Scholastic Achievement: A Multivariate Analysis of Nutritional, Intellectual, Socioeconomic, Sociocultural, Familial, and Demographic Variables in Chilean School-Age Children

Daniza M. Ivanovic, MSc, Hernán T. Pérez, LSc, Manuel G. Olivares, MD, Nora S. Díaz, LSc, Bárbara D. Leyton, LSc, and Rodolfo M. Ivanovic, LSc

From the Institute of Nutrition and Food Technology, University of Chile, Santiago, Chile; and the School of Public Health, Loma Linda University, Loma Linda, California, USA

OBJECTIVE: We determined relative effects of nutritional status, intellectual ability, exposure to mass media, and socioeconomic, sociocultural, familial, demographic, and educational variables on scholastic achievement (SA).

METHODS: This was a cross-sectional study. Exposure to mass media and nutritional, intellectual, socioeconomic, sociocultural, familial, demographic, and educational factors, including approximately 2000 variables, were measured in a representative and proportional sample of 4509 school-age children from elementary and high schools in Chile's Metropolitan Region. The field study was carried out between 1986 and 1987, and data processing, which lasted 15 y, was completed in 2002.

RESULTS: Within the total sample, intellectual ability, level of maternal schooling, head circumference-for-age *Z* score, book reading, in-door plumbing, level of paternal schooling, type of school, quality of housing, height-for-age *Z* score, and calcium intake were the independent variables with the greatest explanatory power in SA variance ($r^2 = 0.508$). In most grades, IA was the independent variable with the greatest explanatory power in SA variance. In adolescents in their fourth year of high school and whose physical growth and intellectual development processes are consolidated, intellectual ability, age, head circumference-for-age *Z* score, book reading, type of school, and level of paternal schooling were the independent variables with the greatest explanatory power in SA variance ($r^2 = 0.60$).

CONCLUSIONS: These findings show that SA is conditioned by multiple factors depending on the characteristics of school-age children, their families, and the educational system. Nutritional indicators of past nutrition are significantly associated with SA, especially head circumference-for-age *Z* score. This information may be useful for health and educational planning. *Nutrition* 2004;20:878–889. ©Elsevier Inc. 2004

KEY WORDS: nutritional status, intelligence, educational measurements, familial characteristics, demography, socioeconomic factors, mass media

INTRODUCTION

Learning is a multifactorial process conditioned by multiple factors the depend on the child, that child's family, and the influence of the educational system that modifies enrollment, attendance, scholastic achievement (SA), and dropout rates.[1,2] In Chile, most of the educational research has focused on the measurement of the socioeconomic determinants of the learning process; in recent years, research related to the effect of nutrition and health on SA or dropout rates has been carried out to assess the effects of other factors.[3–13]

The nutritional status of school-age children, measured through direct and indirect indicators, has been described as positively and significantly associated with SA, thus supporting the idea that this is positively and significantly correlated with the indicators of previous nutrition.[4–14] Undernutrition at a young age may have adverse long-term effects on the SA of school age-children from lower socioeconomic strata (SESs) who graduate from high school; undernourished children have significantly lower birth weights, smaller head circumferences (HCs), lower intellectual quotients (IQs), smaller brain volumes, lower SA level, lower results on academic aptitude tests, and antecedents of level of maternal schooling than their poor peers who were not undernourished at a young age.[11] Level of maternal schooling, brain volume, and undernutrition at a young age has explained most of the IQ variance; with regard to academic aptitude testing for university admission, approximately 95% of the variance was explained by the IQ, length of the corpus callosum, anteroposterior diameter of the brain, and level of maternal schooling.[11] Our recent findings in Chilean school-age children who were graduating from high school confirmed that, independently of SES, age, and sex, high school graduates with similar IQs have similar parameters of nutritional status, brain development, and SA and that past nutri-

This study was supported in part by grants 1841167 and 1880818 from the National Fund for Scientific and Technologic Development and grant S 2169-924F from the Research and Development Department, University of Chile.

Correspondence to: Daniza M. Ivanovic, MSc, University of Chile, Institute of Nutrition and Food Technology, Public Nutrition Area, Avenida Macul 5540 (Entrada El Líbano 5540), PO Box 138-11, Santiago, Chile. E-mail: inta8@abello.dic.uchile.cl or daniza@uec.inta.uchile.cl

Nutrition 20:878–889, 2004

0899-9007/04/$30.00
doi:10.1016/j.nut.2004.06.009

TABLE I.

DESCRIPTION OF THE SAMPLE OF SCHOOL-AGE CHILDREN FROM ELEMENTARY AND HIGH SCHOOL BY SEX AND GRADE

	Total sample		Males		Females		
Grade	*n*	%	*n*	%	*n*	%	Age (y)*
Elementary school							
1	813	18.0	415	17.9	398	18.2	6.06 ± 0.39
2	729	16.2	373	16.1	356	16.3	7.12 ± 0.52
4	733	16.3	371	16.0	362	16.5	9.24 ± 0.79
6	869	19.3	465	20.1	404	18.5	11.28 ± 0.89
8	545	12.0	308	13.2	237	10.8	13.19 ± 0.82
High school							
1	425	9.4	208	9.0	217	9.9	14.27 ± 0.84
4	395	8.8	179	7.7	216	9.8	17.17 ± 0.82
Total sample	4,509	100.0	2,319	100.0	2,190	100.0	10.36 ± 3.52

* Values are mean ± standard deviation.

tional status, brain development, IQ, and SA are strongly and significantly interrelated;[13] however, maternal IQ, brain volume, and undernutrition in the first year of life have been described as the most relevant parameters associated with a child's IQ.[13]

Our previous studies reported that intellectual ability (IA) is the most important independent variable that explains SA.[6,13] Recent findings in Chilean school-age children who were graduating from high school have indicated that SA is conditioned by the IQs of the child and that child's parents, by undernutrition in the first year of life, brain volume, birth weight, and birth height; however, the child's IQ is the most important independent variable that explains approximately 90% of SA variance in males and females.[12,13] As a result, genetic and environmental factors such as a child's IQ, maternal and paternal IQs, nutritional status, brain development, socioeconomic, cultural, and familial conditions, and educational system variables modulate SA, although a child's IQ is the most relevant variable associated with SA for males and females.

In a previous report,[15] we communicated that, independent of SES and age (examined in the present study), HC, sex, maternal and household head schooling levels, height, availability in-door plumbing, and the quality of housing were the most relevant independent variables associated with IA. HC is an indicator of nutritional background and brain development, so these results emphasize the effect of malnutrition at a young age on IA, HC, and subsequent brain development.

Findings by several investigators have confirmed that variables related to familial SES and, in particular, level of maternal schooling consistently explain SA.[16,17] Moreover, children have indicated the importance of their mothers as the most powerful source of nutritional information.[18,19] Maternal nutritional knowledge may affect pre- and postnatal developments of the newborn and the child's. SA[16] Some researchers have emphasized that mothers who were undernourished at a young age have serious problems related to affectivity and communication with their offspring and a low degree of non-verbal expressiveness.[20,21] Higher levels of maternal attention are positively associated with infant development; as a consequence, level of maternal schooling may have its greatest effect on the child's health and IQ, probably because mothers are the main source of intellectual stimulation and enrichment of their psychosocial environment.[22] This may be important for the intellectual development of the children because the IQ is positively influenced by an adequate stimulation.

The effect of exposure to mass media (MME) on SA is controversial because several investigators have reported that, for some children, this exposure, especially to some television programs, has negative effects; however, for most children, television is neither injurious nor beneficial, and some studies even detected a positive effect of television on school performance.[23–25] Other studies have found a small negative relation between television viewing, SA, and intelligence.[26–28] There is evidently a lack of precision concerning the relative effect of MME on SA. However, the possible negative health effects of television viewing on children and adolescents, such as, obesity, poor body image, and decreased school performance, have been analyzed.[29] Some researchers have described a strong association between the prevalence of obesity and the extent of television watching, and higher levels of physical activity have been associated with a lower body mass index and less television watching; however, the relation between TV watching and weight status is more pronounced.[30,31] The relations of early television viewing to school readiness and vocabulary of children from low-income families have been investigated, and the investigators concluded that the relations of television viewed to early academic skills depend primarily on the content of the programs viewed.[32] With regard to printed mass media, reading ability has been described as positively and significantly associated with SA at the onset of high school and learning disabilities as positively and significantly associated with very low birth weight.[22,33]

The aim of this study was to quantitate the relative effects of nutritional, intellectual, socioeconomic, sociocultural, familial, and demographic variables on SA of children in elementary and high schools from Chile's Metropolitan Region. Another purpose was to contribute to the establishment of a model of the behavior of the independent variables in the educational system that affect SA.

MATERIALS AND METHODS

Study Population

The target population (n = 523 158) included all school-age children enrolled in grades 1, 2, 4, 6, and 8 of elementary schools and in grades 1 and 4 of high schools in the Metropolitan Region of Chile in 1986. Their age ranged from 5 y 6 mo to 22 y 1 mo, and they attended public, privately subsidized, and private non-subsidized schools in urban and rural areas. The sampling system was designed to produce a sample that included approximately 1.0% of this population. The representative and proportional sample consisted of 4509 children randomly selected and stratified according to a multistage sampling system by geographic area, county, school grade, sex, and type of school (Table I). Sample size in each stratum was proportional to the size of the stratum in the school-age population and was calculated to have 95% reliability. The grades selected represent the end of the elementary and high school cycles; objectives pursued by curricular programs of the ministry of education have been formulated for each grade. The survey was conducted between 1986 and 1987 in 13 schools in eight counties of the Metropolitan Region of Chile. This sample was representative of 38% of the Chilean school-age population.[34] This study was approved by the Committee on Ethics in Studies in Humans of the Institute of Nutrition and Food Technology, University of Chile.

Scholastic Achievement Testing

SA was evaluated through standard Spanish-language achievement (LA) and mathematic achievement (MA) tests designed specially for this study. The number of items varied with each grade (elementary: grade 1, 16; grade 2 ,16; grade 4, 40; grade 6, 50; grade 8, 62; high school: grade 1, 70) and was similar for LA and MA (1:1); for high school grade 4, the Academic Aptitude Test score was considered (150 items with a maximum score of 900). Content validity was accepted based on the fact that the test had been designed to measure the objectives pursued by the curricular programs of the Chilean ministry of education.[35,36] A pilot test was done in 320 children, and reliability was determined with the Spearman-Brown correlation that compared paired and unpaired item scores, which were 0.92 for LA and 0.97 for MA.[37]. Test consistency for each item was measured by Pearson's correlation coefficient, with values above 0.30 for all items.[37] Results were expressed as percentage of achievement in overall results (SA test; LA + MA) and in LA and MA. Some variables, such as type of school and level attendance, were recorded.

Nutritional Status

We measured weight, height, HC, arm circumference, and triceps skinfold and assessed nutritional status from these measurements. Nutritional status was expressed as weight-for-age *Z* score and height-for-age *Z* score (Z-H).[38] The percentage of adequacy of weight for height was calculated as the percentage of adequacy of weight to the median of weight by height, because most subjects were taller than 121.5 cm.[38]. Body mass index was calculated according to tables from the National Center for Health Statistics (NCHS)[38] and Garrow.[39] HC values were compared with published values[40–44] and expressed as *Z* scores (Z-HC). Z-HC values were similar when applying these tables because the correlation coefficient between these standards was 0.98.[44] Absolute HC values were adjusted by body size (weight and height). Percentages of age-adequate medians for arm circumference, triceps skinfold, arm muscle area, and arm fat area were calculated from data reported by Frisancho.[45] Birth weight was used as an index of prenatal nutrition, weight-for-age *Z* score, Z-H, and Z-HC served as indicators of postnatal nutrition, and percentage of adequacy of weight for height and body mass index were used as indexes of current nutritional status. Nutritional diseases, especially undernutrition at a young, were registered.

Dietary Intakes

Standard procedures were used to collect 24-h dietary recall data by individual interviews. The chemical composition table of Chilean foods was used to calculate the nutrient content of foods.[46] The 1985 Food and Agriculture Organization/World Health Organization/United Nations University (FAO/OMS/UNU) pattern was used as a reference for energy and protein intakes and dietary reference intakes for vitamins and minerals.[47–51]

Intellectual Ability

IA was assessed by Raven's Progressive Matrices Test in book form, with special and general scales for children 4 to 11 y and older than 11 y, respectively, that were validated for the Chilean sample in the present study.[52–55] The test was individually administered by a team of educational psychologists, and the scores were established in a percentile scale according to age: grade 1, superior IA (score ≥95th percentile); grade 2, above average IA (score ≥75th and <95 percentiles); grade 3, average IA (score >25th and <75 percentiles); grade 4, below average IA (score >5th and ≤25th percentiles); and grade 5, intellectually defective (score ≤5th percentile). There was no difference between the percentile scales of the sample and those obtained by Raven.[54,55] Experts from the World Health Organization for developing countries have recommended Raven's test because its results are not affected by culture.[56]

SES and Sociocultural and Familial Variables

SES was measured by applying a scale based on Graffar's modified method, which includes level of schooling, occupation of the household head, and characteristics of housing (building materials, ownership, water supply, and ownership of durable goods) as parameters; this scale has been adapted to Chilean urban and rural populations.[57] This scale divides a sample into six SESs: 1, high; 2, medium to high; 3, medium; 4, medium to low; 5, low; and 6, extreme poverty. The magnitude of MME was assessed by a questionnaire based on open and closed questions that were previously tested.[24] The aim was to record program preferences and exposures to radio, cinema, television, newspapers, magazines, and books other than school texts. Family-related variables, such as numbers of members and of siblings, place between siblings, crowding, alcoholism, and recreation were recorded.

Statistical Analysis

Data were analyzed with variance tests, Scheffé's test for comparison of means (PROC analysis of variance), correlation (PROC correlation), and multiple regression with Bonferroni's corrections (General Lineal Models Procedure, PROC GLM error type III) using SAS software (SAS Institute, Cary, NC, USA).[37,58] Data processing lasted 15 y, included approximately 2000 variables, and was completed in 2002 after the NCHS growth curves and the current recommended dietary allowances for vitamins and minerals had been published.[38,48–51] This study represents the largest study carried out in Chile to assess the determinants of SA with regard to the educational system. This study is quite unique in terms of the extensive numbers of variables that were examined and the combination of nutritional, behavioral, anthropologic, and indirect brain measurements.

RESULTS

Table II lists Pearson's correlation coefficients of nutritional status versus SA in the total sample and by school grade. Birth weight as indicator of prenatal nutritional status correlated positively and significantly with SA only in elementary grade 6. In most grades, undernutrition at a young age correlated inversely and significantly with SA, but the strongest correlation was found in the first year of high school. Nutritional background indicators correlated positively and significantly with SA. Specifically, the correlation across SA, weight-for-age *Z* score, and Z-H decreased when followed from elementary to high school; conversely, the correlation between SA and Z-HC increased as school years advanced and became strongest in high school grade 4. Brachial anthropometric parameters related to body composition correlated positively and

TABLE II.

PEARSON'S CORRELATION COEFFICIENTS BETWEEN NUTRITIONAL STATUS AND SCHOLASTIC ACHIEVEMENT BY GRADE

Anthropometric indicators	Total sample	Elementary school					High school	
		1	2	4	6	8	1	4
Prenatal nutritional status								
Birth weight	0.016	0.075	0.035	−0.053	0.123*	0.007	0.177	0.154
Postnatal nutritional status								
Undernutrition	−0.040§	−0.032	−0.130†	−0.086*	−0.103§	−0.008	−0.135§	−0.088
Z-W	0.245‡	0.183‡	0.175‡	0.178‡	0.265‡	0.250‡	0.161§	0.085
Z-H	0.262‡	0.198‡	0.234‡	0.277‡	0.302‡	0.281‡	0.203‡	0.107
Z-HC	0.220‡	0.238‡	0.208‡	0.211‡	0.281‡	0.229‡	0.291‡	0.368‡
Current nutritional status								
% W/H	0.030	0.078*	0.018	−0.047	0.055	−0.011	−0.086	−0.094
BMI	−0.118‡	0.080*	0.024	−0.019¶	0.073*	0.037	−0.022	0.002
Body composition								
% AC/A	0.158‡	0.110§	0.144‡	0.091*	0.227‡	0.172‡	0.097	0.019
% TS/A	0.082‡	−0.024	0.147‡	0.131†	0.209‡	0.142§	0.039	0.074
% AMA/A	0.173‡	0.149‡	0.037	0.066	0.174‡	0.129§	0.139§	0.096
% AFA/A	0.100‡	0.009	0.145‡	0.121§	0.212‡	0.149†	0.060	−0.019

* $P < 0.05$.
† $P < 0.001$.
‡ $P < 0.0001$.
§ $P < 0.01$.
¶ Not significant,
AC/A, arm circumference for age; AFA/A, arm fat are for age; AMA/A, arm muscle area for age; BMI, body mass index; TS/A, triceps skinfold for age; W/H, weight for height; Z-H, height-for-age Z score; Z-HC, head circumference-for age Z score; Z-W, weight-for-age Z score

significantly with SA in the total sample, and the strongest correlation was observed in elementary grade 6.

Nutrient intake expressed as percentage of adequacy correlated positively and significantly with SA (Table III). The strongest correlations were observed with the intakes of calcium, phosphorus, protein, riboflavin, zinc, and magnesium. In general, the percentages of saturated fatty acids and cholesterol correlated positively and significantly with SA, and an inverse but significant correlation was observed with mono- and polyunsaturated fatty acids. In relation to energy sources, SA correlated positively and significantly with the percentage of energy from protein and fat and inversely with that provided by carbohydrates. Similarly, a positive and significant correlation was detected for the percentage of animal protein.

Pearson's correlation coefficients across intellectual, educational, and MME variables are presented in Table IV. IA correlated positively and significantly with SA, and the correlations increased as the school years advanced. Positive and significant correlations were observed across SA, level of attendance, and type of school, because SA was significantly higher in children attending private non-subsidized schools than in those attending public and privately subsidized schools. In the total sample, an inverse and significant correlation was found between SA and the amount of exposure to radio and, in most elementary and high school grades, with exposure to cinema. Television exposure correlated positively and significantly with SA only in elementary grade 4 and inversely elementary grade 2 and high school grade 4. Reading newspapers, magazines, and books correlated positively and significantly with SA in the total sample; reading newspapers correlated positively and significantly with SA in elementary grade 4 and both high school grades; reading of magazines correlated positively and significantly with SA in elementary grades 1 and 4 and high school grade 1, and reading of books showed the same correlation in elementary grades 2 and 4 and high school grade 4.

Pearson's correlation coefficients across SA and socioeconomic, sociocultural, familial, and demographic variables are listed in Table V. In the total sample and in all elementary and high school grades, the strongest positive and significant correlations were found for levels of maternal and paternal schooling, the quality of housing, and paternal occupation. With respect to family-related variables, in the total sample, SA correlated inversely and significantly with crowding, familial alcoholism, and the number of family members and positively and significantly with familial recreation, place between siblings, and the number of siblings. In the total sample and in each grade of elementary and high schools, SA was significantly higher in younger than in older children and in urban than in rural children. Sex did not correlate with SA, with the exception of elementary grade 2 (higher in females) and high school grade 4 (higher in males).

Table VI presents the multiple regression analysis (PROC GLM error type III) between SA (dependent variable) and most relevant parameters (independent variables). In the total sample, IA, level of maternal schooling, Z-HC, book reading, access to plumbing, level of paternal schooling, type of school, quality of housing, Z-H, and calcium intake were the independent variables with the greatest explanatory power in SA variance ($r^2 = 0.508$). In each elementary and high school grade, IA was the most important independent variable explaining SA variance, with the exception of elementary grade 4 and high school grade 1, in which access to plumbing and Z-HC, respectively, were the most relevant. In children in high school grade 4 whose physical growth and intellectual developmental processes were consolidated, IA, age, Z-HC, book reading, type of school, and level of paternal schooling were the independent variables with the greatest explanatory power in SA variance ($r^2 = 0.600$).

Table VII lists the results of SA testing expressed as the percentage of correct responses (mean ± standard deviation [SD]) in relation to the most relevant parameters in the statistical regres-

TABLE III.

PEARSON'S CORRELATION COEFFICIENTS BETWEEN NUTRIENT INTAKE (PERCENTAGE OF ADEQUACY) AND SCHOLASTIC ACHIEVEMENT BY GRADE

Nutrients	Total sample	Elementary school 1	Elementary school 2	Elementary school 4	Elementary school 6	Elementary school 8	High school 1	High school 4
Energy and protein								
Energy	0.056§	0.023	0.175§	0.009	0.009	0.080	0.063	0.042
Protein	0.206‡	0.048	0.155*	0.055	0.049	0.102*	0.063	−0.081
Minerals								
Calcium	0.307‡	0.131*	0.280‡	0.168‡	0.204‡	0.279‡	0.269‡	0.152*
Phosphorus	0.229‡	0.093	0.186§	0.077*	0.093*	0.146§	0.100	0.087
Iron	0.065†	0.020	0.010	0.020	0.040	0.003	0.011	0.142*
Zinc	0.198‡	0.175§	0.165*	0.132†	0.153‡	0.190‡	0.152§	0.001
Magnesium	0.192‡	0.113*	0.063	0.076*	0.070	0.151§	0.127*	0.004
Copper	0.040*	−0.036	0.029	−0.023	−0.087	−0.017	−0.099	−0.009
Selenium	0.058§	−0.112	−0.092	−0.012	−0.043	0.000	−0.004	0.032
Vitamins								
Vitamin A	0.088‡	−0.007	0.082	0.065	0.053	0.048	−0.004	−0.014
Thiamin	0.009	0.006	−0.139*	0.009	−0.054	−0.005	−0.010	−0.030
Riboflavin	0.199‡	0.019	0.218‡	0.119§	0.168‡	0.170†	0.169§	−0.042
Niacin	0.122‡	0.012	0.196§	0.050	0.058	0.040	−0.010	−0.124*
Vitamin B6	0.142‡	0.121*	0.051	0.122§	0.170‡	0.194‡	0.085	−0.004
Vitamin B12	0.110‡	0.009	0.108	0.064	0.136†	0.084	0.094	−0.005
Folate	0.090‡	0.035	0.013	0.015	−0.055	0.080	−0.042	−0.043
Pantothenic Acid	0.165‡	0.115*	0.183§	0.153‡	0.135†	0.231‡	0.140§	0.103
Ascorbic Acid	0.139‡	0.105	0.109	0.153‡	0.107§	0.146§	0.176†	0.025
Vitamin E	0.029	0.018	−0.054	0.016	−0.049	0.013	0.048	0.041
Fatty acids and cholesterol								
% Saturated	0.116‡	0.124*	0.222†	0.065	0.119§	0.177‡	0.224‡	−0.047
% Monounsaturated	−0.050§	0.063	−0.097	−0.031	−0.034	−0.091*	−0.104*	0.022
% Polyunsaturated	−0.085‡	−0.017§	−0.155*	−0.047	−0.100§	−0.114*	−0.154§	0.035
Cholesterol	0.123‡	0.025	0.199§	0.082*	0.140†	0.165†	0.180†	0.127*
Energy sources								
% Protein	0.164‡	0.135*	0.137*	0.168‡	0.179‡	0.189‡	0.120*	0.043
% Fat	0.192‡	0.121*	0.375‡	0.155‡	0.219‡	0.205‡	0.270‡	0.088
% Carbohydrates	−0.234‡	−0.156§	−0.386‡	−0.202‡	0.268‡	−0.259‡	−0.284‡	−0.100
Protein sources								
% Animal protein	0.296‡	0.209†	0.318‡	0.212‡	0.337‡	0.377‡	0.325‡	0.143*

* $P < 0.05$.
† $P < 0.001$.
‡ $P < 0.0001$.
§ $P < 0.01$.

sion model. School-age children with the highest scores on the SA test had superior IA, parents with a university-level education, Z-HC values above 2 SD, read books other than those from the curricular programs, had good-quality housing connected to a sewerage system, attended mainly non-subsidized schools, had Z-H values above 1 SD, and higher intakes of calcium ($P = 0.0001$). School-age children with very low IA (grade 5) achieved 51.3% compared with their peers with superior IA (grade 1). In the same way, SA increased 49.6% and 44.7% in children whose mothers and fathers, respectively, had received a university-level education compared with those from illiterate parents. Children with Z-HC values below −2 SD achieved only 62.8% compared with their peers who had values higher than 2 SD and those whose values were below −2 SD and 65.7% compared with those whose values were above 1 SD. School-age children who lived in precarious housing performed at 71.0% of the SA obtained by their peers who lived in good-quality housing, and those without plumbing achieved 66.1% compared with those who had plumbing. Children with a calcium intake less than 75% of the dietary reference intake achieved only 75.4% of the SA obtained by their peers who had higher intakes of calcium (>120% of dietary reference intake). Children from public schools had an SA of 78.3% compared with those from private non-subsidized schools. SA values, measured by the number of correct responses, of children who read books other than those from the curriculum were only 2% higher than those of their non-reading peers.

DISCUSSION

The results of the present study demonstrate that learning is a multifactorial process determined by multiple factors, depending on the child, the child's family, and the educational system. IA, level of maternal schooling, Z-HC, book reading, level of paternal schooling, type of school, quality of housing including access to a sewerage system, Z-H, and calcium intake explained 50.8% of the SA variance.

TABLE IV.

PEARSON'S CORRELATION COEFFICIENTS BETWEEN INTELLECTUAL, EDUCATIONAL, AND MME VARIABLES AND SCHOLASTIC ACHIEVEMENT BY GRADE

Variables	Total sample	Elementary school					High school	
		1	2	4	6	8	1	4
Intellectual variables								
IA	0.402‡	0.445‡	0.411‡	0.395‡	0.485‡	0.544‡	0.509‡	0.603‡
Educational variables								
Level of attendance (%)	0.045§	0.074*	0.011	0.070	0.110§	0.157†	0.064	0.018
Type of school (private non-subsidized)	0.211‡	0.296‡	0.232‡	0.232‡	0.331‡	0.258‡	0.334‡	0.124*
MME variables								
Radio	−0.166‡	−0.001	−0.052	−0.071‖	−0.084*	−0.054	−0.146§	−0.116*
Cinema	−0.006	−0.153‡	−0.093*	−0.114§	−0.169‡	−0.201‡	−0.222‡	−0.033
Television	−0.028‖	−0.002	−0.080*	0.114§	0.055	0.039	0.086	−0.126*
Newspaper	0.079‡	−0.008	0.018	0.077*	0.046	0.071	0.263‡	0.141§
Magazines	0.036*	0.073*	0.017	0.160‡	0.064(t)	0.017	0.197‡	−0.009
Books	0.051†	0.032	0.134†	0.161‡	−0.018	0.041	−0.010	0.189†

* $P < 0.05$.
† $P < 0.001$.
‡ $P < 0.0001$.
§ $P < 0.01$.
‖ Tendency, $P > 0.05$ and $P < 0.10$.
IA, intellectual ability as measured by Raven's Progressive Matrices Test; MME, exposure to mass media

Intelligence is one of the most important determinants of SA in all grades, and this is in agreement with our previous findings and with those of others who have emphasized neurodevelopmental and psychological factors as major determinants of educational success.[6,11–13,59,60] Our previous studies reported that IA is the most important independent variable that explains SA at the onset of elementary school.[6] As we previously stated, recent findings in Chilean school-age children graduating from high school have shown that SA is determined mainly by IQ, which explains approximately 90% of the SA variance for males and females; this was also observed recently in a comparative study of Chilean undernourished and well-nourished, poor high school graduates, in whom only IQ explained the SA variance ($r^2 = 0.860$).[11–13] Other studies have emphasized the heritability of intelligence and have estimated that 50% to 60% of a child's intelligence is due to family origin.[61–63] However, the degree to which genetic factors influence human intelligence remains a matter of some controversy.[64]

Findings by other investigators have shown strong relations between intelligence and general achievement, especially for reading; in addition, SES is associated with general achievement and MA, whereas sex-related behaviors are related to motivation.[65]

In the present study, socioeconomic and sociocultural variables were strongly related to SA, as described by other investigators. Educational inequalities indicate the extent to which students from different social origins, as measured by parental education and paternal occupation, have unequal probabilities of SA and whose results suggest that social origin continues to exert a strong influence on school performance.[66] Differences in the content and style of interactions of parents with their children are associated with differences in children's oral and written language skills; with respect to literacy, there is also a strong association with social status, which is much weaker for oral language.[67] Children whose fathers were engaged in non-manual occupations were approximately 1 y ahead in their reading ability compared with those whose fathers were skilled or semiskilled workers; similar results were found in relation to family size, because children from smaller families were ahead of those from larger families, and this is in agreement with our previous results.[68]

However, our results showed that paternal and especially maternal schooling levels are among the most important socioeconomic and sociocultural variables that explain SA. Level of maternal schooling has been described as the most relevant socioeconomic and sociocultural variable that explains SA and IA.[15,16,53] In a recent study that compared undernourished with well-nourished poor Chilean high school graduates, the most relevant independent variables explaining IQ were, in decreasing order of importance, level of maternal schooling, brain volume, and undernutrition in the first year of life ($r^2 = 0.714$), which explained most of the SA variance ($r^2 = 0.860$).[11] The positive and significant effect of level of parental, especially maternal, schooling, on children's IA has been described by several researchers and may be related to the more intensive stimulation of the child; the same may be argued to explain the positive and significant effect on SA of some environmental variables such as the quality of housing and connection to a sewerage system.[17,22,69–73] Other socioeconomic variables such as SES, maternal and paternal occupation, household head (father), and water supply were positively and significantly correlated with SA; these results are in agreement with those from other investigators but did not explain the SA variance in the present study.[3,74–77] Other findings have shown that the significant differences favoring the academic achievement of boys and girls arise from presence of a father at home.[78] Socioeconomic conditions are strongly related to the degree of home stimulation, and SA probably depends on environmental factors in addition to IA.[79–81]

HC has been described as the most important anthropometric index associated with SA in school-age children, and its effect increased as the school years advanced; thus, in high school graduates, HC is the only anthropometric parameter that explains SA and IA.[10,15] Other researchers have confirmed a positive and significant correlation between HC and SA.[82,83] Moreover, educational selectivity correlates with HC but not with weight or height, and correlations between SA and nutritional status indicators expressed as Z scores are stronger than those obtained when the anthropometric parameters are expressed as percentage of adequacy to the median.[10] IA is the most relevant independent vari-

TABLE V.

PEARSON'S CORRELATION COEFFICIENTS BETWEEN SOCIO-ECONOMIC, SOCIO-CULTURAL, FAMILY AND DEMOGRAPHIC VARIABLES AND SCHOLASTIC ACHIEVEMENT BY GRADE

Variables	Total sample	Elementary school 1	Elementary school 2	Elementary school 4	Elementary school 6	Elementary school 8	High school 1	High school 4
Socioeconomic and sociocultural variables								
SES	0.330‡	0.380‡	0.340‡	0.377‡	0.517‡	0.533‡	0.535‡	0.326‡
Maternal schooling	0.396‡	0.398‡	0.451‡	0.390‡	0.484‡	0.527‡	0.511‡	0.364‡
Paternal schooling	0.393‡	0.414‡	0.444‡	0.363‡	0.494‡	0.549‡	0.492‡	0.358‡
Maternal occupation	0.124‡	0.175‡	0.181‡	0.068	0.195‡	0.291	0.051	0.127*
Paternal occupation	0.282‡	0.365‡	0.313‡	0.358‡	0.425‡	0.493‡	0.458‡	0.238‡
Household head (father)	0.059‡	0.049	0.026	0.023	0.078*	0.028	0.158§	0.107*
Quality of housing	0.299‡	0.422‡	0.403‡	0.381‡	0.499‡	0.499‡	0.498‡	0.330‡
Property of housing	0.004	0.155‡	0.007	0.029	0.058	0.116*	0.067	0.025
Sewage	0.271‡	0.244‡	0.312‡	0.396‡	0.330‡	0.339‡	0.224‡	0.080
Water supply	0.089‡	0.100§	0.157‡	0.084*	0.127†	0.028	0.054	0.026
Family variables								
No. of family members	−0.044§	−0.063‖	0.005	0.014	−0.077*	−0.102*	−0.124*	−0.149§
No. of siblings	0.036*	0.043	0.023	0.012	0.031	0.001	0.011	0.107‖
Place between siblings	0.039*	0.043	0.021	0.013	0.033	0.004	0.016	0.102‖
Crowding	−0.122‡	−0.219‡	−0.106§	−0.094*	−0.244‡	−0.280‡	−0.245‡	−0.299‡
Family alcoholism	−0.132‡	−0.106§	−0.221‡	−0.196‡	−0.153‡	−0.124*	−0.228‡	−0.008
Family recreation	0.088‡	0.153‡	0.055	0.089*	0.056	−0.171†	0.102*	0.049
Demographic variables								
Age (y)	−0.276‡	−0.008	−0.152‡	−0.233‡	−0.300‡	−0.250‡	−0.255‡	−0.312‡
Sex	0.029‖	0.015	0.156‡¶	0.055	−0.000	−0.052	−0.098‖	−0.269‡#
Geographic area (urban)**	0.344‡	0.248‡	0.494‡	0.444‡	0.432‡	0.425‡	0.280‡	—

* $P < 0.05$.
† $P < 0.001$.
‡ $P < 0.0001$.
§ $P < 0.01$.
‖ Tendency, $P > 0.05$ and $P < 0.10$.
¶ For girls.
# For boys.
**High school grade 4 did not exist in rural areas.
SES, socioeconomic stratum

able explaining SA, and positive and significant correlations between intelligence and HC have been reported by other investigators.[11–13,62,84–97] HC is a good indicator of nutritional background and brain development and is the most sensitive anthropometric indicator of prolonged undernutrition during infancy, which becomes associated with intellectual impairment.[11–13,98–100] The first 2 y of life are the period of maximum brain growth, and 70% of adult brain weight is attained by the end of the first year. HC values below −2 SD of the mean may be a specific indicator of severe undernutrition in the first year of life.[101–102] Other investigators have emphasized that head size at age 1 y is a good predictor of later intelligence.[84,86,92] In the same way, a positive and significant correlation between brain size and intelligence has been confirmed in students, suggesting that differences in human brain size are relevant to differences in IQ and are dependent on genetic and environmental influences.[11–13,64,91,103] A recent report presented a continuity model that suggested that expanded human mental capacities primarily reflect the increased information processing capabilities of the enlarged human brain, including the enlarged neocortex, cerebellum, and basal ganglia. These increased information processing capacities enhance human abilities to combine and recombine highly differentiated actions, perceptions, and concepts to construct larger, more complex, and highly variable behavioral units in a variety of behavioral domains including language, social intelligence, tool making, and motor sequences.[104] Therefore, from the present results, we can hypothesize that children with suboptimal HC have some degree of alteration of brain development associated with decreased IA and SA.[105] Stunting has been associated with decreased SA and IA values as measured with Raven's Progressive Matrices Test.[10,15,106] However, height as indicator of nutritional background seems to be not the most relevant anthropometric parameter associated with SA especially in high school students, as we described previously and in our results that analyzed SA in a multicausal context.[10]

MME, especially to newspapers, magazines, and books, was positively and significantly associated with SA, although book reading was the only MME that partly explained SA, thus emphasizing the importance of reading on SA. Reading has been positively and significantly associated with SA at the beginning of high school.[17] Radio and cinema exposures had a negative effect on SA, probably because this is an indicator of lifestyle, and school-age children with the lowest SA scores devoted long hours to these activities. No significant association between television exposure and SA was observed in the total sample, and these results are in agreement with our previous findings and those of others.[23–25] However, a positive and significant correlation between television exposure and SA was observed in school-age children in elementary grade 4, and the opposite was found in high school grade 4 and

TABLE VI.

MULTIPLE REGRESSION ANALYSIS BETWEEN SCHOLASTIC ACHIEVEMENT (DEPENDENT VARIABLE) AND MOST RELEVANT PARAMETERS (INDEPENDENT VARIABLES) IN THE TOTAL SAMPLE AND BY SCHOOL GRADE

Independent variables in the statistical model	*F*	Estimate	T for H0: Parameter = 0	Pr > |T|	SEM
Total sample					
Intercept		32.16	4.88	‡	6.60
IA	71.44‡				
Grade 1		9.13	7.26	‡	1.26
Grade 2		5.57	6.85	‡	0.81
Grade 3		0.00	—	—	—
Grade 4		−6.92	−8.05	‡	0.86
Grade 5		−13.02	−9.49	‡	1.37
Maternal schooling	22.98‡	0.67	4.79	‡	0.14
Z-HC	11.81‡	1.15	3.44	†	0.34
Book reading	10.45‡	−2.26	−3.23	§	0.70
Sewage	10.45‡				
With		6.75	5.33	‡	1.27
Without		0.00	—	—	—
Paternal schooling	8.14†	0.47	2.85	§	0.16
Type of school	7.23†				
Public		−2.47	−3.29	†	0.75
Privately subsidized		0.00	—	—	—
Private non-subsidized		−0.01	−0.01	NS	1.24
Quality of housing	5.42				
Single-family unit	§	5.23	3.83	‡	1.36
Solid materials		4.51	4.21	‡	1.07
Light materials		0.00	—	—	—
Self-built		−0.27	−0.28	NS	0.97
Precarious housing (*mejora*)		1.23	0.71	NS	1.72
Z-H	4.78*	0.99	2.19	*	0.45
Calcium intake (%)	3.75*				
<75		−2.78	−2.74	§	1.01
75–120		−1.96	−1.89	‖	1.04
>120		0.00	—	—	—
Model‡¶					

* $P < 0.05$.
† $P < 0.001$.
‡ $P < 0.0001$.
§ $P < 0.01$.
‖ Tendency, $P > 0.05$ and $P < 0.10$.
¶ Root MSE = 14.86, $r^2 = 0.508$, $F = 58.54$.
Grade 1, superior IA; grade 2, above average IA; grade 3, average IA; grade 4, below average IA; grade 5, intellectually defective; IA, intellectual ability as measured by Raven's Progressive Matrices Test; NS, not significant; root MSE, standard derivation of the dependent variable; SEM, standard error of the mean; Z-H, height-for-age Z score; Z-HC, head circumference-for-age Z score

elementary grade 2, making evident a lack of correlation between the relative effect of MME and SA.

Calcium intake appeared in the statistical model as the only nutrient explaining SA. This fact can be explained by a greater intake of dairy products, especially milk, in school-age children with high SA, who belonged to the higher SES. Calcium plays a role in regulated exocytosis by acting as the trigger for fast synaptic transmission and participating in some of the steps preceding vesicle fusion. Investigators have focused considerable attention on the presence of possible calcium sensors, and attention has recently been directed to those sensors that may play roles in the "priming" or transport of these vesicles.[107,108] It seems that higher calcium intakes improve synaptic transmission, which may play an important role in IA and SA. Nutritional education programs that focus on family members may have a positive effect on the improvement of calcium intake.[109]

In this study, the children with the lowest SA scores originated from rural areas, were significantly older than their peers in the same grade, and had a negative nutritional background, with more deficient nutrient intakes and higher incidences of undernutrition at a young age; they also belonged to larger families, lived under more crowded conditions, had higher prevalences of family alcoholism, and lower levels of recreation. They also probably had lower levels of stimulation at home. Therefore, it is possible to conclude that poor nutrition and a disadvantageous environment, particularly with respect to home stimulation, are important factors related to poor school performance. Some investigators have emphasized the relevance of social deprivation as the most important predictor of educational achievement.[74,110]

Despite the fact that age was negatively and significantly correlated with SA in all school grades, it should be noted that school failure becomes manifest at elementary grade 4, because school-age children from a low SES are significantly older than those from other SESs.[111] This represents the result of an educational process in which school failure is fully expressed and significantly associated with a lower IA and more adverse socioeconomic and

TABLE VII.

SA RELATED TO THE MOST RELEVANT PARAMETERS IN THE STATISTICAL REGRESSION MODEL OF THE TOTAL SAMPLE

Independent variables in the statistical model	SA*	*F*†
IA		203.33
Grade 1	69.4[a] ± 17.4 (278)	
Grade 2	61.8[b] ± 18.6 (864)	
Grade 3	54.1[c] ± 20.7 (1858)	
Grade 4	42.5[d] ± 20.1 (882)	
Grade 5	35.6[e] ± 19.9 (264)	
Maternal schooling		147.22
University education	63.9[a] ± 18.1 (574)	
Completed high school	60.3[b] ± 19.3 (1262)	
Did not complete high school	52.3[c] ± 20.4 (672)	
Completed elementary school	46.8[d] ± 21.1 (365)	
Did not complete elementary school	41.6[e] ± 21.4 (963)	
Illiterate	31.7[f] ± 18.9 (48)	
Z-HC		59.40
≥2 SD	62.6[a] ± 21.1 (131)	
0–2 SD	56.8[b] ± 20.6 (1812)	
−2 to 0 SD	50.3[c] ± 21.8 (2145)	
< −2 SD	39.3[d] ± 21.6 (143)	
Book reading		10.80
Yes	54.5[a] ± 21.9 (1816)	
No	52.3[b] ± 21.4 (2302)	
Sewage		347.11
With	55.2[a] ± 21.1 (3700)	
Without	36.5[b] ± 19.2 (487)	
Paternal schooling		137.02
University education	63.7[a] ± 18.2 (899)	
Completed high school	57.3[b] ± 20.1 (1211)	
Did not complete high school	50.7[c] ± 20.4 (554)	
Completed elementary school	46.0[c] ± 21.6 (316)	
Did not complete elementary school	41.3[d] ± 21.4 (790)	
Illiterate	28.5[e] ± 21.0 (41)	
Type of school		131.94
Public	49.9[a] ± 22.3 (2149)	
Privately subsidized	51.2[a] ± 21.3 (1366)	
Private non-subsidized	63.7[b] ± 18.1 (810)	
Quality of housing		119.45
Single-family unit	60.4[a] ± 17.4 (617)	
Solid materials	61.4[a] ± 20.0 (879)	
Light materials	52.7[b] ± 21.0 (1488)	
Self-built	43.7[c] ± 22.1 (1015)	
Precarious housing (*mejora*)	42.9[c] ± 20.2 (188)	
Z-H		89.13
>1 SD	62.3[a] ± 19.6 (265)	
−1–1 SD	55.8[b] ± 21.2 (2568)	
−2 to −1 SD	46.9[c] ± 21.9 (1037)	
< −2 SD	40.9[d] ± 20.3 (265)	
Calcium intake (percentage of adequacy)		123.57
>120	60.5[a] ± 20.7 (462)	
75–120	54.2[b] ± 20.0 (842)	
<75	45.6[c] ± 19.9 (1737)	

* Results are expressed as mean ± SD of the percentage of correct responses (number of subjects). Means with the same superscript letter are not significantly different at P = 0.05 based of Scheffe's test, *F* value, and analysis of variance.

† $P < 0.0001$.

Grade 1, superior IA; grade 2, above average IA; grade 3, average IA; grade 4, below average IA; grade 5, intellectually defective; IA, intellectual ability as measured by Raven's Progressive Matrices Test; SA, scholastic achievement; SD, standard deviation; Z-H, height-for-age Z score; Z-HC, head circumference-for-age Z score

sociocultural conditions, lower levels of paternal and maternal schooling, a more deprived nutritional status, and altered brain development.[11]

Results from other studies have shown that type of school, IQ, and familial background are important predictors of educational achievement. Overall, the model that emerges from the data places achievement motivation in a central role among home background, IQ, personality, type of school, and educational achievement.[59] Other investigations have suggested a positive relation between class size and achievement, the importance of the number of years of professional activity of teachers, and the influence of peers on achievement; other significant factors are school resources, attributes of teachers, student densities in schools, and average income in the school's neighborhood.[112]

In the present study, type of school was the only educational variable that was entered in the multivariate analysis; type of school attended describes several variables related to the educational system, such as the teacher's academic background, methodologies, and infrastructure. Private non-subsidized schools provide school-age children with the best quality of education because they have an adequate infrastructure and engage teachers with better academic backgrounds who apply more modern teaching methodologies. Moreover, private non-subsidized schools tend to enroll school-age children with superior IA scores, from the high SESs, whose parents have higher occupation and schooling levels, have higher Z-HC and Z-H values, higher nutrient intakes, and greater availability of printed MME. From the results of this study, we can confirm that type of school is a less important independent variable that affects SA. This is important because educational policies tend to improve conditions related to the educational system that, although important, are not the most relevant that affect SA.

Significant improvements in the quality of education seem to be positively and significantly associated with improvements in all national sectors, because education is a multifactorial process that is determined by socioeconomic, sociocultural, family, MME, nutritional, intellectual, and educational system factors. In this respect, further research is needed to quantitate the effect of genetic and environmental factors on SA. The question is how to improve IA, the most relevant parameter associated with SA, that depends on genetic and environmental factors, mainly maternal IQ.[11,13] Actions related to the improvement of female education and socioeconomic, sociocultural, health, and nutritional conditions may be of greater importance to improve SA in school-age children.

In summary, our data demonstrate that IA, level of maternal schooling, Z-HC, book reading, access to a sewerage system, level of paternal schooling, type of school attended, quality of housing, Z-H, and calcium intake are most relevant risk factors or predictors associated with SA, with slight differences as the school years advance. Education is viewed as the lever to improve quality of life, and the results of this study may be useful for educational planning.

ACKNOWLEDGMENTS

Authors are grateful to the Ministry of Education of Chile for all the help provided to carry out this research and to Oscar Brunser, MD, for helpful comments and suggestions.

REFERENCES

1. Ivanovic D, Ivanovic R, Middleton S, eds. *Rendimiento escolar y estado nutricional.* Santiago: Universidad de Chile, Institute of Nutrition and Food Technology, 1988
2. Ivanovic D, Ivanovic R. Rendimiento y deserción escolar: un enfoque multicausal. In: Ivanovic D, Ivanovic, R, Middleton S, eds. *Rendimiento escolar y estado nutricional.* Santiago: Universidad de Chile, Institute of Nutrition and Food Technology, 1988, p. 3
3. Schiefelbein E, Simmons J. The determinants of school achievement: a review of the research for developing countries. Ottawa: International Development Research Centre, IDRC-TS 24c, 1981
4. Ivanovic D, Zacarías I, Saitúa MT, Marambio M. Educational achievement and nutritional status of elementary and high school graduates. In: Moyal MF, ed. *Dietetics in the 90s. Role of the dietitian/nutritionist.* London: John Libbey Eurotext Ltd, 1988, p. 331
5. Ivanovic D, Marambio M. Nutrition and education. I. Educational achievement and anthropometric parameters of Chilean elementary and high school graduates. Nutr Rep Int 1989;39:983
6. Ivanovic D, Ivanovic R, Truffello I, Buitrón C. Nutritional status and educational achievement of elementary first grade Chilean students. Nutr Rep Int 1989;39:163
7. Ivanovic D, Vásquez M, Marambio M, et al. Nutrition and education. II. Educational achievement and nutrient intake of Chilean elementary and high school graduates. Arch Latinoam Nutr 1991;41:499
8. Ivanovic D, Vásquez M, Aguayo M, et al. Nutrition and education. III. Educational achievement and food habits of Chilean elementary and high school graduates. Arch Latinoam Nutr 1992;42:9
9. Ivanovic D. Nutrition, and education. IV. Clinical signs of malnutrition and its relationship with socio-economic, anthropometric, dietetic and educational achievement parameters. Arch Latinoam Nutr 1992;42:15
10. Ivanovic D, Olivares M, Castro C, Ivanovic R. Nutrition and learning in Chilean school-age children. Chile's metropolitan area. Survey 1986–1987. Nutrition 1996;12:321
11. Ivanovic D, Leiva B, Pérez, H, et al. Long-term effects of severe undernutrition during the first year of life on brain development and learning in Chilean high school graduates. Nutrition 2000;16:1056
12. Ivanovic D, Almagià A, Toro T, et al. Impacto del estado nutricional en el desarrollo cerebral, inteligencia y rendimiento escolar, en el marco de un enfoque multifactorial. Rev Interam Desar Educat Educ 2000;44(134–135):I–II:3.
13. Ivanovic D, Leiva B, Pérez H, et al. Nutritional status, brain development and scholastic achievement of Chilean high school graduates from high and low intellectual quotient and socio-economic status. Br J Nutr 2002;87:81
14. Toro T, Almagià A, Ivanovic D. Evaluación antropométrica y rendimiento escolar en estudiantes de educación media de Valparaíso, Chile. Arch Latinoam Nutr 1998;48:201
15. Ivanovic R, Forno H, Castro CG, Ivanovic D. Intellectual ability and nutritional status assessed through anthropometric measurements of Chilean school-age children from different socio-economic status. Ecol Food Nutr 2000;39:35
16. Ivanovic R, Castro C, Ivanovic D. No existe una teoría sobre el rendimiento escolar. Rev Educ (Chile) 1995;224:40
17. Sandiford P, Cassel J, Sanchez G, Coldham C. Does intelligence account for the link between maternal literacy and child survival? Soc Sci Med 1997;45:1231
18. Ivanovic R, Truffello I, Buitrón C, Ivanovic D. Educational factors influencing the nutritional learning of elementary first grade Chilean schoolers. Nutr Rep Int 1989;39:1161
19. Ivanovic R, Olivares M, Ivanovic D. Sources of nutrition information of Chilean schoolers. Metropolitan Region Chile Survey 1986–1987. Arch Latinoam Nutr 1991;41:527
20. Alvarez ML, Wurgaft F. Conducta socioafectiva de la madre con lactante desnutrido. Rev Chil Nutr 1981;9:101
21. Alvarez ML, Wurgaft F, Wilder H. Non-verbal language in mothers with malnourished infants. Soc Sci Med 1982;16:1365
22. Smith KE, Landry SH, Swank PR, et al. The relation of medical risk and maternal stimulation with preterm infants' development of cognitive, language and daily living skills. J Child Psychol Psychiatry 1996;37:855
23. Schramm W, Lyle J, Parker E. La televisión y los niños. Barcelona: Hispano Europea, 1965
24. Ivanovic R, Sepúlveda O. Rendimiento escolar y exposición a medios de comunicación de masas en estudiantes de enseñanza media del Área Metropolitana. Rev Sociol 1988;3:73
25. Hagborg WJ. High school student television viewing time: a study of school performance and adjustment. Child Study J 1995;25:155
26. Ridley-Johnson R, Cooper H, Chance J. The relation of children's television viewing to school achievement and I.Q. J Educ Res 1982;76:294
27. Strasburger VC. Does television affect learning and school performance? Pediatrician 1986;13:141
28. Gupta RK, Saini DP, Acharya U, Miglani N. Impact of television on children. Indian J Pediatr 1994;61:153
29. American Academy of Pediatrics, Committee on Public Education. American Academy of Pediatrics: children, adolescents, and television. Pediatrics 2001; 107:423
30. Bar-Or O, Foreyt J, Bouchard C, et al. Physical activity, genetic, and nutritional considerations in childhood weight management. Med Sci Sports Exerc 1998; 30:2
31. Eisenmann JC, Bartee RT, Wang MQ. Physical activity, TV viewing, and weight in U.S. youth: 1999 Youth Risk Behavior Survey. Obes Res 2002;10:379

32. Wright JC, Huston AC, Murphy KC, et al. The relations of early television viewing to school readiness and vocabulary of children from low-income families: the early window project. 1. Child Dev 2001;72:1347
33. Johnson EO, Breslau N. Increased of learning disabilities in low birth weight boys at age 11 years. Biol Psychiatry 2000;47:490
34. Ministerio de Educación Pública de Chile. Estadísticas educacionales. Santiago: Superintendencia de Educación, 1987
35. Ministerio de Educación de Chile. Planes y programas para la educación general básica. Rev Educ 1980;79.
36. Ministerio de Educación de Chile. Planes y programas de estudio para la educación media. Rev Educ 1982;94.
37. Guilford JP, Fruchter B. Estadística aplicada a la psicología y a la educación. Mexico City: McGraw-Hill, 1984
38. National Center for Health Statistics. Growth curves, 2000 (from the Vital and Health Statistics of the National Centers for Disease Control and Prevention, National Center for Health Statistics, No. 314, December 4, 2000). Hyattsville, MD: US Department for Health and Human Services, National Center for Health Statistics, 2000
39. Garrow JS. Treat obesity seriously: a clinical manual. London: Churchill Livingstone, 1981
40. Tanner JM. Physical growth and development. In: Forfar JO, Arneil GC, eds. *Textbook of pediatrics.* Edinburgh: Churchill Livingstone, 1984, p. 273
41. Nellhaus G. Head circumference from birth to eighteen years. Practical composite international and interracial graphs. Pediatrics 1968;41:106
42. Weaver DD, Cristian JC. Familial variation of head size and adjustment for parental head circumference. J Pediatr 1980;96:990
43. Roche AF, Mukherjee D, Guo S, Moore W. Head circumference reference data: birth to 18 years. Pediatrics 1987;79:706
44. Ivanovic D, Olivares M, Castro C, Ivanovic R. Circunferencia craneana de escolares chilenos de 5 a 18 años. Región Metropolitana de Chile. 1986–1987, 1992. Rev Med Chil 1995;123:587
45. Frisancho AR. New norms of upper limb fat and muscle areas for assessment of nutritional status. Am J Clin Nutr 1981;34:2540
46. Schmidt-Hebbel H, Pennacchiotti M, Masson L, Mella MA. Tabla de composición química de alimentos chilenos. Santiago: Universidad de Chile, Facultad de Ciencias Químicas y Farmacéuticas, 1990
47. FAO/OMS/UNU. Energy and protein requirements. World Health Organization. Technical Report Series No. 724. Geneva: World Health Organization, 1985
48. Food and Nutrition Board, Institute of Medicine. Dietary reference intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline. Washington, DC: National Academies Press, 2000
49. Food and Nutrition Board, Institute of Medicine. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, DC: National Academies Press, 2000
50. Food and Nutrition Board, Institute of Medicine. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academies Press, 2002
51. Food and Nutrition Board, Institute of Medicine. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride. Washington, DC: National Academies Press, 2000
52. Ivanovic R, Forno H, Durán MC, et al. Estudio de la capacidad intelectual (Test de Matrices Progresivas de Raven) en escolares de 5 a 18 años. I. Antecedentes generales, normas y recomendaciones. Región Metropolitana. Chile. 1986–1987. Iberpsicologia 2003;8.1.1. (Complete version is published in Rev Psicol Gen Apl Esp 2000;53:5.)
53. Ivanovic D, Forno H, Castro C, et al. Estudio de la capacidad intelectual (Test de Matrices Progresivas de Raven) en escolares de 5 a 18 años. II. Interrelaciones con factores socioeconómicos, socio-culturales, familiares, de exposición a medios de comunicación de masas, demográficos y educacionales. Rev Psicol Gen Apl (Esp) 2001;54:443
54. Raven JC. Test de Matrices Progresivas. Escala Especial Buenos Aires. Buenos Aires: Piados, 1957
55. Raven JC. Test de Matrices Progresivas. Escala General. Buenos Aires: Piados, 1957
56. Pollitt E. Evaluación de la conducta en los estudios sobre las consecuencias funcionales de la malnutrición. Descripción de métodos. In: OPS/OMS, editor. Ambiente, nutrición y desarrollo mental. Publicación científica No 450. Washington, DC: OPS/OMS; 1983:58.
57. Alvarez ML, Muzzo S, Ivanovic D. Escala para medición del nivel socioeconómico en el área de la salud. Rev Med Chile 1985;113:243
58. SAS introductory guide. Statistics. Car, NC: SAS Institute, 1983
59. Cassidy T, Lynn R. Achievement motivation, educational attainment, cycles of disadvantage and social competence: some longitudinal data. Br J Educ Psychol 1991;61:1
60. Rostain AL. Assessing and managing adolescents with school problems. Adolesc Med 1997;8:57
61. Avancini G. El fracaso escolar. Barcelona: Herder, 1982
62. Johnson FW. Biological factors and psychometric intelligence: a review. Genet Soc Gen Psychol Monogr 1991;117:313
63. Lynn R, Hattori K. The heritability of intelligence in Japan. Behav Genet 1990;20:545
64. Reiss AL, Freund LS, Baumgardner TL, Abrams MT, Denckla MB. Contribution of the FMR1 gene mutation to human intellectual dysfunction. Nat Genet 1995;11:331
65. Oakland T, Wechsler S, Bensusan E, Stafford M. The construct and measurement of achievement among Brazilian children. School Psychol Int 1994;15:133
66. Guppy N, Mikicich P, Pendakur R. Changing patterns of educational inequality in Canada. Can J Sociol 1984;9:319
67. Wells G. Some antecedents of early educational attainment. Br J Sociol Educ 1981;2:181
68. Fogelman KR, Goldstein H. Social factors associated with changes in educational attainment between 7 and 11. Educ Stud 1976;2:95
69. Melhuish EC, Lloyd E, Martin S, Mooney A. Type of childcare at 18 months. II. Relations with cognitive and language development. J Child Psychol Psychiatry 1990;31:861
70. Carter RL, Resnick MB, Ariet M, Shieh G, Vonesh EF. A random coefficient growth curve analysis of mental development in low-birth-weight infants. Stat Med 1992;11:243
71. Duncan GJ, Brooks-Gunn J, Klebanov PK. Economic deprivation and early childhood development. Child Dev 1994;65:296
72. Casey PH, Barrett K, Bradley RH, Spiker D. Pediatric clinical assessment of mother-child interaction: concurrent and predictive validity. J Dev Behav Pediatr 1993;14:313
73. Agarwal DK, Awasthy A, Upadhyay SK, et al. Growth, behavior, development and intelligence in rural children between 1–3 years of life. Indian Pediatr 1992;29:467
74. Schiefelbein E, Farrel J. Eight years of their lives: through schooling to the labour market in Chile. Ottawa: International Development Research Centre, IDRC 191e, 1982
75. Clifton R. Socio-economic status and educational performances: a comparison of students in England and New Zealand. Int J Comp Sociol 1983;24:187
76. Vera Noriega A, Mejia LA, Saucedo S, Del Refugio Palacios M. Psychological, nutritional, socio-economic aspects and family relations of Mexican children with low school performance. Arch Latinoam Nutr 1990;40:475
77. Desai U. Determinants of educational performance in India: role of home and family. Int Rev Educ 1991;37:245
78. Sciara FJ. Effects of father absence on the educational achievement of urban black children. Child Study J 1975;5:45
79. Felner RD, Brand S, DuBois DL, et al. Socio-economic disadvantage, proximal environmental experiences, and socioemotional and academic adjustment in early adolescence: investigation of a mediated effects model. Child Dev 1995; 66:774
80. Degarmo DS, Forgatch MS, Martinez Jr CR. Parenting of divorced mothers as a link between social status and boys' academic outcomes: unpacking the effects of socio-economic status. Child Dev 1999;70:1231
81. Georgiou SN. Parental attributions as predictors of involvement and influences on child achievement. Br J Educ Psychol 1999;69:409
82. Ishikawa T, Furuyama M, Ishikawa M, Ogawa J, Wada Y. Growth and achievement of large-and small-headed children in a normal population. Brain Dev 1988;10:295
83. Desch LW, Anderson SK, Snow JH. Relationship of head circumference to measures of school performance. Clin Pediatr 1990;29:389
84. Nelson KB, Deutschberger J. Head size at one year as a predictor of four-year IQ. Dev Med Child Neurol 1970;12:487
85. Van Valen L. Brain size and intelligence in man. Am J Phys Anthropol 1974;40:417
86. Fisch RO, Bilek MK, Horrobin JM, Chang PN. Children with superior intelligence at 7 years of age: a prospective study of the influence of perinatal, medical and socio-economic factors. Am J Dis Child 1976;130:481
87. Susanne C. On the relationship between psychometric and anthropometric traits. Am J Phys Anthropol 1979;51:421
88. Hack M, Breslau N. Very low birth weight infants: effects of brain growth during infancy on intelligence quotient at 3 years of age. Pediatrics 1986;77:196
89. Ounsted M, Moar VA, Scott A. Head circumference and developmental ability at the age of seven years. Acta Paediatr Scand 1988;77:374
90. Hack M, Breslau N, Weissman B, et al. Effect of very low birth weight and subnormal head size on cognitive abilities at school age. N Engl J Med 1991;325:231
91. Willerman L, Schultz R, Rutledge JN, Bigler ED. In vivo brain size and intelligence. Intelligence 1991;15:223

92. Botting N, Powls A, Cooke RW, Marlow N. Cognitive and educational outcome of very low-birthweight children in early adolescence. Dev Med Child Neurol 1998;40:652
93. Rushton JP. Race, evolution, and behavior: a life-history perspective, 2nd special abridged ed. Port Huron, MI: Charles Darwin Research Institute, 2000
94. Rushton JP, Ankney CD. Brain size and cognitive ability: correlations with age, sex, social class, and race. Psychon Bull Rev 1996;3:21
95. Rushton JP, Ankney CD. Size matters: a review and new analyses of racial differences in cranial capacity and intelligence that refute Kamin and Omari. Pers Indiv Differ 2000;29:591
96. Vernon PA, Wickett JC, Bazana PG, Stelmack RM. The neuropsychology and psychophysiology of human intelligence. In: Sternberg RJ, ed. *Handbook of intelligence.* New York: Cambridge University Press, 2000, p. 245
97. Wickett JC, Vernon PA, Lee DH. Relationships between factors of intelligence and brain volume. Pers Indiv Differ 2000;29:1095
98. Rumsey JM, Rapoport JL. Assessing behavioral and cognitive effects of diet in pediatric populations. In: Wurtman RJ, Wurtman JJ, eds. *Nutrition and the brain. Volume 6.* New York: Raven Press, 1983, p. 101
99. Stoch MB, Smythe PM. Moodie AD, Bradshaw D. Psychosocial outcome and CT findings after gross undernourishment during infancy: a 20-year developmental study. Dev Med Child Neurol 1982;24:419
100. Ivanovic D. Does undernutrition during infancy inhibit brain growth and subsequent intellectual ability? Prospective overview. Nutrition 1996;12:568
101. Winick M, Rosso P. Head circumference and cellular growth of the brain in normal and marasmic children. J Pediatr 1969;74:774
102. Winick M, Rosso P. The effect of severe early malnutrition on cellular growth of human brain. Pediatr Res 1969;3:181
103. Andreasen NC, Flaun M, Swayze V, et al. Intelligence and brain structure in normal individuals. Am J Psychiatry 1993;150:130
104. Gibson KR. Evolution of human intelligence: the roles of brain size and mental construction. Brain Behav Evol 2002;59:10
105. Ivanovic D, Leiva B, Pérez H, Olivares M, Díaz N, Urrutia MS, et al. Head size and intelligence, learning, nutritional status and brain development. Neuropsychologia 2004;42:1118.
106. Aboud F, Salmuel M, Hadera A, Addus A. Intellectual, social and nutritional status of children in an Ethiopian orphanage. Soc Sci Med 1991;33:1275
107. Duncan RR, Shipston MJ, Chow RH. Double C2 protein. A review. Biochimie 2000;82:421
108. Liu SQ, Cull-Candy SG. Synaptic activity at calcium-permeable AMPA receptors induces a switch in receptor subtype. Nature 2000;405:454
109. Barr SI. Associations of social and demographic variables with calcium intakes of high school students. J Am Diet Assoc 1994;94:260
110. Singh S, Sinha AK. Relative importance of social deprivation, intelligence, punctuality, and ethnicity in predicting educational achievement. Psychologia 1986;29:176
111. Ivanovic R, Ivanovic D. Características socioeconómicas, socio-culturales, familiares y demográficas de estudiantes de Educación Básica y Media (Región Metropolitana de Chile, 1986–1987). Rev Sociol 1990;5:183
112. Rowley JCR, Leckie N. A further look at the determinants of educational achievement. Can J Sociol 1977;2:339