihood. New York, Springer; _____, (2001). Locfit for S+2000, Lucent.

[10] Reported by, de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J., "Development of a WHO growth reference for school-aged children and adolescents," Bulletin of the World Health Organization 2007;85:660-7, the 5-19 growth reference was designed to return z-score results similar to the 0-5 growth standard near 60 months.

[11] Z-score results for ages 0-5 were reported by Calitri, R., "Contribution of native Brazilian foods to nutrients in diets, 1974-2003," Presented at 7th International Food Data Conference, Sao Paulo, Brazil, 10/24/2007. The sample represented 15,542,850 children 0-5, 18.81 percent stunted (HAZ), 5.4 percent underweight (WAZ), 5.88 or 5.87 percent wasted (WHZ or BAZ), and 24.22 percent (3,765,211) with one or more of these conditions. Above the second standard deviation of weight for height or BMI for age, 16.94 or 19.12 percent could be classified as obese, 9.48 and 9.11 percent were above 2 s.d. in weight or height for age, and 25.82 percent suffered from one or more of these conditions. Overall, 6,379,554 children were outside the second standard deviation of one of the child development monitoring indices so over 2002-3 general childhood malnutrition was 41.04 percent among persons 0-5. Seasonal patterns were clearly visible.

declines steadily only after age 13, and remains positive through age 19. Substantial changes in z-score quintiles across time have been observed in longitudinal studies of younger children.[12] In longitudinal studies of adolescents, contemporaneous factors have been reported to influence cognitive development and adult health status.[13]



We focus here on contemporaneously gathered information, rather than examining factors influencing children's growth during the 19 years before 2002. In previous research, nutritional status (represented by nutrient consumption) was examined using the POF surveys of 1987/8 and 1995/6, covering 11 cities,[14] where strong similarities with 2002/3 POF in the distribution of family income, expenditure, schooling and other factors were visible, whose influence on nutritional sufficiency was similar to their influence reported here on anthropometric nutritional status.

In presenting detailed z-score results for children 5-19, we begin with schooling status. The POF distinguished five categories of school attendance, enrolled, in private or public school, no longer in school, never attended school, and unknown. Average z-scores for these categories are detailed in Table 2, with standard deviations for height for age. Malnutrition milestones are reported in Table 2f.[15]

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[12] For example, 10,844 children covered 1959-1967 by Kaiser Foundation Health Plan in Oakland, California were followed longitudinally from 0 to 60 months. For children beginning in the lowest quartile of height-for-age, 70 percent ascended at least one major quartile at 0-6 months. Even at 54-60 months, 40 percent ascended. (Mei, et al., "Shifts in Percentiles of Growth during Early Childhood: Analysis of Longitudinal Data from the California Child Health and Development Study," Pediatrics, 113.6, June 2004, 617-627). Adolescent growth, seasonally unstable at lower U.S., 1994-96 household incomes, increased and stabilized at upper incomes (Calitri, Op. Cit, Ch. 3).

[13] Currie, Janet, "Understanding the Relationship Between Child Health and Long-Term Socioeconomic Status" Seminar presentation, Milano School of Public Policy, N.Y., 12/03/2008, following a large sample of Manitoba, Canada health care enrollees longitudinally from ages 0-24, modeling young adults on earlier health and cognitive status, but absent anthropometric or other nutritional factors. See also, Golden, M.H.N., "Is complete catch-up possible for stunted malnourished children?" in Waterlow & Schurch, eds., Op. Cit. 1994, for discussion of developmental plasticity; Currie, Janet & Stabile, "Socioeconomic Status and Health: Why is the Relationship Stronger for Older Children?" NBER Working Paper #9098 (Cambridge, MA: National Bureau of Economic Research) August 2002; and Pearce, et al., "Growth in early life and childhood IQ at age 11 years: the Newcastle Thousand Families Study," International Journal of Epidemiology, 2005; 34:673-677, where height at age 9 and 13 were more significant than birth weight in predicting IQ.

[14] Calitri, R, Op. Cit, 2002.

[15] Table 2f: School Attendance and Malnutrition Status, Children 5-19, POF, Brazil, 2002/3

Status of Enrollment	- 2 > S. D.			2 < S.D.		-2 > S.D. > 2		Population
	Stunting	Wasting	S or W	Gigantism	Obesity	S, W or O	Any	(n=50,237)
In School - Private	6.04%	4.52%	10.40%	7.43%	9.70%	18.52%	23.82%	6,284,157
In School – Public	9.95%	6.11%	15.43%	3.56%	5.86%	19.89%	22.43%	35,245,910
Left School	8.69%	3.80%	11.81%	0.89%	2.67%	14.31%	15.12%	3,582,708
Never Attended	17.64%	7.55%	24.03%	3.97%	9.74%	31.65%	34.45%	1,552,195
Unknown	34.97%	16.77%	49.12%	6.37%	7.73%	53.11%	59.48%	39,528
Total	9.60%	5.77%	14.79%	3.89%	6.26%	19.70%	22.49%	46,704,498

Though the focus of this paper is on average z-scores, details of malnutrition require discussion. Due to familiarity, percentages are displayed above. In Table 2fn, the data are in odds, relative to nutritional status in Private Schools.

Table 2: School Attendance and Nutritional Status z-scores, Children 5-19, POF, Brazil, 2002/3

Status	Population	Weighted Mean (Std. Dev.)			Sample
		Height/Age	BMI/Age	W/A (< 11 yrs)	
In School – Private	6,284,157	0.10 (1.37)	0.20	0.30	6,324
In School – Public	35,245,910	-0.40 (1.34)	-0.09	-0.31	38,189
Left School	3,582,708	-0.55 (1.10)	-0.07	-0.56	3,846
Never Attended	1,552,195	-0.78 (1.61)	0.03	-0.51	1,820
Unknown	39,528	-1.07 (1.91)	-0.18	-0.51	58
Total	46,704,498	-0.36	-0.05	-0.26	50,237

Standard deviations, presented for height for age, were similar for the other measures. Table 2 indicates that there were consistent differences in the three WHO 2007 anthropometric indicator averages across categories of school enrollment. Private school students were above the WHO reference average in all measures. Public school students were 0.5 standard deviations (s.d.) below private school students in height for age, 0.25 s.d. below in BMI, and 0.6 s.d. lower in weight for age. Average height for age was lower for school-leavers, and even lower for those who had not attended school. Weight for age, available in the WHO reference through age 10, was also lower among school leavers and those who had never attended school.

Figure 4 displays height for age across ages.

Table 2fn: Odds of School Attendance and Malnutrition Status, Children 5-19, POF, Brazil, 2002/3

Status of Enrollment	- 2 > S. D.			2 < S.D.		-2 > S.D. > 2		Population
	Stunting	Wasting	S or W	Gigantism	Obesity	S, W or O	Any	
In School - Private	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
In School - Public	1.65	1.35	1.48	0.48	0.60	1.07	0.94	5.61
Left School	1.44	0.84	1.14	0.12	0.28	0.77	0.63	0.57
Never Attended	2.92	1.67	2.31	0.53	1.01	1.71	1.45	0.25
Unknown	5.79	3.71	4.73	0.86	0.80	2.87	2.50	0.01

Students at public school are 65 percent more likely to have become stunted, but 40 percent less likely to be obese compared with private school students. Relative to public school students, and despite their shorter stature on average, and because they are older, children who left school are less likely than public school students to have become stunted or wasted. The exogeneity of their lower standard deviation is discussed further. Staying in school imposes a nutritional status penalty on younger children relative to leaving; but those who never attended school were the only group unambiguously worse off (except in reaching extreme height) than public school students.

Height for Age, Ages 5-19, by School Attendance, POF, Brazil, 2002/3

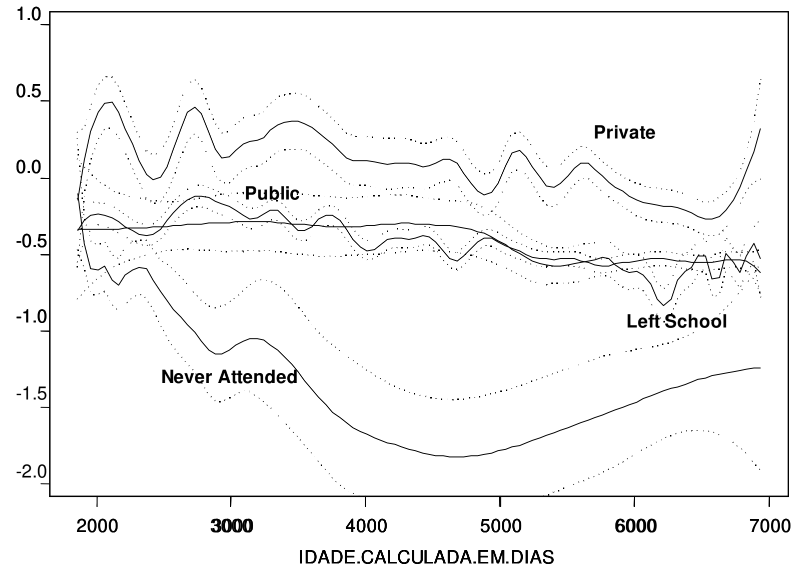
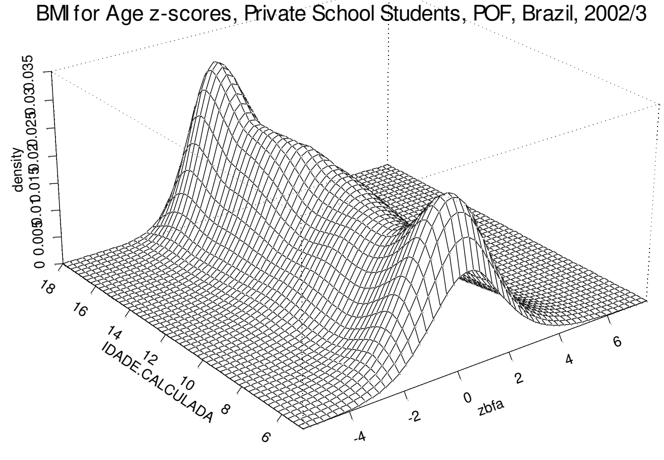


Figure 4 displays much regularity across age in nutritional status differences between categories of school enrollment. Private school students were consistently taller at all ages. At early ages, from 5-10, public school students were slightly shorter than those who had already left school. Older public school students were slightly taller than those no longer attending, but remained significantly disadvantaged relative to private school attendees. These differences may indicate that for younger children, attending school limits physical activity and hence development.[16] Since one consequence of physical inactivity, when diets are adequate, is increasing body mass, or fat to lean ratio, the occasional result is obesity. Figure 5 displays the population density of z-scores among private school students. We have already noted relatively less wasting among private school students. The figure indicates most wasting is concentrated at younger ages. There is a bulge above +2 s.d. among the youngest students, indicative of some obesity. Not visible from this perspective is a decline in obesity with age corresponding to that of wasting. There were similar declines of wasting and obesity with age among public school students, but improvements not nearly as dramatic as

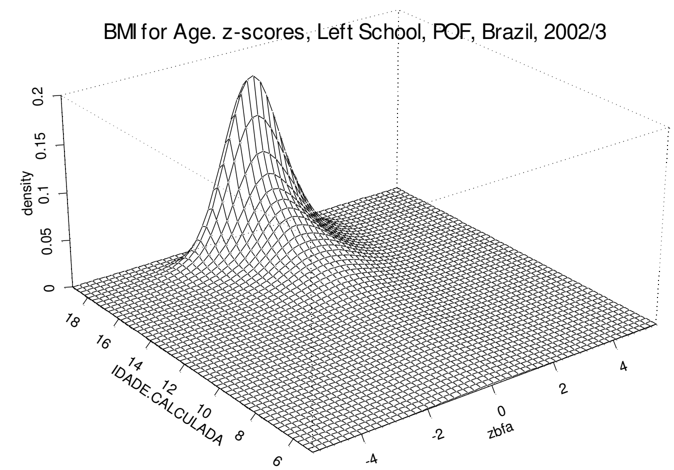
BMI for Age z-scores, Private School Students, POF, Brazil, 2002/3

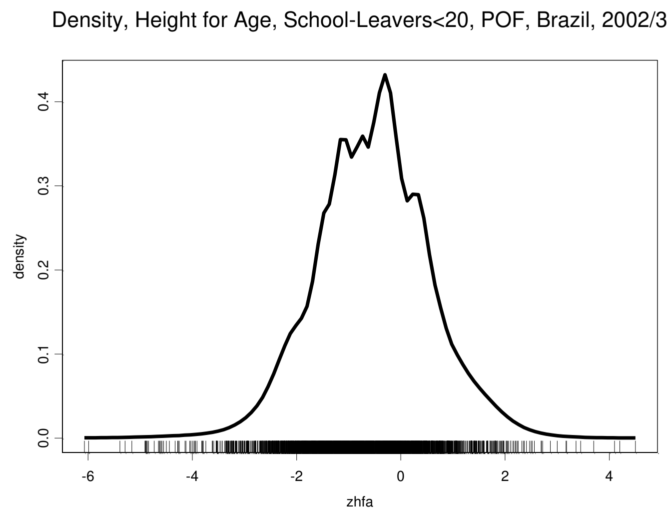


[16] It should not be neglected that intense daily physical activity is recommended during adolescence, that, if diet is adequate, will build bone density to levels that extend active lifespan.

those with age in private school.[17] The concentration of students in private education at youngest ages is sufficient to hollow the density of public school students. The relatively smaller number of private school students above age 9 evidences a structural differentiation of private education in Brazil.

The BMI for age density for school leavers, displayed in figure 6, beyond its exponential concentration above age 12, also becomes increasingly dispersed with age, in both directions, evidencing very substantial proportions of both wasting and obesity in the oldest children. Evidently, leaving school presents children with greatly increased risks of inadequate diet. The complexities of transition from school to work in Brazil are not likely to be greater than in any other country. To illustrate, the density of height for age among school leavers is displayed in figure 7. There is a visible and relatively anomalous peak in the number of school-leavers whose height for age is developmentally normal. This suggests the possibility of a selection mechanism in the labor market, whose description is beyond the scope of this paper.[18] More attention is also due to the large "shelf" in the density from ~ -0.5 through the mean at -0.55, to ~ - 1.5 z-scores. The average height for age of school-leavers wanders across this range, as daily personal earnings from work increase from near nothing towards 5 reales per day. These two features account for the diminished standard deviation of school-leavers' z-scores relative to other enrollment groups. For all that leaving school before the end of childhood to enter the labor market is a well accepted path it apparently can deliver a severe blow to biological development, unless nutritional conditions are well-monitored.

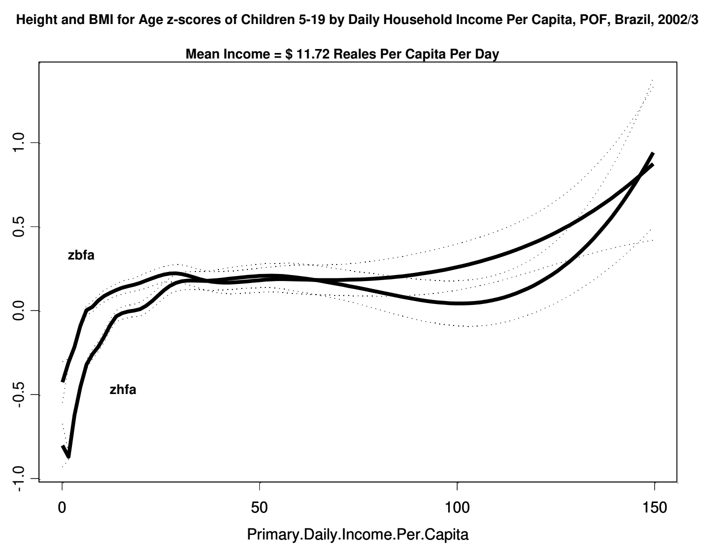




[17] "Adaptive" is a term used by Moffat, T., Galloway, T., "Adverse Environments: Investigating Local Variation in Child Growth," American Journal of Human Biology, 19:676-683 (2007), to describe living circumstances in an upper SES neighborhood in Hamilton Ontario where children 6-10 were HAZ 0.38, BMIZ 0.14, compared with HAZ 0.09, BMIZ 0.39 among low SES children. Brazilian children in public school do not often reach such levels.

[18] See, for example, Cueto, S., "Height and Weight as predictors of Achievement, Grade Repetition and Dropout in Rural Peru," presentation at, "School Children in the Developing World: Health, Nutrition and School Performance" conference, UCLA, 2/18-20/2004, a longitudinal study where taller children were more likely than shorter children to have dropped out, due to an appearance, "…no longer perceived as school-age, but working-age."

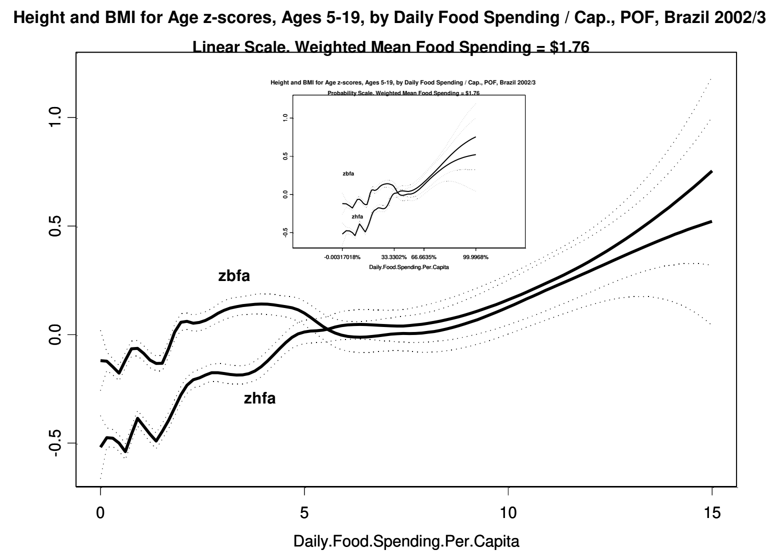
We now turn to the factors impinging on differences in nutritional status just illustrated. The principal measures in general use for assessing economic impacts on child nutritional status are the income of the household, and its expenditures.[19] Daily household income per capita is used for discussion here: the monthly household income reported by the POF divided by household size and 30. Household income per capita was lowest for children under 10 and greatest for children over 14. The same can be said for aggregated income from work, and both overall expenditures, and food spending. All of these measures followed similar patterns across ages; but the averages were stratified by school enrollment category. Household spending per capita/day ranged from 11 to 18 reales among private school households, and increased with age from 3 to 5 reales per day for public school households. In other words households with public school students aged 5-10 spent on average 1 U.S. dollar per day per capita on all items.



The fits of height for age and BMI for age to household per capita income are displayed in Figure 8. The mean income was $11.82 reales, roughly equivalent to U.S. $3.94 in 2003, quite close to the left margin in figure 8. It is evident that the strongest relationship of daily income per capita with both height and BMI z-scores was confined to the mean income and lower. Apparently, Increases of income between $20 and $100/Cap/dy negligibly impact child nutritional status. Increases of income over the middle range also had little impact on the sufficiency of nutrient consumption in the 1987/8 and 1995/6 POF data.[20] As 2002/3 incomes increased above $100/Cap./dy., into the top 1.0 percent of incomes, z-scores increased towards the level of 0.7 standard deviations observed using the WHO 2007 Reference Standards in some northern European countries.[21]

[19] Gallo, P.R., et. Al., “Fatores de risco ao retardo de crescimento estatural em crianças de baixo nível económico e social de São Paulo, Brasil,” Archivos Latinamericanas de Nutricion, v.50 n.2 Caracas jun. 2000, find level of income almost three times more influential on linear growth retardation than birth weight, next among 18 other variables.
[20] Calitri, Op. Cit., 2002.
[21] De Onis, et al., Op. Cit, 2007.

The non-food uses of income increase in proportion as mean income is approached from below; so it should come as no surprise that household expenditure on food displays a more direct relationship with child nutritional status than does income. The relationship of household food spending, aggregated from detailed food purchases, and schoolchild nutritional status is displayed in figure 9. At first glance, there are similarities with income; but only BMI for age displays any substantial non-reactivity to food spending across the middle of its range. When the x-axis is rescaled to probabilities, as in the smaller graph set within figure 9, the efficacy of food spending across all its levels as a positive influence on child nutritional status is more clearly visible in a steady rise of height for age z-scores above the per capita mean level (1.76 reales), and even in some abatement of the tendency towards above-normal BMI for age, above food spending of 4.5 reales per capita (USD 1.50), the upper 6 percent of the population, by this metric. Food spending was also found to much more strongly associate with nutritional sufficiency than income in previous research on the POF 1987/8 and 1995/6.



Though only 12 percent of children received income, a fairly distinct relationship of children's personal income from work with both height for age and BMI for age is displayed in figure 10. The mean income of children with income was $1,100 per annum. Positive changes in height for age (lower line) were visible only above the mean level. BMI for age (upper line) responded positively to personal income below the mean, presumably as at low income levels, available income would be utilized for fattening rather than growth-inducing snacks. However, ambiguity of the OLS results for BMI for age presented below suggests further examination is desirable.

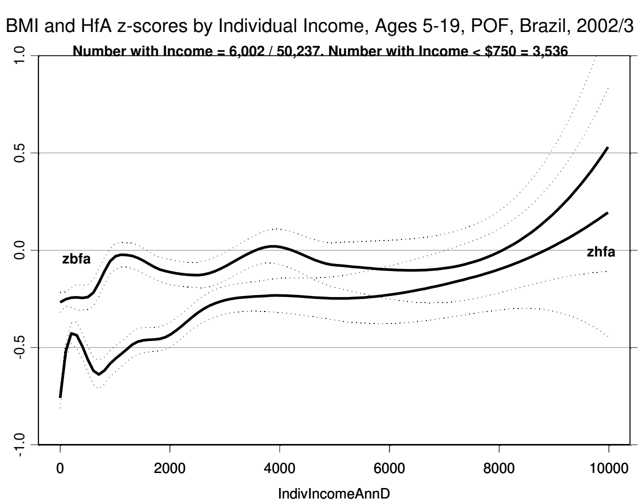
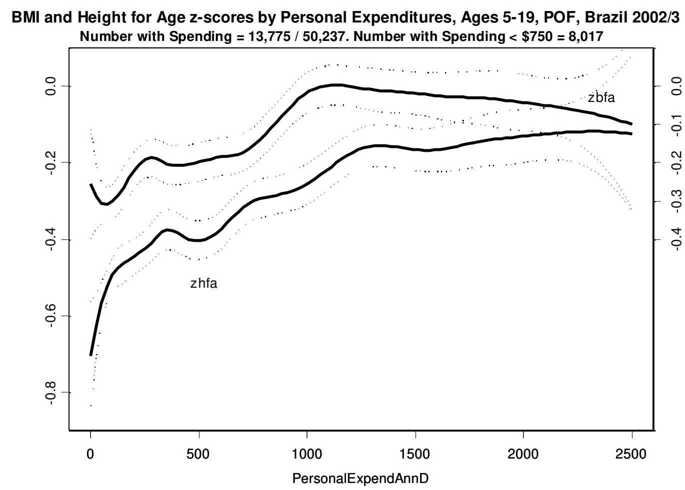
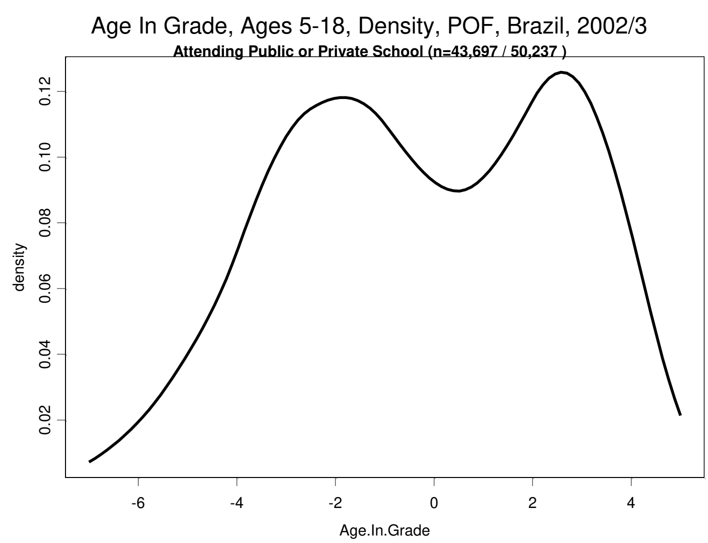


Figure 11 illustrates the relationship of nutritional status with children's personal expenditure. Some 27 percent of children reported personal expenditure. The mean level was $1,195.15 annually, but median was $592. The positive response of nutritional status to increased spending persists up to the mean level, and above for height for age (lower line).

Tabulations were also made of the expenditure of children on food away from home ($372.83/Annum), tobacco products ($280.49), and games, sports and entertainments ($298.12). Together, these three categories totaled 79.6 percent of all spending by children. However, children's spending was heterogeneous; and only 98 of the children sampled had spending on all 3 of these categories; so results from OLS tests were ambiguous, and for the most part insignificant. Expenditure on tobacco was highest among school-leavers and private school students, for example, so was associated both negatively and positively with nutritional status. Some 16 percent of children spent money on food away from home, however. Among this group, personal food spending was associated with improved nutritional status, in much the same pattern as was household food spending.



In addition to school enrolment status and years in school, the POF also collected data on level of instruction in 14 categories. An exploratory variable for age in grade was generated using a linear transformation, subtracting the child's actual age in years, -6 from level of instruction. The density for the resulting variable is displayed in figure 12, illustrating that age in grade is bi-modal, with the number of children ahead of grade roughly equivalent to the number behind grade. However, a larger number of children under 13 were ahead of grade than behind; and the number of children behind grade increased with age. This pattern is a familiar one to most teachers, and has been documented internationally.[22] The average level of age in grade (-0.56 years) exhibited little variation across degrees of latitude, in contrast with other variables examined.



[22] See, Wake M., et al., "Does height influence progression through primary school grades?" Archives of Disease in Childhood, 82, 4, April 2000, for results also indicating age in grade as a lesser influence upon girls than boys.

There were slight differences between the sexes in the relationship of age in grade and nutritional status. Male and female patterns for height for age across age in grade are presented in figure 13. It is evident that both boys and girls at very low grade levels for their age are significantly lower in stature. The positive relationship between height for age and age in grade is quite strong for boys (thicker line). Girls (thinner line) exhibit little variation in height for age from -2 to +1 years age in grade.

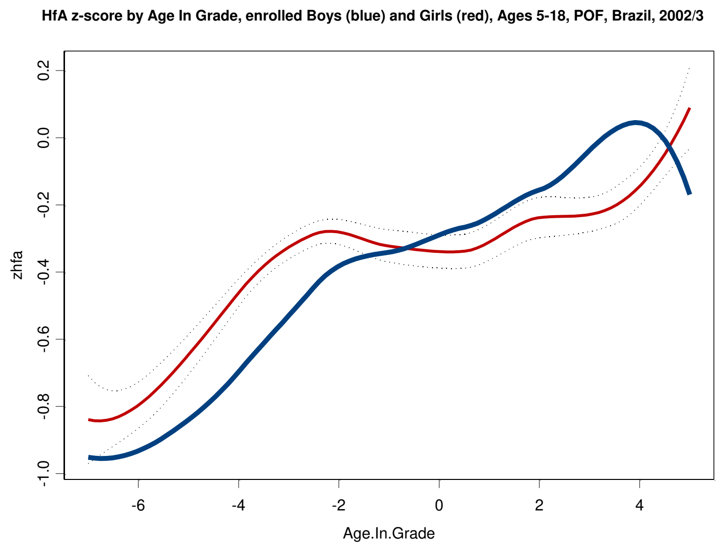
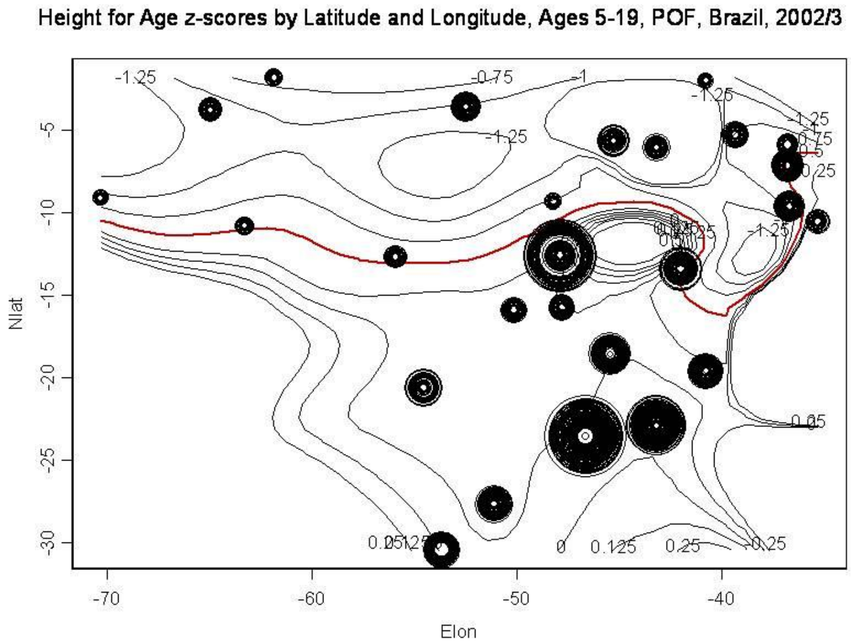


Figure 14 presents BMI for age across age in grade. The relationship is again much stronger for boys (thicker line) than girls (thinner line). BMI for age decreases steadily as age in grade increases (negatively) for boys. In contrast, there is little response of girls' BMI for age across negative levels of age in grade. Girls who are more than one year ahead of grade exhibit increases in BMI for age.

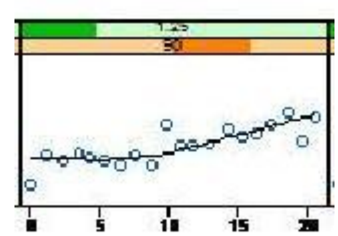
Two further dimensions require some discussion before concluding, those of space, and time. In order to examine geographic patterns of child nutritional status, local regressions were calculated on latitude and longitude. Figure 15 displays the geographic pattern of height for age.

Figure 15 illustrates that variations in height for age are largely latitudinal. In other words, there is a distinct tendency for height for age to improve with distance from the equator. Geographic strata were also visible in BMI for age; but running southerly from west to east, less clearly latitudinal.



There is some difficulty, however, in modeling the spatial character of nutritional status across the entire country. Provincial geographic centroids were identified relatively easily; but the POF sampled each province in regions, urban, suburban and rural areas whose geographic dispersion could not be modeled from information available. However, a UNICEF project in Brazil, the "Municipal Seal of Approval," has gathered substantial social, economic, and child status information at the municipal level.[23] It appears feasible that this data from Brazil's 4,490 municipios can be used to project from POF provincial urbanization strata to achieve a greater degree of spatial resolution than was possible above.

The major outcomes and indicators were also analyzed using methods of spatial statistics.[24] The variograms of both height and BMI for age were increasing with distance omnidirectionally, indicative of a large-scale trend or nonstationary underlying stochastic process. Figure 16 displays the best fit from a series of diagnostic tests for geographic anistrophy in height for age. The trend is across latitudes from south to north, confirming the pattern identified in figure 15 using local regression.



[23] Carvalho, M., "UNICEF Municipal Seal of Approval in the Brazilian Semi-Arid Region as a tool to reduce poverty and inequality," presented at "Rethinking Poverty: Making Policies that Work for Children" Conference, New School, 4/23/2008, (www.equityforchildren.org).

[24] See, Mathsoft, S+SPATIALSTATS Users Manual, Seattle, Mathsoft Inc., 1996; _____,S+SpatialStats Version 1.5 Supplement, Mathsoft, Seattle, 2000.

While figure 16 displays some change in the variation from 0 (purely local) to 1 (near neighbors 1 degree distant), additional distance, up to 9 degrees, does not add much to variation. There is increasing variation only at distances above 9 degrees. The implication for modeling is that local models are unlikely to be destabilized by the inclusion of nearby communities. This is an inducement to further development of nutritional status models built upon data from localities, at finer resolution than the provincial level considered here.

It is also possible to examine seasonal variations of nutritional status using the POF data. The number of interviews daily was relatively steady across the survey period. The IBGE certifies the POF as nationally representative as of 1/15/2003, but reports interviews by survey week. Previous work suggests that representative subsamples can be extracted for a variety of sub-periods within the survey period.[25] It was possible to estimate interview dates at daily frequency by adding age in days to date of birth (m/d/y). The resulting variable runs from 7/3/2002 through 7/10/2003, and contains only one significant outlier from the reported survey week.

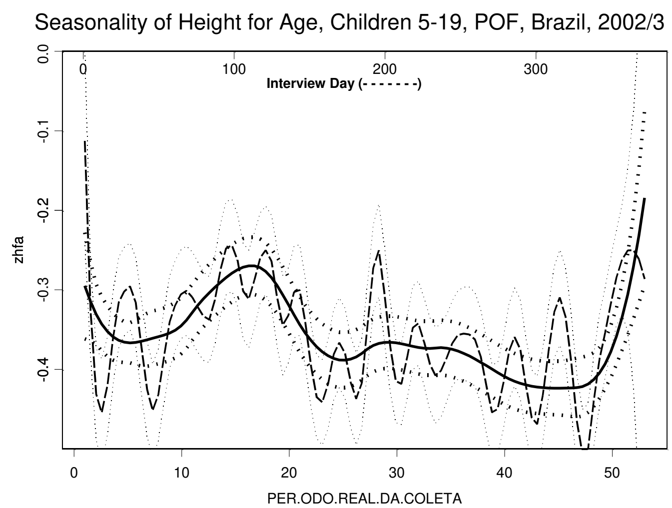
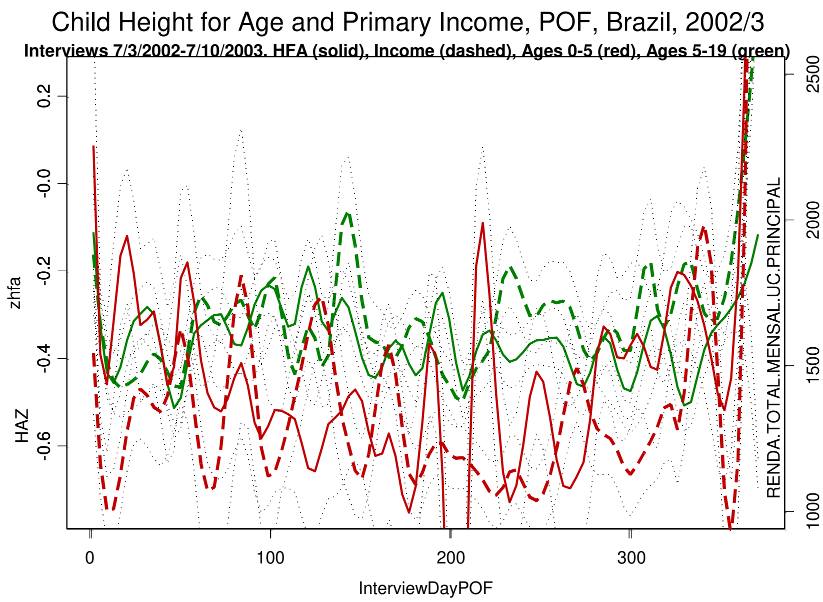


Figure 17 displays two fits of height for age across time, survey weeks (solid line) and interview days (dashed line). For the higher frequency daily data, residuals were minimized at narrower bandwidth (0.125) than for the weekly data (0.325). Every fluctuation of the daily mean crosses the weekly mean, an indication of stability in estimate. The smoothed functions suggest that the third week of September and first week of July are particularly good times for children's nutrition. On a national level, coincident student censuses during the first weeks of the school year would render optimistic estimates if children's nutritional status were projected from them across the year. When this analysis is replicated at the level of enrolment pattern or location, seasonal differences in height for age (and BMI for age) remain significant. Their timing does not always confirm with the national pattern. Not unremarkably, the national pattern is replicated by public school students. There was strong nutritional status seasonality for private school students, across 0.3 s.d. at the weekly frequency, more than twice the national range, but peaking during the holiday season at year's end, rather than in early fall. In a preliminary exploration of regional seasonality differences, the early fall peak in height for age was nearly completely suppressed above -12 degrees latitude, and much amplified below -20 degrees latitude.

[25] Calitri, R., Op. Cit, 2002, Chapter 2.

Given that both interview days and survey dates are available, it appears possible to utilize time series methods to test the strength of some of the relationships of family, school and community factors described. Figure 18 displays height for age (solid lines) and primary household income (dashed lines) across interview days. The figure contains results for children ages 0-5 (red; lower tracks) and children ages 5-19 (green; upper tracks). Especially for children in the 0-5 age range, household income is quite variable seasonally. Both younger and older children display some worsening of nutritional status over the warm months (winter in the northern hemisphere).



The apparently coincident patterns of presumably causal and outcome variables made it seem reasonable to test the relationships using Granger causality, a method of assessing the significance of lagged values of one variable in adding predictive accuracy to the autocorrelation or lagged values function of a second variable.[26] In order to test the method, weekly averages (53) were estimated for selected variables. The weekly percentage change in each variable was then calculated, resulting in a set of "differenced" series (across 52 periods) whose bivariate relationships were then tested in an autoregression over 2 lags (AR2). Wald test probabilities fill the causation matrix displayed in Table 3.

Table 3. Granger Causation of Nutritional Status Outcomes and Factors (bivariate AR2) , POF, Brazil, 2002-3

	Significance at 10 % level = **bold**	CAUSING								
		ZBFA	ZHFA	FoodSp/Cap	HH.Inc./Cap	Av.Age	Nlat	Elon	StuntOrWasted	Age in Grade
CAUSED	ZBFA		0.11	**0.10**	0.68	0.93	0.42	0.78	0.64	0.63
	ZHFA	0.64		0.66	0.70	0.85	**0.07**	0.67	0.45	0.48
	FoodSp/Cap	**0.08**	0.48		0.33	0.61	**0.06**	0.11	**0.04**	0.90
	HH.Inc./Cap	0.64	0.92	0.35		0.37	0.77	0.88	0.90	0.20
	Av.Age	0.93	0.85	0.66	0.38		0.69	0.71	**0.04**	0.86
	Nlat	0.79	0.13	0.11	0.52	0.56		**0.04**	0.34	0.59
	Elon	0.46	0.72	0.14	0.89	0.18	**0.04**		0.89	0.51
	StuntOrWasted	0.75	0.11	**0.08**	0.93	**0.06**	**0.05**	0.33		0.16
	Age in Grade	0.84	0.51	0.96	0.39	0.66	0.32	0.56	0.13	

The direction of causation in Table 3 runs from columns to rows. Food spending per capita Granger causes BMI for age z-score at the 10 percent level of significance and Granger causes stunting or wasting at the 8 percent level. The BMI z-score Granger causes food spending at 8 percent. Latitude

[26] See, Zivot, E., Wang, J., "Modeling Financial Time Series with S-Plus," Springer, 2006 for the method utilized.

Granger causes height for age, food spending and stunting or wasting. Stunting or wasting Granger causes food spending. There are two feedback relations; average age and stunting or wasting Granger cause each other, as do latitude and longitude. Feedbacks are often revelatory of structure. The prevalence of stunting and wasting at younger ages was discussed above. The national structure of Brazil is characterized by a northerly widening across degrees of longitude as visible in figure 15. This experiment suggests that time series methods developed for study of dynamic processes are particularly well-suited to the study of nutritional status in children, hardly surprising given the dynamic character of their growth and development. Further Granger causation experiments relating child nutritional status with series derived from the POF, and economic series published by IBGE appear warranted.

Given discussion in the UNICEF report on the situation of children and adolescents in Brazil (Op. Cit), and other places, it has seemed relevant to report on the racial differences of nutritional status. Table 4 presents some of the measures discussed by race. Table 4f reports malnutrition by race.[27]

Table 4: Characteristics by Race, Children 5-19, POF, Brazil, 2002/3

Race	White	Dark	Yellow	Brown	Indigenous	Unknown	Total
Population	21,760,572	2,874,214	243,771	21,633,391	130,384	62,164	46,704,496
Primary Income/Mo.	2,181	1,248	3,734	1,112	1,091	3,308	1,635
Primary Inc./Cap./Dy.	16.46	8.73	23.40	7.43	7.05	25.19	11.82
Daily Food Spd./Cap.	2.02	1.46	2.52	1.53	1.38	1.53	1.76
Height for Age Z	-0.18	-0.23	-0.27	-0.55	-1.44	-0.70	-0.36
BMI for Age Z	0.07	-0.08	0.28	-0.16	0.22	-0.49	-0.05
Sample	19,203	2,252	153	28,341	216	72	50,237

It can be seen that nutritional status of white children is somewhat better than that of children of other races. Table 4 also reports measures of income and food spending seen above to influence child nutritional status overall. Though both material measures are higher for white children than for black, brown or indigenous children, we shall report shortly that race is a significant additional factor in the nutritional status of Brazil's children.

[27] Table 4f indicates that while malnutrition is different in character across races, no race was completely immune. This table furthers the impression that Indigenous children are particularly subjected to stunting.

Table 4f: Malnutrition by Race, Children 5-19, POF, Brazil, 2002/3

Race	White	Dark	Yellow	Brown	Indigenous	Unknown	Total
Population	21,760,572	2,874,214	243,771	21,633,391	130,384	62,164	46,704,496
Stunting	8.04%	7.04%	7.19%	11.34%	38.45%	16.34%	9.60%
Wasting	5.57%	5.33%	2.91%	6.07%	1.82%	12.76%	5.77%
Gigantism	4.78%	3.87%	2.95%	3.04%	0.60%	2.63%	3.89%
Obesity	8.10%	4.63%	9.16%	4.61%	7.40%	0.00%	6.26%
Stunted or Wasted	13.26%	11.89%	10.09%	16.60%	39.85%	21.59%	14.79%
S, W, or O	19.69%	15.47%	18.70%	20.12%	45.79%	21.59%	19.70%
Any	23.11%	18.77%	21.57%	22.23%	46.01%	24.23%	22.49%
Sample	19,203	2,252	153	28,341	216	72	50,237

Most of the relationships discussed here were non-linear in character, if unimodal; and a full exploration of their interactions is not completed. Weighted ordinary least squares experiments suggest most of the variables explored so far are significantly associated with differences in nutritional status. We report first, in table 5, experiments incorporating student income and expenditure alongside other factors in models of height for age and BMI for age.

Table 5a. Dependent Variable: Height for Age	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	0.997	0.225	4.433	0.000
Nlat	-0.025	0.002	-12.385	0.000
Schooling: Private, Public, Left School, Never Attd.	-0.079	0.027	-2.969	0.003
Level of Instruction	-0.066	0.008	-7.808	0.000
Race: White, Dark, Yellow, Brown, Indigenous	-0.050	0.011	-4.691	0.000
Mean Food Deflator	-0.241	0.123	-1.953	0.051
Total.HHIndInc.Cap.Dy	0.007	0.002	2.985	0.003
Total.HHIndSpdg.Cap.Dy	0.003	0.003	1.071	0.284
Daily.Food.Spending.Per.Capita	0.031	0.008	3.881	0.000
Personal.Income.Daily	0.008	0.003	2.676	0.008
Personal.Spending.Daily	0.010	0.004	2.780	0.006
AgeInGrade	0.070	0.008	8.400	0.000

Residual standard error: 31.99 on 5014 degrees of freedom
Multiple R-Squared: 0.1068
F-statistic: 54.5 on 11 and 5014 degrees of freedom, the p-value is 0
45211 observations deleted due to missing values

Table 5b. Dependent Variable: BMI for Age	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	0.169	0.236	0.718	0.473
Nlat	-0.010	0.002	-4.713	0.000
Schooling: Private, Public, Left School, Never Attd.	0.189	0.028	6.788	0.000
Level of Instruction	-0.043	0.009	-4.927	0.000
Race: White, Dark, Yellow, Brown, Indigenous	-0.022	0.011	-1.948	0.052
MeanFoodDeflator	0.020	0.129	0.158	0.874
Total.HHIndInc.Cap.Dy	0.003	0.002	1.465	0.143
Total.HHIndSpdg.Cap.Dy	0.004	0.003	1.431	0.152
Daily.Food.Spending.Per.Capita	0.012	0.008	1.376	0.169
Personal.Income.Daily	-0.001	0.003	-0.190	0.850
Personal.Spending.Daily	0.014	0.004	3.893	0.000
AgeInGrade	0.045	0.009	5.178	0.000

Residual standard error: 33.53 on 5014 degrees of freedom
Multiple R-Squared: 0.03139
F-statistic: 14.77 on 11 and 5014 degrees of freedom, the p-value is 0
45211 observations deleted due to missing values

With height for age as the dependent variable, all coefficient values were of the expected sign and t-values significant, except for the intercept and local inflation. Latitude was most influential, suggesting that further assessments at the provincial level and below are desirable. As far as BMI for age is concerned, results are more ambiguous; the insignificant negative impact of personal income on BMI may be related with differences between enrollment groups, as 1/3 of school-leavers worked, but 1/7 children in school. Enrollment status (Schooling) and age in grade were most significant. It is interesting that children's spending was more influential on BMI than their households' spending.

Including children's personal income and spending in the analysis reduces the sample size very substantially. Table 6 reports experiments on a more robust set of variables, retaining only age, age in grade, schooling type and race as individual indicators and adding the household variables and community variables discussed and also response levels to a variety of living conditions questions.

Table 6. Height and BMI for Age, with Personal, Household, Community, National and Sample Factors
Children 5-19, and their households, Pesquisa de Orcamentos Familiares, Brazil, 2002/3.

Population weighted OLS. Dependent Variable:	Height for Age			BMI for Age		
Factor 5% signif. = *Italic*. Both models 5% = **Bold**	Coeff.	t value	Pr(>|t|)	Coeff.	t value	Pr(>|t|)
(Intercept)	0.0076	0.0797	0.9364	0.1039	1.0775	0.2813
Personal and Schooling Factors						
Years ahead of Grade Cohort	**0.0696**	**15.1435**	**0.0000**	**-0.0218**	**-4.6833**	**0.0000**
School: Private, Public, Left School, Never Attd.	**-0.0974**	**-8.3042**	**0.0000**	-0.0155	-1.3012	0.1932
Race: White, Dark, Yellow, Brown, Indigenous	**-0.0324**	**-7.2417**	**0.0000**	**-0.0287**	**-6.3367**	**0.0000**
Age	**0.0011**	**3.6473**	**0.0003**	**-0.0045**	**-15.2250**	**0.0000**
Household and Nutrition Factors						
Household Food Spending Per Capita per Day	**0.0543**	**9.7825**	**0.0000**	**0.0506**	**9.0054**	**0.0000**
Undesirability of Food Type	**-0.0791**	**-6.2830**	**0.0000**	-0.0140	-1.0992	0.2717
Number of Foods consumed by household	**-0.0028**	**-5.1119**	**0.0000**	**-0.0041**	**-7.4169**	**0.0000**
Sufficiency of Available Food	**0.0487**	**5.0598**	**0.0000**	**0.0539**	**5.5301**	**0.0000**
Total HH Income from Work	**0.0036**	**4.9829**	**0.0000**	**0.0028**	**3.7938**	**0.0001**
House not too dark	**0.0661**	**4.4377**	**0.0000**	0.0039	0.2616	0.7936
Total HH Spending by Individuals	**0.0023**	**2.7073**	**0.0068**	**-0.0024**	**-2.7392**	**0.0062**
Food Consumption, Kg/Cap./Day	**0.0149**	**2.1290**	**0.0333**	-0.0017	-0.2418	0.8089
Roof not too leaky	0.0271	1.9345	0.0531	**0.0378**	**2.6589**	**0.0078**
Monthly Household Income	0.0000	-1.7495	0.0802	**0.0000**	**-6.7063**	**0.0000**
Few problems with humidity	-0.0240	-1.7106	0.0872	**-0.0283**	**-1.9960**	**0.0459**
Few problems with deterioration	0.0243	1.7003	0.0891	**0.0829**	**5.7316**	**0.0000**
Poorness of living conditions	0.0028	0.3015	0.7630	0.0082	0.8752	0.3815
Household Income Per Capita per Day	-0.0001	-0.1501	0.8807	**0.0049**	**5.0284**	**0.0000**
Community Factors						
Unavailability of Garbage Service	**-0.0685**	**-6.5167**	**0.0000**	-0.0127	-1.1939	0.2325
Unavailability of Electricity	**-0.0644**	**-5.0709**	**0.0000**	0.0018	0.1416	0.8874
Unavailability of Drainage	**-0.0360**	**-4.3975**	**0.0000**	**-0.0276**	**-3.3202**	**0.0009**
Few problems with pollution	**-0.0526**	**-3.3836**	**0.0007**	-0.0204	-1.2967	0.1947
Unavailability of Water Service	**-0.0318**	**-3.3439**	**0.0008**	**-0.0246**	**-2.5521**	**0.0107**
Neighbors not too noisy	**-0.0423**	**-2.7948**	**0.0052**	0.0218	1.4201	0.1556
Few problems with violence	**0.0386**	**2.7800**	**0.0054**	**-0.0993**	**-7.0626**	**0.0000**
Reason for no food expense or unavailability	**0.0328**	**2.5681**	**0.0102**	0.0145	1.1195	0.2630
Ease of Obtaining Income	0.0126	1.9181	0.0551	**0.0461**	**6.9124**	**0.0000**
Unavailability of Street Lighting	-0.0118	-1.1443	0.2525	-0.0178	-1.7061	0.0880
Space not too little	-0.0040	-0.3050	0.7603	**0.0551**	**4.1730**	**0.0000**
National and Sample Factors						
Latitude	**-0.0252**	**-25.2989**	**0.0000**	**-0.0037**	**-3.6407**	**0.0003**
Longitude	**0.0089**	**8.6008**	**0.0000**	**-0.0074**	**-7.0422**	**0.0000**
Population Weights	**0.0000**	**-4.4919**	**0.0000**	**0.0000**	**3.3496**	**0.0008**
Residual standard error:	39.32	on 46446 d.f.		39.84	on 46446 d.f.	
Multiple R-Squared:	0.1006			0.0425		
F-statistic:	162.3	p-val: 0		64.42	p-val: 0	

In the models reported in table 6, the variables have been classified as individual, household, community or national and sample factors, and arranged in order of significance in the height for age regression. Only the intercept and 2 out of 32 variables were not significantly related with height for age or BMI for age. The variables discussed in text are all significant, and signed as anticipated except for anomalies, such as the sign on number of foods to indicate modeling has not been optimized.

The coefficient values and their significance were not completely stable to addition or deletion of variables. Yet, the list of major factors significantly related with both height and BMI, particularly the household factors of food spending, overall spending, and income, and location, our proxy for national structure, remained relatively unchanging amidst other factors. The individual and schooling factors, except age, remained properly signed and significant through numerous experiments. Sex was only occasionally influential, and will require modeling on dependent variables other than sex-normed z-scores. The addition of a number of community variables added significance to the explanatory power of the experiments; but It is important to understand their relative importance, as attempts have been made to substitute "food security" using indices of household factor numbers 2 and 4, and sometimes 3, for consumption based nutritional status, or child anthropometrics as used here.

Considerable further work with additional variables is needed to amplify the details of this study, in particular to examine the relative influences of anthropometric nutritional status of older family members, alongside economic and social factors on the nutritional status of children.[28] The explanatory power of the experiments shown is relatively slight, particularly for BMI, despite the large number of variables, in the absence of dietary components. It does seem indisputable that children's nutritional status depends to some extent on their own activity, but with some certainty also on actions at school, household, community and national levels.

Conclusions

Studies of school nutritional census have found them to be valid indicators of differences of schoolchild nutritional status between communities.[29] The results presented here suggest that measurements of heights and weights at fixed annual intervals are not likely to adequately represent the nutritional status of children across the year. For this purpose, continuing population surveys are needed to complement school – based nutritional monitoring.

There are a number of additional lessons to be learned regarding the interaction of individual, school, family, and community factors. Measurements of anthropometric nutritional status as discussed here are essential in monitoring the well-being of children. Yet, without food in the model, their explanatory value is slight. Consumption surveys such as the POF also gather considerable details about the types and quantities of foods children consume. In their absence, other evidence may be necessary, market monitoring, or supermarket tapes or account books, if available. Evidently in using such data, a survey such as the POF has made itself useful by collecting details of the markets where all purchases were made, allowing the food system to be modeled consistently with nutritional status outcomes.

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[28] It will be particularly interesting to see whether findings on heritability of height using the Fels longitudinal data (1929-date; and part of the support for the WHO 2007 Reference Standards ages 5-19) by, Czerwinski, S. A., et al., "Genetic factors in physical growth and development and their relationship to subsequent health outcomes," American Journal of Human Biology, 19:684-691, 2007, can be replicated in data from contemporary Brazil.

[29] Morris, S. S., and Flores, R., "School Height Censuses Are Reliable and Valid Tools for Small-Area Targeting of Nutrition Interventions in Honduras," Journal of Nutrition, 2002, 1188-1193,

In addition to surveying their consumers, it is also necessary to survey foods. Estimates of the nutrient contents of foods and their contribution to development will provide data that is most likely to increase the explanatory power of childhood nutritional status monitoring efforts. At present the nutritional components of only a fraction of the foods consumed in Brazil have been fully or even minimally identified. Though a considerable amount of scientific work is occurring, it is hardly a crash program. The backlog is immense, and not entirely due to a lack of money for studies. There is unwillingness to confront what the studies have already found, that required nutrients for physical development are several times greater than the usually promulgated maintenance diet designed for untrained levels of activity.[30]

In terms of policy suggestions, a considerable time has elapsed since the POF 2002/3 concluded, so it is necessary to be somewhat general. Of first order is recognition that nutritional opportunities must be provided for children. Children have a right to the foods that are necessary for their growth and development. Their diets must be "adequate," 97 percent probability that all nutrient intakes are as required, and not over limits. It is necessary for children to have adequate nutrients available in order to sustain unimpeded exercise and mental activity, exercise at levels that older people often perceive as excessive, mental development best accomplished through interactions with cohorts at similar levels.

The evidence from Brazil suggests that during early school years, physical activity as well as nutrition may be restricted during schooling. Nutritional limitations may impede children's ability to develop mentally at the normal rates of well-nourished children. Children entering the labor force fall under considerable nutritional risk. Children's nutritional status is dependent to some extent on their own activity, but also on actions at the school, household, community and national levels. Further improvements at all these levels remain necessary despite several generations of nutritional growth.

Under the current environment of public economic commitments, it seems relevant to conclude with a lesson hardly limited to Brazil. When population nutrition improves, considerable investments are required: to expand housing and exercise space, to retool manufacturing, to plan for more wear and tear, to accommodate increased flows through food systems, to reduce crime and abuse, and, of course, to expand the schools to hold all the children who can now keep up.

[30] For example, in the U.S. 1994-6 CSFII, protein intake by developmentally active adolescents averaged 4 g./kg./dy. Inactive adolescents consumed 1 g./kg./dy., the internationally recommended level for populations.