Association of *Helicobacter pylori* Infection and Height of Mexican Children of Low Socioeconomic Level Attending Boarding Schools

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Abstract. This study evaluated the association between *Helicobacter pylori* infection and height in a population of schoolchildren of a low socioeconomic level regarding growth-related micronutrient status. It was a cross-sectional study of 685 children 5–13 years of age. Height and weight were recorded, a 13C urea breath test was performed for detection of *H. pylori*, and a blood sample was obtained for determination of micronutrient status. *Helicobacter pylori* infection was found to be associated with the height of children. Children with *H. pylori* infection are, on average, 1.32 cm lower (95% confidence interval [CI] = –2.22 to –0.42) in height than children without infection. There was an effect modification by age: for every one-year increase in age, height was 0.66 cm less (95% CI = –1.17 to –0.15) in children with *H. pylori* infection. This finding suggests that *H. pylori* infection has a negative effect on the growth of children.

INTRODUCTION

*Helicobacter pylori* infection is one of the most common bacterial infections in humans and is present in more than 50% of the population worldwide. In Mexico, the prevalence of antibodies against *H. pylori* was estimated to be 42.5% in 5–9-year-old children and 55.5% in 10–14-year-old children, according to the 1998 National Serologic Survey.

A decrease in height-for-age is an indicator of diverse negative factors such as an inadequate diet in either quantity or quality, the effect of repeated infectious disease episodes, poor sanitary conditions, and difficulty getting access to health services. According to the 2006 National Health and Nutrition Survey, in Mexico, the prevalence of low height-for-age in children 5–11 years of age was 10.4% in boys and 9.5% in girls.

*Helicobacter pylori* infection has been associated with several diseases in adults, particularly chronic gastritis, duodenal or gastric peptic ulcer, and gastric carcinoma. Even when the infection is acquired during the first years of life, its consequences on children's health are not known. In this group, *H. pylori* infection has been associated with iron deficiency and anemia. A greater frequency of *H. pylori* has also been reported in short-stature children and adolescents, and children who acquire the infection during follow-up have been shown to have a decreased growth rate. However, these studies have not considered other factors that may affect child's growth such as zinc and vitamin A status.

Therefore, the aim of this study was to evaluate the association between *H. pylori* and height in a school-age, low socioeconomic population, and consider the micronutrient status related to growth.

MATERIALS AND METHODS

**Study population.** A cross-sectional study was conducted from June 2005 through September 2006. Eight hundred nine schoolchildren of the 945 eligible schoolchildren participated in this study. The participates were 5–13 years of age and of low socioeconomic status. The children at any of three public boarding schools in Mexico City participated. Their parents or tutors signed an informed consent form; in addition, schoolchildren more than seven years of age were asked to give their assent to participate in a research study. The protocol was reviewed and approved by the Research and Ethnic Committees of the Mexican Institute of Social Security and the National Institute of Public Health. The study was authorized by the Secretariat of Public Education.

**Anthropometric measurements.** Weight and height were measured. According to the technique suggested by Lohman and others, height and weight were recorded for children without shoes and wearing light clothes, standing straight, with their weight uniformly distributed on both feet and their arms hanging freely on the sides. The height measurement was performed by two independent observers. If the difference between them was ≥ 0.5 cm, the measurement was made again. The average measurement was used. Before starting each work session, the stature meter was checked for calibration using a standard 60-cm stick. An Easy Glide Bearing wall stadiometer (Perspective Enterprises, Portage, MI) with a reading precision of 1 mm was used. The height measurements were reported in centimeters, approximating the reading to the nearest 0.1 cm. For weight measurement, a digital scale (model 881; Seca, Hamburg, Germany) with a reading precision of 50 g for weights up to 50 kg and of 100 g for greater weights was used. Accuracy of the scale was maintained by using calibration weights. These measurements were made by dieticians who participated in the standardization process.

The body mass index was obtained (weight in kg/height in m²) and the schoolchildren were classified by using the cut-off points of Cole and others. Schoolchildren were classified by age and sex as being thin, normal, and overweight or obese.

**13C urea breath test.** The test to detect *H. pylori* consisted of collecting two samples of expired air. The basal sample was obtained 10 minutes after a child had ingested a beverage containing 2 g of citric acid (Citra-LP; San Miguel Proyectos Agropecuarios S.P.R., Hidalgo, Mexico) to delay gastric emptying. Immediately afterward, children were given 50 mg
of $^{13}$C-labeled urea dissolved in 150 mL of water, and the final sample was collected after 30 minutes. The $^{13}$CO$_2$:CO$_2$ ratio was calculated for the samples before and after the ingestion of $^{13}$C urea. A change of $\geq 5$ parts/1,000 was considered positive.\textsuperscript{13,14} Samples were measured on a mass spectrometer (Breath-MAT plus; Finningen, Breman, Germany). The sensitivity and specificity of the test in children are $> 90\%$.\textsuperscript{15}

**Micronutrient nutritional status.** A venous blood sample (4.7 mL) was taken from each child to determine hemoglobin, ferritin, zinc, and retinol serum concentrations. Hematocytometry was automatically performed by using the cyanometahemoglobin method (Beckman Coulter, Fullerton, CA). Hemoglobin concentrations were adjusted according to altitude above the sea level.\textsuperscript{16} Ferritin was measured by radioimmunooassay (Immunotech SA, Marseille, France). Retinol concentration was determined by high-performance liquid chromatography and zinc concentration was determined by atomic absorption spectrometry (Perkin Elmer, Wiesbaden, Germany). A moderate/severe iron deficiency was a ferritin level < 18 μg/L, and a normal/mild deficiency was a ferritin level $\geq 18$ μg/L.\textsuperscript{17} Hemoglobin, zinc, and vitamin A concentrations were grouped by tertile.

**Socioeconomic status.** The study population consisted of children attending public boarding schools, a program offered by the Secretariat of Public Education for low-income families. However, to obtain more detailed information on possible differences because of the degree of socioeconomic exclusion, a questionnaire was also administered asking about housing conditions, ownership of goods (radio, television, videotape recorder, refrigerator, washing machine, store, oven, heater, telephone, computer, motorcycle, or car).

Goods possessed in each home were added. Homes were grouped under the corresponding quintile according to the obtained score and were further classified into two categories: the most marginal socially corresponded to the lowest two quintiles, and the least marginal socially corresponded to the highest three quintiles.

**Overcrowding.** When the number of persons living in the house divided by the number of sleeping rooms was $\geq 3$, the house was considered overcrowded.

**Statistical analysis.** The demographic characteristics of the studied population were summarized using descriptive statistics. The schoolchildren’s height in cm was the dependent variable. An initial analysis assessed the mean difference of the height adjusted for age and sex according to socioeconomics and health study population’s characteristics. The variables related to the micronutrient concentration were assessed either as continuous or as categorical values. Socioeconomic status analysis was performed by principal components.\textsuperscript{18}

In the evaluation of the association between $H.\ pylon$ and the schoolchildren’s height, we computed adjusted coefficients of height through use of a linear regression model with a Gaussian-link function. We used generalized estimating equations to account for correlations between participants in the same school boarding with an exchangeable correlation structure. This analysis considered the possible confounding effect of age, sex, degree of socioeconomic marginality, overcrowding, and iron nutritional status (hemoglobin concentration and iron deficiency according to ferritin concentration). Possible interactions between $H.\ pylon$ and hemoglobin concentration, age, and degree of socioeconomic marginality were also considered.

The most parsimonious model included $H.\ pylon$ infection, age (centered at nine years of age, which corresponds to the mean age of the studied population), sex, $H.\ pylon$ interaction with age, degree of socioeconomic marginality, and hemoglobin concentration adjusted for altitude and centered on the lower level within the normal range (11.5 g/dL for schoolchildren < 12 years of age and 12.0 g/dL for children $\geq 12$ years of age).

Using this model, we calculated the interaction value to determine the precise value for the effect modify variable (age) in which the estimated effect of $H.\ pylon$ infection was different for the child’s height.\textsuperscript{19} Models were checked to comply with the assumptions for linear generalized models.\textsuperscript{20} The analysis was performed using the STATA version 8.2 statistical software (StatCorp., College Station, TX).

**RESULTS**

Information was collected on 809 schoolchildren of the 945 who were invited to participate in this study. One hundred twenty-one children (15%) were excluded because of lack of information on their socioeconomic questionnaire. Another three were excluded because they had diseases related to growth. Thus, the statistical analysis was performed on the data collected for 685 schoolchildren. No statistically significant differences were found in the height adjusted to age and sex among the children who remained in the analysis and those who were excluded. Because of an insufficient amount of serum, the measurement of vitamin A and zinc was only feasible in 52.3% (n = 358) and 69.6% (n = 477) of the studied children, respectively. The general characteristics of the studied population are summarized in Table 1.

The mean ± SD age was 9.2 ± 1.8 years; 62.6% of the participants were female. Low height for age (stunting) was present in the 6.0% of schoolchildren; 22.3% of the children were overweight or obese. The mean ± SD hemoglobin level was 13.9 ± 1.0 g/dL, and 30.6% of the children had moderate or severe iron deficiency according to the ferritin concentration. Almost 35% had $H.\ pylon$ infection.

Height means adjusted for age and sex according to the sociodemographic and health characteristics of the studied population are summarized in Table 2. Schoolchildren with $H.\ pylon$ infection were shorter than children who were not infected ($P = 0.002$). With respect to the iron nutritional status and to the tertile of hemoglobin concentration, the mean height was greater in children in the second and third tertiles than in those in the first tertile. Schoolchildren with severe or moderate iron deficiency were shorter than children with mild or no iron deficiency, according to the ferritin concentrations ($P = 0.040$). Schoolchildren with a higher degree of socioeconomic marginality were shorter, on average, than children with a lower degree of socioeconomic marginality ($P = 0.0001$). No significant differences on height were found among schoolchildren according to home overcrowding and among the vitamin A and zinc tertiles.

The multivariate analysis showed a negative, age-dependent association between $H.\ pylon$ infection and the schoolchildren’s height, adjusting by sex, degree of socioeconomic marginality and hemoglobin concentration. Because the $H.\ pylon$ effect on height was modified by age, the effect increases as children get older. Nine-year-old $H.\ pylon$-infected schoolchildren measured an average $-1.98$ cm (95% confidence interval
H. pylori infection and height of schoolchildren

**TABLE 1**

General characteristics of the study population (n = 685), Mexico[a]

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>9.2 ± 1.8</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>256 (37.4)</td>
</tr>
<tr>
<td>Females</td>
<td>429 (62.6)</td>
</tr>
<tr>
<td>Anthropometric measurements</td>
<td></td>
</tr>
<tr>
<td>Height, cm (95% CI)</td>
<td>131.0 ± 11.7</td>
</tr>
<tr>
<td>Weight, kg (95% CI)</td>
<td>31.0 ± 9.4</td>
</tr>
<tr>
<td>Height for age (Z score)†</td>
<td>-0.44 ± 0.98</td>
</tr>
<tr>
<td>Normal (≥ –2 Z score)</td>
<td>644 (94.0)</td>
</tr>
<tr>
<td>Stunted (&lt; –2 Z score)</td>
<td>41 (6.0)</td>
</tr>
<tr>
<td>Body mass index, kg/m²‡</td>
<td>17.7 ± 2.9</td>
</tr>
<tr>
<td>Thinness</td>
<td>3 (0.5)</td>
</tr>
<tr>
<td>Normal</td>
<td>529 (77.2)</td>
</tr>
<tr>
<td>Overweight and obese</td>
<td>153 (22.3)</td>
</tr>
<tr>
<td>Hemoglobin, g/dL</td>
<td>13.9 ± 1.0</td>
</tr>
<tr>
<td>First tertile (9.4–13.4)</td>
<td>231 (33.7)</td>
</tr>
<tr>
<td>Second tertile (13.5–14.4)</td>
<td>251 (36.6)</td>
</tr>
<tr>
<td>Third tertile (14.5–18.1)</td>
<td>203 (29.7)</td>
</tr>
<tr>
<td>Ferritin, μg/L (n = 682)§</td>
<td>26.1 (24.8–27.4)</td>
</tr>
<tr>
<td>Normal/mild iron deficiency</td>
<td>473 (69.4)</td>
</tr>
<tr>
<td>Moderate/severe iron deficiency</td>
<td>209 (30.6)</td>
</tr>
<tr>
<td><em>H. pylori</em> infection</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>446 (65.1)</td>
</tr>
<tr>
<td>Positive</td>
<td>239 (34.9)</td>
</tr>
<tr>
<td>Degree of socioeconomic marginality</td>
<td></td>
</tr>
<tr>
<td>Less</td>
<td>409 (59.7)</td>
</tr>
<tr>
<td>More</td>
<td>276 (40.3)</td>
</tr>
<tr>
<td>Overcrowding at home (n = 682)§</td>
<td></td>
</tr>
<tr>
<td>No (persons per room &lt; 3)</td>
<td>366 (53.7)</td>
</tr>
<tr>
<td>Yes (persons per room ≥ 3)</td>
<td>316 (46.3)</td>
</tr>
<tr>
<td>Vitamin A (μmol/L) (n = 358)§</td>
<td>1.43 ± 0.50</td>
</tr>
<tr>
<td>First tertile (0.47–1.15)</td>
<td>120 (33.5)</td>
</tr>
<tr>
<td>Second tertile (1.16–1.61)</td>
<td>119 (33.2)</td>
</tr>
<tr>
<td>Third tertile (1.62–3.39)</td>
<td>119 (33.3)</td>
</tr>
<tr>
<td>Serum zinc (μmol/L) (n = 477)§</td>
<td>14.4 ± 2.7</td>
</tr>
<tr>
<td>First tertile (4.6–13.0)</td>
<td>159 (33.3)</td>
</tr>
<tr>
<td>Second tertile (13.1–15.3)</td>
<td>159 (33.3)</td>
</tr>
<tr>
<td>Third tertile (15.3–26.2)</td>
<td>159 (33.3)</td>
</tr>
</tbody>
</table>

[a] Values are the mean ± SD (n %), or geometric mean (95% confidence interval).
† World Health Organization.‡
‡ Cut-off points of Cole and others.††
§ Change in n between variables by missing information.

[CI] = –2.97 to –0.99, P = 0.0001) (Tables 3 and 4) less than same-age, uninfected children. For each one-year increment in age greater than seven years, children with *H. pylori* infection had an average height difference of –0.66 cm (95% CI = –1.17 to –0.15) (P = 0.012) compared with same-age, noninfected children (Table 3).

Additionally, the results of this model (Table 3) show that for each increment in hemoglobin g/dL, the height increases 1.08 cm (95% CI = 0.84–1.32, P = 0.0001). The association between *H. pylori* infection status and schoolchildren’s height did not depend on the hemoglobin concentration, i.e., the hemoglobin concentrations did not modify the effect of *H. pylori* status on the schoolchildren’s height.

Although the children in this study were at a low socioeconomic level, a difference in height could still be detected among the schoolchildren with the highest degree of socioeconomic marginality versus those with the lowest degree of socioeconomic marginality. Schoolchildren coming from the lowest income homes were –1.38 cm (95% CI = –2.28 to –0.48, P = 0.003) shorter than children from homes that were not of the lowest income, adjusting for other variables included in the model.

According to the results obtained by this model, Table 4 shows an estimated effect of *H. pylori* infection on the height per year, per age of the studied children.

**DISCUSSION**

This study found an association between *H. pylori* infection and a decreased height in schoolchildren. This association was modified by age, with older children showing greater effects.

Some cross-sectional studies have reported results similar to ours regarding the existence of this association, as well as its dependence on age. Perri and others found a significant association only for children more than 8.5 years of age: 25.8% of children this age and infected by *H. pylori* and a decreased height in schoolchildren. This association was confirmed by others found a 1.1-cm difference in the height increment per year, per age of the studied children.

According to the results obtained by this model, Table 4 shows an estimated effect of *H. pylori* infection on the height per year, per age of the studied children.

**Table 2**

Mean heights (cm) adjusted for age and sex according to the sociodemographic and health characteristics of the study population (n = 685), Mexico[a]

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean height in cm (95% CI)</th>
<th>P‡</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>H. pylori</em> infection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative (n = 446)</td>
<td>131.5 (131.0–132.1)</td>
<td>Ref.</td>
</tr>
<tr>
<td>Positive (n = 239)</td>
<td>130.1 (129.3–130.8)</td>
<td>0.002</td>
</tr>
<tr>
<td>Hemoglobin concentration, g/dL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First tertile (9.4–13.4) (n = 231)</td>
<td>129.6 (128.9–130.4)</td>
<td>Ref.</td>
</tr>
<tr>
<td>Second tertile (13.5–14.4) (n = 251)</td>
<td>131.3 (130.5–132.0)</td>
<td>0.003</td>
</tr>
<tr>
<td>Third tertile (14.5–18.1) (n = 203)</td>
<td>132.2 (131.4–133.1)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Serum ferritin (n = 682)§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal/mild iron deficiency (ferritin ≥ 18 μg/L)</td>
<td>131.4 (130.8–131.9)</td>
<td>Ref.</td>
</tr>
<tr>
<td>Moderate or severe iron deficiency (ferritin &lt; 18 μg/L)</td>
<td>130.3 (129.5–131.1)</td>
<td>0.040</td>
</tr>
<tr>
<td>Overcrowding at home (n = 682)§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No (persons per room &lt; 3)</td>
<td>134.0 (130.8–132.0)</td>
<td>Ref.</td>
</tr>
<tr>
<td>Yes (persons per room ≥ 3)</td>
<td>130.7 (130.0–131.4)</td>
<td>0.128</td>
</tr>
<tr>
<td>Vitamin A (μmol/L) (n = 358)§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First tertile (0.47–1.15) (n = 120)</td>
<td>131.6 (130.3–132.8)</td>
<td>Ref.</td>
</tr>
<tr>
<td>Second tertile (1.16–1.61) (n = 119)</td>
<td>132.8 (131.6–133.9)</td>
<td>0.172</td>
</tr>
<tr>
<td>Third tertile (1.62–3.39) (n = 119)</td>
<td>133.0 (131.8–134.2)</td>
<td>0.106</td>
</tr>
<tr>
<td>Serum zinc (μmol/L) (n = 477)§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First tertile (4.6–13.0) (n = 159)</td>
<td>130.8 (129.8–131.7)</td>
<td>Ref.</td>
</tr>
<tr>
<td>Second tertile (13.1–15.3) (n = 159)</td>
<td>130.4 (129.5–131.3)</td>
<td>0.570</td>
</tr>
<tr>
<td>Third tertile (15.3–26.2) (n = 159)</td>
<td>130.5 (129.6–131.5)</td>
<td>0.683</td>
</tr>
</tbody>
</table>

[a] CI = confidence interval; Ref = reference category.
† World Health Organization.‡
‡ By Wald statistics and multiple regression models.
§ Change in n between variables by missing information.
The mechanisms by which Helicobacter pylori infection may affect growth have not been identified, but possible mechanisms such as dyspepsia and hypochlorhydria have been proposed. It has been suggested that this infection may reduce food intake because of its association with dyspepsia. Nevertheless, most infected subjects remain asymptomatic and the proportion of children with dyspeptic symptoms may be similar among infected subjects remain asymptomatic and the proportion of children with dyspeptic symptoms may be similar among infected and noninfected children. 25

The effect of Helicobacter pylori infection on children’s growth may be related to the immune response on infection. Helicobacter pylori infection provokes an increase in some cytokines, therefore inducing chronic inflammation. 26 Infection with Helicobacter pylori could produce a systemic immuno-stimulation and subsequent growth retardation. 27 Infections may also decrease appetite and increase the nutritional requirements because of a catabolic phase relationship with the immune response.

In this study, we found a positive relationship between serum hemoglobin concentration and schoolchildren’s height, despite children exhibiting a normal hemoglobin concentration. To date, we cannot explain this fact, but it has been suggested that a decreased intake of iron-containing food may be related to a reduction on the total caloric intake and protein intake. Furthermore, iron deficiency has been associated with a greater risk of morbidity. 28 Studies conducted in Thailand, India, and Kenya have found improvement in growth after anemic children were given iron supplements. 29–32

Helicobacter pylori infection has been associated with iron deficiency and iron-deficiency anemia. 33–36 In a study that included adolescents in South Korea, Choe and others found that the height-for-age mean was less in those who had Helicobacter pylori infection and anemia because of iron deficiency. The authors concluded that infection, together with iron-deficiency anemia, more than infection per se, may affect growth. 37–39 Süoglu and others in a study comprising a population 4–16 years of age found that the mean height-for-age Z score in Helicobacter pylori-infected and iron-deficiency anemic patients was lower than in patients who were non–iron-deficiency anemic and negative for Helicobacter pylori infection. 35 Yokota and others reported that Helicobacter pylori strains in iron-deficiency anemia patients showed a better ferric ion uptake and a fast, iron-dependent growth compared with strains from patients without iron-deficiency anemia. 40 The capability of Helicobacter pylori for ferric ion uptake could be a causal factor for the iron-deficiency anemia. 35–36 Hypochlorhydria has also been proposed as a mechanism by which Helicobacter pylori is associated with anemia and iron deficiency because non-heminc iron absorption is decreased in persons with this condition. 41–43 In our study, no effect modification according to the hemoglobin concentrations on the association between Helicobacter pylori infection and schoolchildren’s height was found. Nevertheless, we found that the hemoglobin concentration was independently associated with height in these children. This important association should be evaluated in further studies.

This study was carried out with children from low-income families. All of them attended public boarding schools. However, even in this group, which could be considered economically homogeneous, differences in height could be

### Table 3

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Height in cm (n = 685), adjusted coefficients* (95% confidence interval)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. pylori infection</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>-1.32 (–2.22 to –0.42)</td>
<td>0.011</td>
</tr>
<tr>
<td>Positive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, centered (years)†</td>
<td>5.65 (5.38–5.92)</td>
<td>0.0001</td>
</tr>
<tr>
<td>H. pylori × age interaction</td>
<td>-0.66 (–1.17 to –0.15)</td>
<td>0.012</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>1.71 (1.47–1.96)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Degree of socioeconomic marginality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More</td>
<td>-1.38 (–2.28 to –0.48)</td>
<td>0.003</td>
</tr>
<tr>
<td>Hemoglobin, centered‡</td>
<td>1.08 (0.84–1.32)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Average height (constant)§</td>
<td>127.4 (126.5–128.2)</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

*Adjusted coefficients for variables listed that account for correlations between participants in the same school boarding using generalized estimating equations.
† Age centered at nine years.
‡ Hemoglobin adjusted and centered at the lower value within the normal range (11.5 g/dL for children <12 years of age and 12.0 g/dL for children ≥12 years of age).
§ Mean height when the independent variables match the value of the reference category or the one used to center it.

**Table 4**

Estimated effect of Helicobacter pylori infection on the schoolchildren’s height by age, Mexico

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Effect of Helicobacter pylori infection on height in cm (95% CI)†</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>-0.66 (–1.75 to 0.42)</td>
<td>0.230</td>
</tr>
<tr>
<td>8</td>
<td>-1.32 (–2.22 to –0.42)</td>
<td>0.004</td>
</tr>
<tr>
<td>9</td>
<td>-1.98 (–2.97 to –0.99)</td>
<td>0.0001</td>
</tr>
<tr>
<td>10</td>
<td>-2.63 (–3.92 to –1.35)</td>
<td>0.0001</td>
</tr>
<tr>
<td>11</td>
<td>-3.29 (–4.98 to –1.60)</td>
<td>0.0001</td>
</tr>
<tr>
<td>12</td>
<td>-3.95 (–6.09 to –1.81)</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

* CI = confidence interval.
† Coefficients adjusted for age, sex, degree of socioeconomic marginality, and hemoglobin centered and take account for correlations between participants in the same school boarding using generalized estimating equations.
identified according to the degree of socioeconomic margin-
ality, but no significant differences in average height among
schoolchildren according to vitamin A or zinc concentra-
tions could be found. The micronutrient deficiency of zinc or
A vitamin has been associated with growth retardation, and
supplementation studies with zinc have shown increases in the
children's height. Nevertheless, most schoolchildren in this
study had normal serum zinc and retinol concentrations.

The results of this study should be interpreted with caution
because the study was a cross-sectional study. We should rec-
ognize a possible problem of temporal ambiguity. It is possible
that schoolchildren who are nutritionally compromised have
more susceptibility to initial Helicobacter pylori colonization, they could be
more susceptible to chronic infection, or the infection influ-
ences nutritional status. However, the different effects of infec-
tion on the height in relation to age, with the effects increasing
as children get older, suggested that this chronic infection
influences the schoolchildren's height. Prospective studies are
required to confirm the results of this study. Other possible
limitation is residual confounding. Helicobacter pylori infec-
tion and growth restriction have a risk factors relationship
with socioeconomic level. We attempted to control for these
factors by including only schoolchildren with a low socioeco-
nomic level in our study. Additionally, we include degree of
socioeconomic marginality in the analysis.

Helicobacter pylori infection was associated with shorter
height in schoolchildren. This association is age dependent;
i.e., the effect increases as children get older. These results sug-
gest that H. pylori infection has a negative effect on children's
growth. In this study, we also found an association between
hemoglobin concentration and height. Additional information
is needed to understand the effect of iron on growth.

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