Survival and Physical Growth in Infancy and Early Childhood

Study of Birth Weight and Gestational Age in a Guatemalan Indian Village

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Many factors contribute independently or jointly to the cause and pathogenesis of low birth weight. Attempts to identify these factors in a given population, however, are usually unsuccessful, and conclusions are equivocal. Among the variables related to fetal growth, socioeconomic status and size of the mother consistently show positive correlations. Thus, incidence of low birth weight, defined as less than 2,501 gm (5.5 lb), is lowest in the nations with the highest standard of living. Although the United States is among the most developed nations, its incidence of low birth weight among its population groups of low socioeconomic class is highest among its population groups.

The problem is more serious in developing nations. but it is extremely difficult to assess there because of inadequacy or lack of statistical data. Data on birth weight in these countries are usually derived from hospital records that, aside from their inaccuracy, are not representative of the rural and peripheral urban population. Nevertheless, even such limited reports from Latin America, Asia, and Africa indicate low birth weight rates ranging from 16% to 26%.

The magnitude of the problem of low birth weight can only be assessed by prospective observation of communities that are representative of larger areas or regions. One such study has been underway since 1963 in a typical Guatemalan Indian village, Santa Maria Cauque. When the

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Infants</th>
<th>M–nWeight ±SD, lm</th>
<th>R.n тем</th>
<th>% &lt; 2,501 gm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>37</td>
<td>2.595±360</td>
<td>1.510-3.313</td>
<td>35</td>
</tr>
<tr>
<td>1965</td>
<td>45</td>
<td>2.573±376</td>
<td>1.635-3.267</td>
<td>42</td>
</tr>
<tr>
<td>1966</td>
<td>46</td>
<td>2.506±321</td>
<td>1.344-3.135</td>
<td>46</td>
</tr>
<tr>
<td>1967</td>
<td>59</td>
<td>2.580±389</td>
<td>1.710-3.374</td>
<td>41</td>
</tr>
<tr>
<td>1968</td>
<td>57</td>
<td>2.510±422</td>
<td>1.357-3.903</td>
<td>44</td>
</tr>
<tr>
<td>1969</td>
<td>53</td>
<td>2.526±448</td>
<td>1.194-3.387</td>
<td>38</td>
</tr>
<tr>
<td>1971</td>
<td>60</td>
<td>2.564±328</td>
<td>1.745-3.310</td>
<td>48</td>
</tr>
</tbody>
</table>

* Data obtained from subjects in Santa Maria Cauque, Guatemala, 1964 through 1971.
* The study began Feb 11, 1964; infants born before this date are not included.
Table 2.-Weight and Height of Cohorts Born in Different Years by Age-
  Age, mo

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Birth</th>
<th>3</th>
<th>6</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight, gm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>2.595 ±118t</td>
<td>5.288 ±224</td>
<td>6.501 ± 251</td>
<td>7.341 ± 269</td>
</tr>
<tr>
<td>1967</td>
<td>2.580 ±1101</td>
<td>5.149 ±187</td>
<td>6.326 ± 190</td>
<td>7.113 ± 264</td>
</tr>
<tr>
<td>Height, cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>46.5 ± 0.7</td>
<td>56.4 ±0.8</td>
<td>61.5 ±0.7</td>
<td>67.6 ± 1.0</td>
</tr>
<tr>
<td>1967</td>
<td>45.7 ± 0.6</td>
<td>55.8 ±1.4</td>
<td>61.6 ±1.5</td>
<td>67.5 ±2.3</td>
</tr>
<tr>
<td>1970</td>
<td>45.7 ± 0.5</td>
<td>54.8 ±0.9</td>
<td>60.3 ±0.7</td>
<td>65.8 ±0.8</td>
</tr>
</tbody>
</table>

- Data obtained from subjects in Santa Maria Cauque, Guatemala, 1964 to 1972.
- Mean ±SD.

study began, this community, near Guatemala City at an altitude of 1,890 meters (6,200 ft), had a population of 1,071. By 1971, when observations reported here were completed, it had grown to 1,370 people, and it has been growing at a rate of 3% per year with minimal migration. The birth rate has been approximately 50 per 1,000 population, with an infant mortality of about 90 per 1,000 livebirths. Deliveries take place at home according to tradition and custom. Breast feeding is begun shortly after birth; and the total lactation period is one to four years. Chronic, protein-calorie malnutrition and a high rate of infection are prevalent in people of all ages.

SUBJECTS AND METHODS

Early in 1963, a health center, staffed by a team of health workers, established a firm association with villagers that permitted observations on virtually the whole population. The center provides care and serves as a base of operations. Services consist of treatment of illnesses and injuries. However, immunization programs were deficient and no large-scale nutritional or health intervention was implemented during the period of observation (1963 to 1972).

The key factor responsible for the completeness and high accuracy of the collected data was an early acquaintance with the village authorities, leaders, women, and folk midwives. Deliveries were reported when they took place. Auxiliary public health nurses, posted in the village around the dock (including weekends), visited the homes within one hour of an infant's birth, measuring the newborn and collecting pertinent information about the mother and the infant and their immediate environment.

There were 465 deliveries during the study period, resulting in 460 singletons and ten twins. Among the singletons, 446 were born alive: birth weight was obtained on 430 (96) and gestational age on 416 (94). All infants remained under observation and were weighed and measured periodically.

RESULTS

There was a remarkable constancy in the pattern of fetal growth, infant mortality, and postnatal growth during the study period. The mean and standard deviation of birth weight were similar during the individual years of the study, as was the incidence of low-birth-weight infants (Table 1). Likewise, the mean weight and height at various ages, exhibited by the yearly cohorts, were quite stable (Table 2). Although some environmental and social characteristics changed during the study period (for example, the average area of land for...
cultivation per family decreased by 20%, more men became landless laborers, the water supply was improved, electric current became available, and there was a slight decrease in the illiteracy rate), such changes apparently did not result in alterations of behavior of important biological variables used to measure fetal and postnatal growth. This constancy of biological measurements permits the following analysis and interpretations.

Survival

A direct correlation between gestational age and survival was also noted. This association, however, was not as clear-cut, although products of gestation of less than 37 weeks had a higher mortality than term newborns (Table 3). Survival of term infants was almost always associated with large birth weight. Since, under field conditions, birth weight can be determined better than gestational age, it becomes a good predictor of survival in the neonatal and postneonatal period.

The relationship of fetal maturity (defined by the combination of birth weight and gestational age) to survival is described elsewhere. Preterm infants died more often than was expected. The small-for-date infants born at term had a high mortality in the first two years of life. Term infants adequate for gestational age fared the best.

Postnatal Growth

All of the 430 singletons with known birth weight and all of the 416 with known gestational age were observed prospectively. Seven children were lost to follow-up because of migration. Other attrition in numbers was due to the fact that the data are

Fig 2.-Mean head circumference curves of cohorts of children defined by birth weight. Santa Maria CauQue, Guatemala. 1964 to 1972. Numbers in curves denote children measured.

Fig 3.-Mean weight curves of cohorts of children defined by gestational age, Santa Maria Cauque, Guatemala. 1964 to 1972. Numbers in curves denote children measured.
Weight curves as a function of gestational age tended to show only two distinct groups, "the preterm and the term infants" (Fig 3). The same applies to height and head and chest circumferences. Head circumference correlated well with gestational age during the first 15 months of life; thereafter, differences were less noticeable. It should be stressed that head circumference and gestational age correlated well during the period of head growth, and particularly in the first months of life.

The growth pattern as a function of fetal maturity (defined by birth weight and gestational age) is described elsewhere." Preterm infants with very low birth weights had the worst growth curves. Small-for-date infants born at term were next, and term infants adequate for gestational age grew best.

### Table 3-Infant Deaths in Relation to Birth Weight

<table>
<thead>
<tr>
<th>Birth Weight</th>
<th>No. of Infants</th>
<th>Deaths</th>
<th>Ap</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1,501</td>
<td>5</td>
<td>3 (60)</td>
<td>1 (200)</td>
</tr>
<tr>
<td>1,501-1,750</td>
<td>11</td>
<td>2 (182)</td>
<td>3 (273)</td>
</tr>
<tr>
<td>1,751-2,000</td>
<td>17</td>
<td>4 (235)</td>
<td>4 (235)</td>
</tr>
<tr>
<td>2,001-2,250</td>
<td>47</td>
<td>2 (43)</td>
<td>2 (43)</td>
</tr>
<tr>
<td>2,251-2,500</td>
<td>99</td>
<td>3 (30)</td>
<td>0</td>
</tr>
<tr>
<td>2,501-2,750</td>
<td>2 (16)</td>
<td>2 (24)</td>
<td></td>
</tr>
<tr>
<td>2,751-3,000</td>
<td>82</td>
<td>0</td>
<td>2 (24)</td>
</tr>
<tr>
<td>3,001-3,250</td>
<td>32</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3,251-3,500</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;3,500</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>430</td>
<td>16 (37)</td>
<td>15 (35)</td>
</tr>
</tbody>
</table>

- Data obtained from 430 singleton infants in Santa Maria cauque, Guatemala, 1964 to 1973.
- Deaths and in parentheses, rate per 1,000 live births of that birth weight category.

The association between low birth weight and survival was so striking that infant mortality stands out as an indicator of fetal growth and maternal health. On the basis of the data presented, it can be assumed that an infant mortality of 100 'per' 1,000 in similar regions where infants are breast fed indicates a 30% to 40% incidence of low birth weight, providing tetanus neonatorum is not a problem in the area. This concept, however, cannot be generalized to all situations. For example, a high infant mortality may occur despite a low incidence of low birth weight if infants are improperly weaned at an early age, as presently occurs in large urban centers of developing nations. An international investigation of childhood mortality" has shown that the interaction of poverty, low birth weight, improper weaning, and infectious disease accounts for most premature deaths throughout large urban areas of Latin America.

Observations reported here show that fetal growth is correlated with postnatal physical growth. Infants...
after birth. These factors, whether the variable measured was weight, height, or head and chest circumferences. This applied throughout the length of the study, i.e., seven years. Differences of weight became accentuated with time; those of head circumference were greater during the first 15 months of life, and particularly in the first month.

The relationship between birth weight and postnatal physical growth has been the concern of many workers who found positive correlations by retrospective analysis.1–I. Prospective studies have been done all too infrequently. For instance, two studies have shown that premature and small-for-date infants grow abnormally,1–I despite the provision of an adequate environment. The comprehensive study of the 1958 cohort of British infants disclosed that birth weight and gestational age were positively correlated with postnatal growth and development.1

Little of this type of information is available from developing countries.

One study of Nigerian infants whose birth weights were below the tenth percentile for the region showed that they had a poorer weight gain than children with larger birth weight.5 A similar observation was recorded for Gambian newborns observed prospectively in their rural environment.6

The relationship of birth weight and postnatal physical growth is important because psychomotor retardation, intellectual impairment, and lower survival are the sequelae of suboptimal fetal and postnatal growth and development.v–> Thus, birth weight is important as a predictor not only of survival, but also of physical and intellectual development, particularly in preindustrial societies which have a very high incidence of low birth weight.

The importance of the present study lies in the fact that it is an eight-year prospective field observation of virtually the whole population of newborns in a typical Guatemalan village under natural conditions and without a variability imposed by intervention. We still need to learn more about the cause and pathogenesis of low birth weight in developing countries in order to devise some type of control and achieve prevention. The role played by maternal nutrition cannot be denied, and measures to improve it must be undertaken. However, more emphasis should be given to assessing the contribution of certain pathologic processes in the mother that are susceptible to treatment or prevention. Infectious diseases are an example of such a process because they are a direct or a contributing cause of maternal malnutrition, as well as a cause of fetal growth retardation, abnormal development, and premature delivery. Although our knowledge of the factors responsible for the high rates of low birth weight in whole communities is still incomplete, application of what is already known can be an exciting challenge to those concerned with the solution of this problem.

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References

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