Socioeconomic and Anthropometric Correlates of Linear Enamel Hypoplasia in Children from Solis, Mexico

Alan H. Goodman* - Gretel H. Pelto** - Lindsay H. Allen** - Adolfo Chavez***
* School of Natural Science, Hampshire College, Amherst, MA 01002, (USA).
** Dept. Nutritional Sciences, University of Connecticut, Storrs, CT 06269 (USA).
*** Instituto Nacional de la Nutricion, Division de Nutricion de la Comunidad Tlahpan. D.F., 14000 (Mexico).

Abstract.

In order to better understand the etiology of linear enamel hypoplasias (LEH) in prehistoric and contemporary groups, we studied their association with socioeconomic status (SES) and anthropometric measures of nutritional status in children from Solis, Mexico (n = 296). Enamel hypoplasia on upper, permanent incisor teeth was inversely associated with SES, height-for-age, and weight-for-age. The strongest associations were found for hypoplasias developing closest to the time of measurement of anthropometric and socioeconomic status. The consistent association between these measures suggests that LEH is a sensitive indicator of within-community variation in living conditions.

Introduction.

In recent years two converse trends have emerged in paleopathology. One trend involves the questioning of whether skeletal markers of disease (and stress) should be read as signs of individual and population maladaptation. Ortner (1979), for example, long ago raised the important challenge of whether skeletal markers of infection might just as well be considered signs of the struggle to adapt. At the same time, the use of other skeletal indicators of disease and stress, such as linear enamel hypoplasia (LEH), has expanded without serious questioning of their meaning for health, development and adaptation (Goodman & Rose, 1990).

These trends, both the questioning of the underlying meaning of skeletal indicators of health, and uncritical acceptance of them in paleopathological contexts, has lead us to begin a series of studies of the meaning and correlates of one skeletal indicator, linear enamel hypoplasia, in contemporary situations. It is our belief that such studies are essential to further understanding the significance of linear enamel hypoplasia in prehistory. As well, such studies suggest that enamel hypoplasia might be useful as a measure of childhood conditions in
contemporary populations. The specific purpose of this paper is to report on the socioeconomic and nutritional status correlates of enamel defects in contemporary, rural Mexican children. We report on differences in mean socioeconomic status, height-for-age and weight-for-age in children with and without enamel hypoplasia on upper permanent incisor teeth.

Methods and population.

This research was an outgrowth of the Collaborative Research Support Program (CRSP) study of nutrition and function (Allen & al., 1987). The purpose of the CRSP is to better understand the functional consequences of mild-to-moderate undernutrition. Mild-to-moderate undernutrition is of significance because it is the most prevalent form of malnutrition in the contemporary world and is likely to have been endemic throughout most of human history. Despite its pervasiveness, we know little of the functional costs of this form of malnutrition (Allen, 1984).

The research site is located in the Temascalcingo region of the Mexican highlands, about 170 Km northwest of Mexico City and at an altitude of about 2200 meters (Figure 1). The immediate area, the Solis Valley, includes 13 villages, each of about 1,000 individuals. Children from five of these villages were included in this study. Living conditions are somewhat «typical» for a rural community in highland Mexico, and perhaps much of the developing world. Roads are unpaved and there is little sanitation. Houses are small, usually consisting of from one to three rooms. The dominant food item is tortillas, though in wealthier families this traditional food is given way to bread and pastas. The fluorine content of water in the valley is less than 1 ppm.

Children in this populations begin to exhibit growth faltering around the sixth month of age (Allen & al., 1987). At weaning most children are at least 2 months below National Center Health Statistics (NCHS) referent values for weight and 1.5 Z-scores below NCHS values for height. The major logical correlates of poor growth are low intake of animal products and the limited diversity of the diet (Allen & al., 1987).

The dental data are from 7-9 year-old children who were targeted for inclusion in the CRSP study, and their school siblings. The sample includes 296 children, ages 5 to 15, with slightly more males than females. Defects were scored on anterior teeth by development zones approximating sixths of true crowns from the incisal to the cervical border.

Classification followed the Federation Dentaire International (FDI) index of developmental defects of dentin and enamel (1982; Clarkson, 1989). Four types of defects were found. Whiting opacities and linear enamel hypoplasia were most prevalent, followed by hypoplastic pits and yellow opacities. Nearly half the children had one or more enamel opacities and one or more enamel hypoplasias (Goodman & al., 1987; Goodman, 1988). In the permanent incisors the majority of hypoplasia developed in the middle (second to fourth) zones, suggesting a peak age at formation from about 12 to 30 months.

The following analysis includes only permanent dentition defects, and focuses on linear enamel hypoplasia, the most
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Figure 1. Map of Mexico and location of Solis Valley field site.

Figure 2. Comparison of mean Z-score of weight-for-age for individuals with and without linear enamel hypoplasias (LEH) on developmental zones of the upper central incisor.
common developmental defect found in prehistoric populations. Patterns of association are presented between LEH found on any anterior permanent tooth, upper central incisors; and lateral incisors (the most hypoplastic teeth) and three dependent variables: socioeconomic status, Z-score of height-for-age and Z-score of weight-for-age (Tables 1-3). Height and weight Z-scores were calculated via a U.S. Center for Disease Control (CDC) program, based on National Center for Health Statistics (NCHS) data. Socioeconomic status is based on household characteristics such as the type of walls, flooring and roof; the number of rooms; and signs of material wealth such as ownership of chickens and other animals. Finally, data are presented on mean SES and anthropometric scores for individuals with and without hypoplasia by developmental zone on the maxillary central incisor, the single most hypoplastic tooth (Figures 2-4).

**Results.**

**Weight-for-Age.**

A consistent decrease (more negative) Z-score for weight is found for those with hypoplasia versus those without hypoplasia. These differences approach significance for the central incisor and the total of the permanent anterior teeth, and are significant for the lateral central incisor (Table 1).

<table>
<thead>
<tr>
<th>Table 1: Mean Weight-x for enamel hypoplasia on permanent teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary I1</td>
</tr>
<tr>
<td>Maxillary I2</td>
</tr>
<tr>
<td>Anterior Teeth</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Mean Height for enamel hypoplasia on permanent teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary I1</td>
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<tr>
<td>Maxillary I2</td>
</tr>
<tr>
<td>Anterior Teeth</td>
</tr>
</tbody>
</table>

The pattern of scores suggests that the relationship between presence of a defect developing toward the junction, or after (Figure 2). A consistent scores in found at these differences are two zones.
Table 1. Mean Weight-for-Age Z-scores for individuals with and without linear enamel hypoplasia on permanent teeth.

<table>
<thead>
<tr>
<th></th>
<th>LEH</th>
<th>no LEH</th>
<th>T value</th>
<th>2-tail P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\bar{X}$ (s.d.)</td>
<td>$\bar{X}$ (s.d.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxillary I1</td>
<td>-1.29 (.59) (71)</td>
<td>-1.13 (.65) (137)</td>
<td>1.72</td>
<td>.086</td>
</tr>
<tr>
<td>Maxillary I2</td>
<td>-1.38 (.51) (28)</td>
<td>-1.15 (.65) (180)</td>
<td>2.04</td>
<td>.047</td>
</tr>
<tr>
<td>Anterior Teeth</td>
<td>-1.27 (.59) (89)</td>
<td>-1.12 (.67) (119)</td>
<td>1.69</td>
<td>.093</td>
</tr>
</tbody>
</table>

Table 2. Mean Height-for-Age Z-scores for individuals with and without linear enamel hypoplasia on permanent teeth.

<table>
<thead>
<tr>
<th></th>
<th>LEH</th>
<th>no LEH</th>
<th>T value</th>
<th>2-tail P</th>
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<tbody>
<tr>
<td></td>
<td>$\bar{X}$ (s.d.)</td>
<td>$\bar{X}$ (s.d.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxillary I1</td>
<td>-1.66 (.76) (56)</td>
<td>-1.47 (.85) (121)</td>
<td>1.40</td>
<td>.162</td>
</tr>
<tr>
<td>Maxillary I2</td>
<td>-1.78 (.79) (20)</td>
<td>-1.50 (.83) (157)</td>
<td>1.39</td>
<td>.168</td>
</tr>
<tr>
<td>Anterior Teeth</td>
<td>-1.67 (.81) (71)</td>
<td>-1.44 (.83) (106)</td>
<td>1.85</td>
<td>.066</td>
</tr>
</tbody>
</table>

The pattern of weight-for-age Z-scores suggests that the strongest relationship between weight and the presence of a defect occurs for defects developing toward the cemento-enamel junction, or after about 30 months (Figure 2). A consistent decrease in Z-scores in found at all zones. However, these differences are greatest for the last two zones. Height-for-Age.

Z-scores for height-for-age are also consistently less for groups with LEH. However, these differences only approach significance for the anterior permanent tooth total (Table 2). By developmental zone there is a consistent decrease in mean height Z-score with hypoplasia (Figure 3). This decrease ap-
Table 3. Mean socioeconomic status (SES) scores for individuals with and without linear enamel hypoplasia on permanent teeth.

<table>
<thead>
<tr>
<th></th>
<th>LBH</th>
<th>No LBH</th>
<th>T value</th>
<th>2-tail P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X (s.d.)</td>
<td>X (s.d.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxillary I1</td>
<td>211.4 (103.7)</td>
<td>238.0 (106.5)</td>
<td>2.00</td>
<td>.047</td>
</tr>
<tr>
<td></td>
<td>(92)</td>
<td>(190)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxillary I2</td>
<td>210.6 (109.9)</td>
<td>232.1 (105.5)</td>
<td>1.15</td>
<td>.252</td>
</tr>
<tr>
<td></td>
<td>(37)</td>
<td>(245)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior Teeth</td>
<td>217.1 (108.8)</td>
<td>238.1 (107.2)</td>
<td>1.66</td>
<td>.099</td>
</tr>
<tr>
<td></td>
<td>(118)</td>
<td>(164)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

proaches significance at the next to last zone (37 to 44 months) and is significant at the most cervical zone (45-52 months).

Socioeconomic Status.

A consistent decrease in socioeconomic status (SES) in seen in those with hypoplasia versus those without hypoplastic defects (Table 3). The decrease in SES of those with hypoplasia approaches significance for the permanent anterior tooth total and is significant for the upper central incisor.

By developmental zone there is a consistent decrease in SES mean with hypoplasia (Figure 4). Very similar to the data shown above for the anthropometric measurements, this difference is greatest for the last two developing zones.

Discussion.

While hopefully a step in the right direction, this study provides a highly imperfect measure of the association between LEH and socioeconomic or nutritional status. First, sample sizes are limited by missing data, especially for height measurements (Table 2). This has surely contributed to the unevenness of the results. Secondly, the anthropometric measures are cumulative indicators of nutritional status, while dental defects may be due to relatively short term events. Third, this study is not prospective. Growth and socio-economic status are not measured during tooth crown formation.

Despite the limitations inherent in this study, the degree of association between LEH and nutrition and socioeconomic status reaffirms the notion that LEH is related to general conditions of life. These data are consistent with prior experimental and epidemiological data on hypoplasia and nutritional status. Sweeney & al. (1971) have linked deciduous hypoplasia to second and third degree malnutrition, measured by growth status, in Guatemalan children. Enwonwu (1973) has similarly found clear associations between socioeconomic status and severe hypoplasia in deciduous teeth of children in Nigeria. This study extends from Sweeney's

Figure 4. Comparison of enamel hypoplasias (LEH) and Enwonwu's in first tooth defect, a sign of malnutrition and severe hypoplasia.

The pattern of results is associated with hypoplasia during 3 to 4.5 years of age: (1) the more severe defects compared to right after birth, (2) occurrence or (3) a necessary to cause.

We have recently re-examined the data from these children, from Mexico (Goodman & al., 1973) using the same criteria, and there is a significant increase in the number of LEH cases.
Using data, especially for- 
ments (Table 2). This has 
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the anthropomet-
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il and epidemiological 
a and nutritional sta-
(1971) have linked 
s to second and third 
tion, measured by 
entral children. 
 has similarly found 
 severe hypoplasia 
of children in Niger-
ns from Sweeney's 
and Enwonwu's in focusing on perma-
ent tooth defect, a less severe degree 
of malnutrition and, we believe, less se-
vere hypoplasia.

The pattern of results, with strongest 
associations for hypoplasia occurring 
during 3 to 4.5 years of age, may be due 
to: (1) the more recentness of these 
defects compared to LEHs occurring 
right after birth, (2) their lower rate of 
occurrence or (3) an increased stress 
necessary to cause these defects.

We have recently been able to 
prospectively follow another group in 
Mexico (Goodman & al., 1991). Some of 
these children, from Tesonteopan, Mex-
ico have received daily nutritional sup-
plements, and therefore, their nutrition-
al status is much better than their peers. 

Those with improved nutritional status 
have about half the prevalence of LEH 
as their non-supplemented peers. Here 
as well, the greatest difference between 
supplemented and non-supplemented 
adolescents is found in the prevalence of 
hypoplasia developing after about 30 
months (Goodman & al., 1991).

In conclusion, this study has 
reaffirmed the notion that hypoplasia 
are related to general conditions of life in 
marginal environments. It is our hope 
that studies of enamel defects in living 
populations will both help us to under-
stand the significance of these defects 
in prehistory and will become important 
in their own right as tools for under-
standing the stresses of contemporary 
conditions.
References.


