

Breastfeeding, Nutrition, Infection and Infant Growth in Developed and Emerging Countries
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BREAST-FEEDING, INFECTIONS AND INFANT OUTCOMES: AN INTERNATIONAL PERSPECTIVE

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ABSTRACT

Most rural mothers from Puriscal, a typical transitional population in Costa Rica, breast-feed their infants; more than one half breast-feed beyond 6 months. This situation was brought about by commencement of rooming-in and promotion of breast-feeding in the maternity where most Puriscal infants are delivered. Before such interventions were implemented, most infants were not breast-fed or were nursed for a few months only. In addition, feeding pooled human colostrum and milk to "high-risk" neonates was followed by a marked decrease in incidence of early neonatal infections. Exclusive breast-feeding for at least the first month of life was associated with optimal infant growth, regardless of degree of maturity at birth. Breast-fed infants grew better than non-breast-fed infants. Periods of weight loss or growth arrest were relatively uncommon in Puriscal, and when occurred, they were associated to infectious diseases, and, to a lesser degree, child neglect, abuse or deficient home technology. These observations were contrasted with a previous study in the Indian village of Cauqué, in Guatemala, where optimal child growth was observed in breast-fed infants during the first semester of life, despite marked socioeconomic deprivation. Beyond this period, however, growth faltering was considerably more common in Cauqué rather than in Puriscal as a result of a greater incidence of infectious diseases and poorer home technologies in Cauqué. Infections resulted in diminished calorie intake, nutrient wastage, weight loss, growth arrest and premature death. These studies show that the control and prevention of malnutrition and premature death lies in great part in

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the success to control and prevent infectious disease, more than in correcting whatever deficiencies appear in the village diet. This predicate does not apply to situations in which there is evident food shortage.

1. INTRODUCTION

The initiation, characteristics and duration of breast-feeding are determined by host and environmental factors. The following factors play a role in the success of breast-feeding: social and cultural traditions, type and intensity of activities of mothers, infant maturity at birth, type and intensity of maternal stress, degree of commitment to nurse and level of maternal modernity (1). The interaction among these factors vary according to the level of social, educational and economic development, as well as to the quality of the environment in which they occur. The ecology of breast-feeding, as seen from an international perspective, shows a continuum ranging from absolute success to nurse most infants observed in traditional societies, to a high rate of failure to breast-feed characteristic of transitional and modern populations (Table 1). In many countries, traditional, transitional and modern populations coexist; the traditional are generally found in rural areas (2). Awareness of the importance of breast-feeding, along with public health interventions, have prompted an increase in breast-feeding in industrial countries in recent times (3), but incidence and duration of breast-feeding have not attained the levels observed in traditional societies (1,2).

2. FIELD STUDIES AND PROCEDURES

The author's experience is derived from three "human laboratories": a) Santa María Cauqué, a village of Cakchiquel Indians in Guatemala; b) Puriscal, a region with about 150 communities of mestizo and caucasian ethnicity in Costa Rica; and c) Limoncito and Abrojo, two communities of Guaymi Indians in Costa Rica. Limoncito and Abrojo are "traditional" communities of people living close to or in the forest, in relative isolation (4). Santa María Cauqué is a "traditional" crowded community in which many inhabitants still live relatively isolated from large urban centers (5). Puriscal is a transitional region of mestizo and caucasian people living in semi-urban and rural conditions, but with ready access to information and transport (6). While breast-feeding has been preserved in the Amerindian populations, it had decreased considerably in Puriscal, until interventions were begun in 1977, to be described later.

Three prevalence surveys were made of the Guaymi Indians, each lasting two to three days, in 1978, 1979, and 1981. In these surveys, more than one half of the total villagers was included (4,7). "Population laboratories" were defined in Santa María Cauqué (5) and in Puriscal (6), for prospective observation of mother/infant dyads, each lasting approximately 10 years. Study periods were 1965 through 1984 for Cauqué, and 1978 through 1988 for Puriscal. (The Puriscal study still continues). Personnel used standard techniques and methods were kept uniform throughout the studies, to minimize variation in data quality.

Table 1
Features of traditional, transitional and modern societies

	Traditional	Transitional	Modern
Fertility	high	high or declining	low
Childbirth: place position	at home squatting	at home, in clinics lying-in	in clinics lying-in
% Low birth weight	< 15	8-15	< 8
breast-feeding	universal	declining*	low or none*
Infant mortality	high	high or declining	low
Rate of diarrhea: 0-5 months 6-11 months	low high	high or declining high or declining	very low very low
Malnutrition type	kwashiorkor, marasmus	marasmus	uncommon

* Rising in many traditional and modern societies

3. BREAST-FEEDING AND NUTRITION OF CHILDREN FROM A SYLVAN SOCIETY: LIMONCITO AND ABROJO

Good maternal and child nutrition was apparent to experienced field workers visiting these Guaymi Indian settlements. Paradoxically, the diet was definitely poor, monotonous, and low in animal proteins and fats (8,9). On the other hand, the prevalence of intestinal helminths was very low (10), and rotaviruses and Cryptosporidium were not detected when more than one half of the people were examined (10,11). Small outbreaks of flu, hepatitis and diarrhea coincided with visits by outsiders or returning residents. Except for scabies, fleas, head lice and the pathology due to accidents, aging and so forth, there was no constant level of complaint or morbidity in this deprived isolated population (8,9).

Breast-feeding, Infections and Infant Outcomes

The frequency of low birth weight among the Guaymi of Costa Rica is unknown. Infants are exclusively breast-fed for the first five or six months of life, and are weaned after 18 months or longer (8,9). Infant mortality attributed to congenital defects, respiratory distress, injuries and other serious pathology is presumed high, in view of absent or scarce medical services resulting from their marked isolation.

Stunting begins during weaning, and is very evident in children and adolescents. However, people are strong and stocky, including women in reproductive age (9). Stunting results from nutritional adaptation (12), and in the case of the Guaymi is not accompanied by wasting, probably due to the relative absence of infectious diseases (8,9). Weight for height ratios were obtained (there were no complete records of birth dates to calculate weight for age), revealing that most preschool children in the village were well nourished (Figure 1). Thus, the progressive "physiologic stunting" observed (9) results from nutrient deprivation due to limited food availability. No moderate or severe malnutrition was found among children, adolescents or adults in those three surveys (4,9).

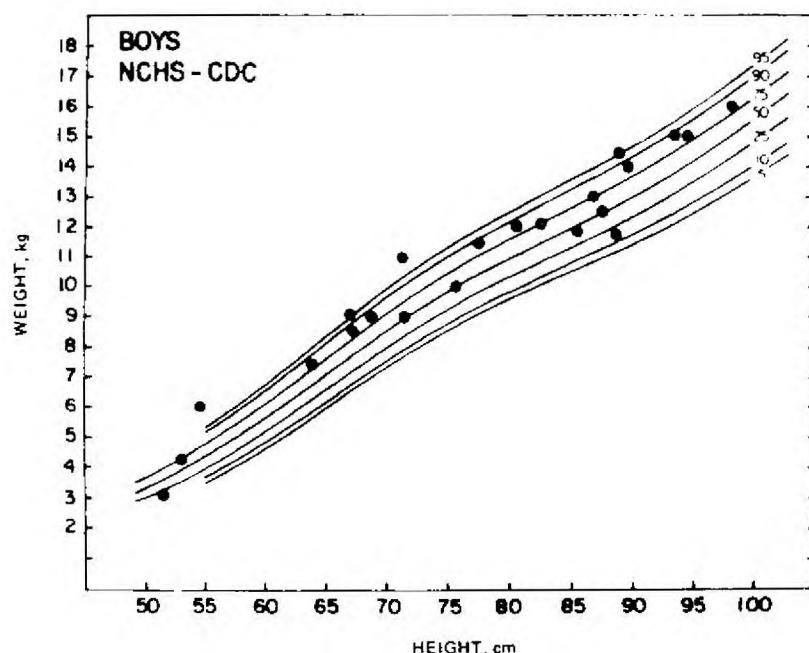


Figure 1 Weight for height (length) of 22 Guaymi preschool boys of Limoncito, Costa Rica, who virtually consisted in the universe of children at that age. All but one had adequate Wt/Ht, at least two were overweight, and most were above the 50 percentile of the NCHS curve. All girls had adequate Wt/Ht ratios also.

4. BREAST-FEEDING, INFECTION AND GROWTH OF CHILDREN FROM A TRADITIONAL SOCIETY: CAUQUÉ

Most contemporary Amerindians do not live like the Guaymi; they dwell in crowded cities, towns and villages in highlands and costal zones or scattered throughout plains, valleys and sierras. The study of one typical village, Santa María Cauqué, revealed that childbirth occurs in the home in the traditional manner, and is followed by universal mother-bonding and breast-feeding (5). Mature milk from a lactating friend or relative is available to the baby within minutes of birth and until mother's milk becomes available. Neonates who survive the first two days of life, breast-feed successfully, even if they were pre-term or had intrauterine growth retardation (5). Mothers carry their babies at all times in the back or side and sleep with them, favoring ad libitum milk intake. Exclusive breast-feeding for four to six or seven months is customary, but small amounts of sweetened fluids, rice water or herbal infusions are irregularly given during the first few days of life; weaning is started sometimes after three months of age (5). These fluids may carry pathogenic infectious agents, as even colostrum and milk of village women contain high numbers of enteric bacteria (13). Moreover, most infants are soiled by maternal feces and perineal fluids during natural birth (5). These events explain the presence of enteroviruses, pathogenic bacteria and cysts of protozoa in meconium and feces passed in the first days of life (5). However, village neonates are usually symptomless and free from diarrhea and impetigo, probably due to protection conferred by milk. Indeed, secretory immunoglobulin A (s-IgA) is found in high levels in colostrum and milk of Cauqué women, persisting throughout lactation (14) although this immunity may not be enough to counteract heavy bacterial loads found, for instance, in village weaning foods (15). Thus, few infections are found in breast-fed infants of those spread by person-to-person contact (enteric bacteria and respiratory viruses), or by the fecal-oral and water-born routes (enteroviruses and intestinal protozoa). As weaning begins, usually in the second semester of life, a greater exposure to infection leads to development of a changing and persistent flora and fauna of intestinal pathogens (5,6,16-18).

Few episodes of infectious disease occur during exclusive breast-feeding, but morbidity rises when weaning begins, to reach the high test level in the second year of life. Overall, the mean number of episodes per child per year, in the first three years of life, was around 8 of diarrhea, and a similar number of vomiting/anorexia and respiratory infection (Table 2) (17,18). Similar rates have been found in other regions of the world (19-21), all in marked excess of morbidity of children in industrial nations (22,23).

The weight and length curves of breast-fed infants during the first three to six months of life, in Cauqué or other traditional societies, follow the growth tracks of curves of National Center for Health Statistics, NCHS (24). Thereafter, growth velocity diminishes, leading to significant growth retardation in the second year of life (5,16-18,25). While there is some catch-up growth, deficits persist throughout childhood (Figure 2) (5). This phenomenon seems to be universal to less developed and industrial societies (26). In fact, many or most adults in traditional and transitional societies are stunted. Growth deficits are greater in infants who experienced intrauterine growth retardation, or were born prematurely (see Figure 2) (5,17,18,25).

Table 2
Infectious morbidity rates in Cauqué and Puriscal infants

Age, months	Number of infants	Person- months	Enteric	Respiratory
Cauqué, 1964-1969 (5):				
0-5	45	270	33.3	15.9
0-11	45	270	63.0	23.0
Puriscal, 1979-1989 (6):				
0-5	115	690	4.2	5.5
6-11	114	684	7.5	7.7

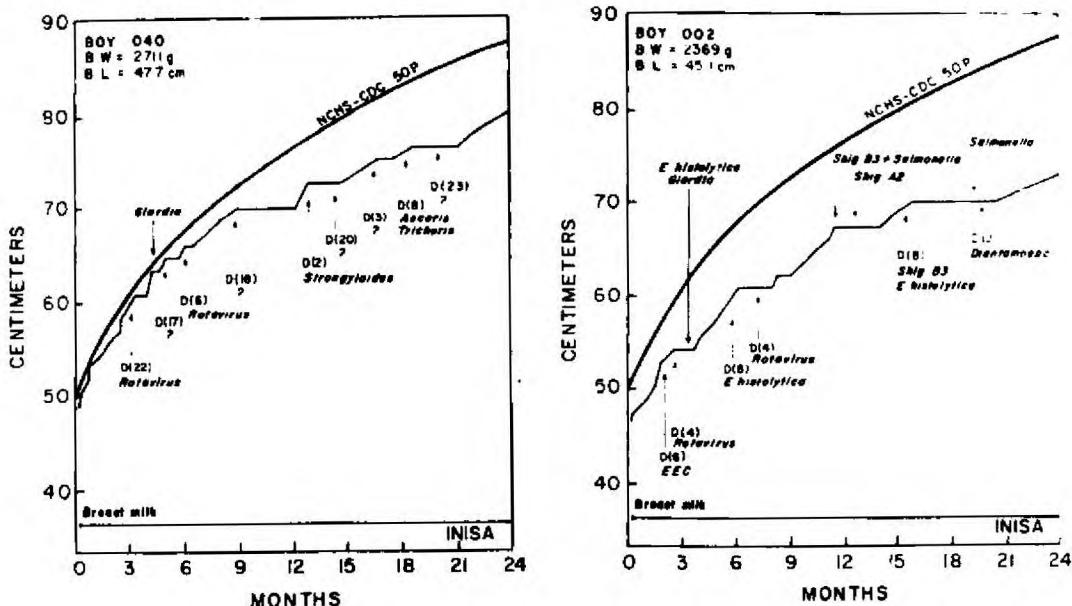


Figure 2 Body length curves of two Cauqué boys in the first two years of life. The boy at left had adequate birth weight (B.W.) and birth length (B.L.). Periods of growth arrest were found associated with specific and non-specific diarrheas. The boy at right was born with low birth weight and short body length. Again, diarrhea was associated with growth arrest, but of greater magnitude than in the previous child. The cumulative nutritional effect results in marked growth retardation at an early age.

Infectious diseases have a marked negative effect on child growth (5,16,17,18,25,27,28). Diarrheal disease was found to be the most important cause of anorexia and diminished food intake in Cauqué (30-31) and other communities (31,32), as well as the main cause of weight loss (5,16,17,25,27-30). The cumulative effect of infectious events on growth, seems to account for the endemic wastage and stunting in traditional societies (5,25,34), more than claimed deficiencies in local village diets. Although often local weaning foods may not satisfy calorie and protein needs, in general they are not limiting when the child is healthy (3), or when deficits are viewed as a function of the child current weight (29, 30): the nutritional value of breast milk during prolonged breast-feeding should not be underestimated (34). Cauqué children remain at the breast for 18 to 30 months or longer (5). The valuable nutritional contribution of small amounts of human milk can not be denied, but children may waste at the breast if adequate and safe food supplements are not introduced at the proper time, for instance, around 6 months of age. (It can be postulated that the high rates of diarrheal disease in traditional societies result from contaminated weaning foods; the complex "weaning food-diarrhea" then led to prolongation of non-supplemented breast-feeding throughout the world in time immemorial). Prolonged breast-feeding has been fundamental for survival of children who otherwise would have died prematurely of infection and acute malnutrition. The toll, however, has been high in terms of wastage, stunting and other sequelae.

5. BREASTFEEDING, INFECTION AND CHILD GROWTH OF CHILDREN IN A TRANSITIONAL SOCIETY: PURISCAL

The transition from a traditional to a modern society consists in modification of social, economic and biologic behaviors which affects the work of the mother, natural birth, mother/infant bonding, breast-feeding and child support and care. Such changes trigger certain "social pathology", like failure to care and breast-feed the baby, and child neglect, abuse and abandonment (1,35,36). Overt societal alterations are more evident in deprived urban settlements, but they also occur among affluent city dwellers and poor rural people alike. During the 1950's and 1960's, Costa Rica experienced a drastic decline in breast-feeding, coincidental with "urbanization" of rural families, enrollment of women in labor, modernity of women, and mother-infant separation and bottle feeding in the maternity. There was a collateral marked increase in cesarean sections, anesthesia and other interventions known to be deleterious to breast-feeding (1,35,36). In the late 1970's, this country had the lowest rate of infants starting breast-feeding in Latin America (37). About one fourth did not breast-feed at all, and of those who did, about one half were at the breast by six months of age (38,39).

Studies on growth and development and their possible determinants began in Puriscal in 1979, and still continue (6,38,39). Puriscal is a region with small rural communities consisting of dwellings with varying degree of scattering ("rural concentrated" and "rural disperse"). Cohorts of mothers from Puriscal delivered at the Hospital San Juan de Dios and were observed prospectively (6) in a similar fashion as in Cauqué (5). Marked differences in environment and host were obvious, however, between Cauqué and Puriscal (Table 3). Also studies on enteric infection were not as detailed as in Cauqué, except for rotaviruses (40) and Cryptosporidium (41), agents either not recognized or not considered important for humans at the time of the

Cauqué study. Due to significant advances in health and social development in Puriscal, most deliveries are in hospital or clinics. Unfortunately, analgesia, cesarean section and episiotomy, known to interfere with initiation of breast-feeding, were frequently recorded (6). These deleterious factors were partially neutralized by several hospital interventions started in 1977, aimed at promoting infant nutrition and health (Table 4) (38,39). Rooming-in, promotion of breast-feeding, promotion of mother-infant interaction, and feeding of pooled human colostrum and milk to "high risk" neonates (low birth weight, congenital defects, sepsis, respiratory distress) were implemented within a one year period (38,39). A marked decrease in early neonatal (first 7 days of life) morbidity and mortality attributed to infections, was recorded shortly after the onset of interventions. Comparison with rates of early morbidity and mortality in the pre-intervention period showed a marked decline in diarrhea, sepsis, bronchopneumonia and meningitis (Figures 3 and 4). The decrease in infectious pathology appears related to immunity from colostrum and milk; in fact, there was no significant change in rates of non-infectious diseases, pre-term or immature neonates during the observation period. Low infectious morbidity rates persisted to date, despite relaxation of aseptic technique as a result of overconfidence of hospital staff. Deaths due to diarrhea and necrotizing enterocolitis were not recorded again after interventions had been in effect for one year. No detectable improvement in maternal health, obstetric practice, fetal growth, or medical care of the neonate were noted during the observation period. Severe economic recession began in 1980 and continued for about 7 years, affecting hospital budget and the quality of care. There has not been increases in the number of neonatologists or other health personnel during the period of declining infectious morbidity. Concomitantly, there has been a significant decrease in early neonatal abandonment, even of those babies born with defects or illness (38, 39). The phenomenon is attributed to improved mother-infant bonding (35,36) in the hospital; deterioration of the program was recorded twice in periods of budgetary or managerial difficulty.

The interventions described were rapidly replicated, with local variations, in other hospitals around the country (42). Within two years, about 95% of the neonates in Costa Rica were sucking colostrum from their mothers, and the "high risk" neonates received pooled colostrum and milk from volunteer donors. At present, only one major hospital has not properly effected the interventions; deficient data collection has not permitted demonstration of changes in morbidity during the observation period in that hospital. News of the possible transmission of the human immunodeficiency virus (HIV) through breast-feeding, affected operation of most milk banks in the country during 1987 and 1988; fear among the staff and a decline in donors resulted in the closing of some of them. Feeding mother's milk to her own infant, along with detection of women with overt risk of HIV infection, are currently emphasized.

With the interventions, most infants have been put at the breast immediately or within a few hours after birth, and most have been nursed for at least one month (Figure 5). Although introduction of supplements was customarily made in the first month of life in many instances, from 50 to 70 percent breast-fed for at least 6 months. The sharp increase in incidence and duration of breast-feeding in Puriscal with regard to preintervention levels - an increase which also took place in the whole nation - has persisted with no significant differences observed in prevalence of exclusive and supplemented breast-feeding, nor in duration of breast-feeding, among consecutive cohorts (Figure 5). Deficits in breast-feeding can be traced to iatrogenic

practice, for instance, cesarean section, a strong negative correlate with incidence and duration of breast-feeding (6).

Table 3
Environment and host characteristics in Cauqué and Puriscal

Characteristic	Cauqué 1964 - 1971	Puriscal 1979 - 1986
Altitude, meters	1,800	1,400 to 100
Population	1,500	24,000
Ethnicity	Amerindian	mainly Mestizo
Setting, crowding	rural, crowded	rural, sparse
Percent literate	56	85
Percent use latrine, toilet	32	95
Percent with piped water	7	84
Percent women with <u>Ascaris</u>	83	5
Percent women with <u>Shigella</u>	9	< 1
Percent women with bacteriuria	27	6
Mean birth weight, g	2,549	3,131
Percent with low birth weight	42	8
Percent born with < 37 wk (PT)*	7.5	3.7
Percent born TSGA*	33.8	3.9
Ratio TSGA:PT	4.5	1.05
Infant Mortality/100 live births	80	12
Percent deaths due to low birth weight	70.7	72.7
Percent with measles vaccine	0	90
Percent with oral polio vaccine	0	95
Percent newborns with <u>Shigella</u>	3.6	0
Human milk intake, ml, 1-3 months	674	640
Energy intake, kcal, 6 months	400	461
Protein intake, g, 6 months	7	5.8

*PT = pre-term; TSGA = term small for gestational age

Table 4
Interventions in the maternity of the hospital San Juan de Dios,
Costa Rica

Onset and duration	Description
<u>Pre-intervention period:</u>	
A. 1969 to mid 1977	- Separation of dyad; formula feeding
<u>Interventions:</u>	
B. mid 1977 *	- Rooming-in **; promotion of breast-feeding
C. mid 1978 *	- B plus colostrum feeding
D. mid 1979 *	- C plus mother/infant interaction
1987 *	- Complete rooming-in

* to the present time; ** only during the day

Attitudes towards breast-feeding markedly changed with the interventions. A relaxed atmosphere of happy mothers nursing and caring for their babies was typical of the post-partum ward, soon after rooming-in and promotion of breast-feeding were started (38, 39). This condition contrasted with the stressed and unhappy mothers in the pre-intervention period. Furthermore, in Puriscal, women started breast-feeding in the presence of visitors without shame. These cultural changes were noted within months of commencement of interventions, and have persisted ever since.

Child growth in Puriscal has been adequate during the study period, despite the prevailing poverty and deprivation in many homes, which, nevertheless, is considerably less than that

observed among the Amerindians. The mean growth curves (weight and length) of infants follow the NCHS curves (43,44). Most infants tend to follow growth tracks defined by birth weight or fetal maturity (Figure 6). This favorable situation is due, in part, to good personal hygiene and sanitation in the region, and in part, to introduction of weaning foods at the appropriate age. However, there were not marked differences between Puriscal and Cauqué regarding nutrient intake (see Table 3), and the dominant differential seem to be the infectious environment and the morbidity rates which are excessively large in Cauqué. The more favorable condition of Puriscal infants makes it difficult to demonstrate a clear effect of breast-feeding on growth.

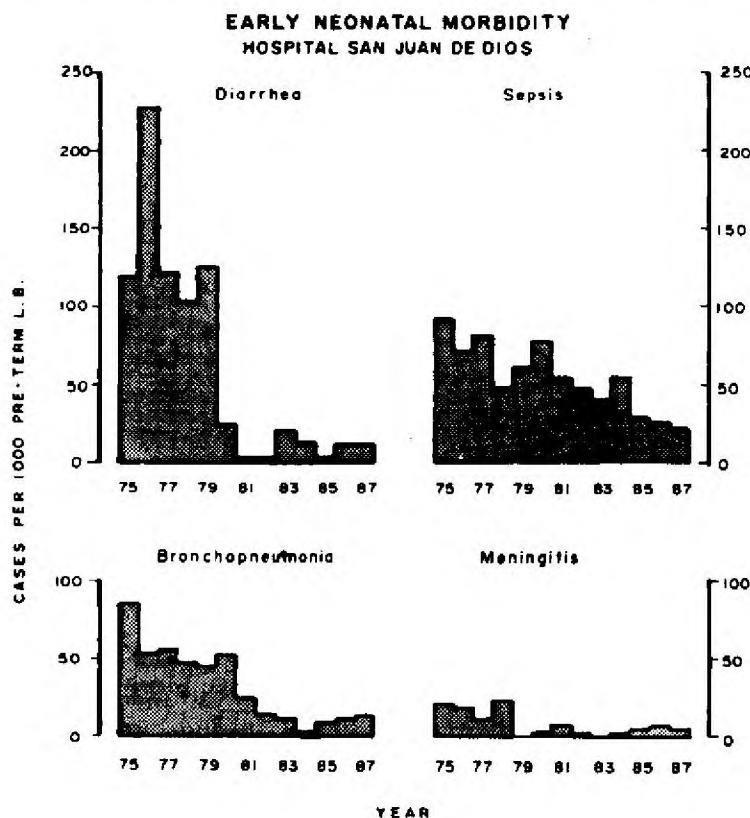


Figure 3 Early neonatal (first 7 days of life) infections morbidity, expressed as cases per 1000 neonates with less than 38 weeks of gestational age, San Juan de Dios Hospital, 1975-1987. In 1975 and through September 1977, neonates were separated from mothers at delivery, and were bottle fed until discharge. Rooming-in started in September 1977 and was followed by promotion of breast-feeding, feeding pooled human colostrum and milk to "high risk" neonates, and mother/infant stimulation of pre-term or ill infants. A marked decline in diarrhea and other infectious processes was noted shortly after implementation of hospital interventions.

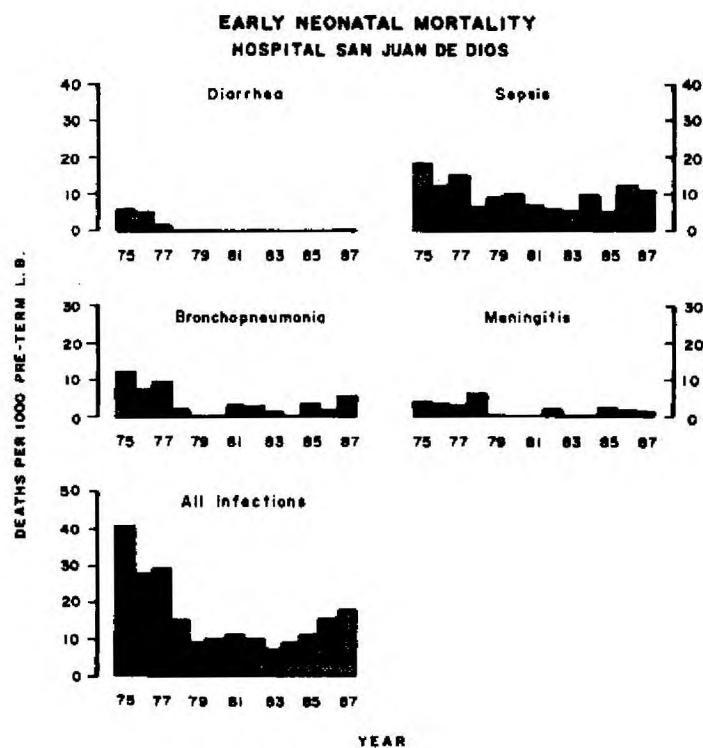


Figure 4 Early neonatal mortality attributed to infection, expressed as deaths per 1000 neonates with less than 38 weeks of gestational age, San Juan de Dios Hospital, 1975-1987. As indicated above, interventions to promote breast-feeding started in September 1977. No deaths due to diarrhea have been recorded since 1978; infectious diseases have decreased significantly during the observation period.

Even though, Puriscal breast-fed infants (with low and adequate birth weight) grew better than those who were not breast-fed (Figures 7 and 8). When a particular Puriscal child exhibited growth faltering or failure to thrive, more often than not the explanation was repeated infections, resulting in life histories similar to those of Cauqué children (Figure 9).

6. COMMENTS

The health promoting attributes and protective effect of breast-feeding against infection have been documented in studies in traditional and industrial societies. Community and laboratory studies demonstrated the protective effect of human colostrum and milk against infection (1, 5, 45-50). Colostrum and milk have antibodies against many pathogenic agents (46-47), Giardia (51), bacterial enterotoxin (52, 53) and rotaviruses (52, 54).

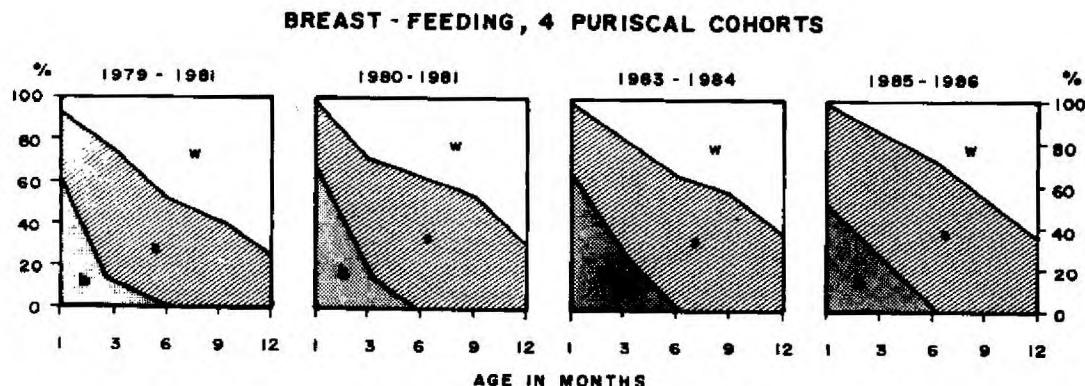


Figure 5 Incidence and duration of breast-feeding among four cohorts of Puriscal infants observed for one year, showing that they have been consistent throughout the study. The overall percentage of weaned children was lower in the 4th cohort (1985-86) than in the 1st (1979-80).

Non antibody factors have been found in human milk with capacity to block adherence of respiratory bacteria to mucosal surfaces (55). The existence of an "anti-inflammatory" role of human milk is likely, in view of its limited paucity of inflammatory factors and high levels of anti-inflammatory principles (56). Cells with blastic transformation capacity can be found in colostrum, after being primed in the intestinal wall following maternal exposure to antigens (57), an incredible mechanism of future potential in child immunization. Furthermore, the mechanical act of breast-feeding blocks many opportunities for exposure of the infant's mouth to pathogenic agents (58).

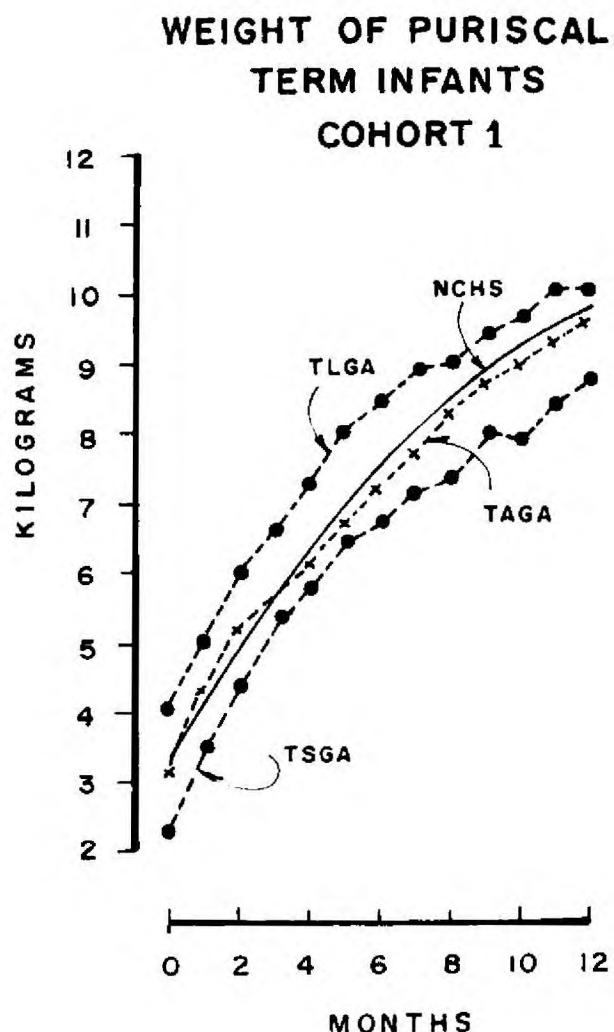


Figure 6 Mean weight curves of three sub-cohorts of Puriscal term infants defined by fetal maturity, in comparison with the 50th percentile of the NCHS curves, in the first year of life. There is trend to depart slightly from the reference at the end of the first year of life, especially for the term-small for gestational age infants.

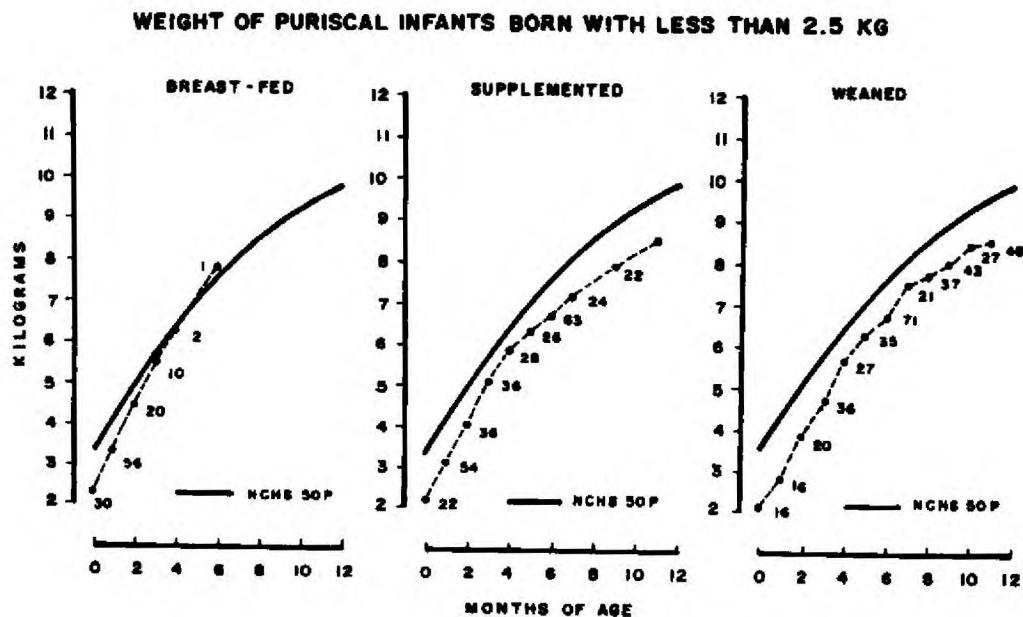


Figure 7 Mean weight curves of three sub-cohorts of Puriscal infants born with less than 2.5 kilograms, defined by type of feeding, in comparison with the NCHS curve, in the first year of life. (Figure in curves indicate number of children measured each time). Low birth weight breast-fed infants grew better than supplemented or weaned infants during the first semester of life.

Breast milk is rich in nutrients, electrolytes and water (1). Exclusively breast-fed infants living in hot and humid climates do not seem to require additional water (59). Human milk can correct mild and moderate states of dehydration (5), an attribute that protects against water-borne infections. The beneficial effect of breast-feeding and human milk is more evident for infants exposed to high doses of infectious agents, who also benefit more from prolonged breast-feeding, as opposed to those infants who are less exposed to infection. Breast-feeding favors optimal growth of infants during the first 4 to 8 months of life, in poor or advanced communities

alike (4,5,6,60-61). Breast-fed infants grow better than weaned infants, regardless of fetal immaturity or low birth weight (5). Furthermore, heavily contaminated environments do not seem to affect the growth rate of breast-fed infants during the first semester of life (5). Obviously, exclusively breast-fed infants perform better in traditional societies where pathogenic agents are relatively absent, as in the case of the Guaymi (4) or the Australian aborigines (62), who thrived under extreme poverty and limited food supply. Acculturation brings about exposure of traditional societies to pathogens and to unhealthy "western diets". Such negative influence does not necessarily run parallel to improved hygiene and alimentation. The Australian aborigines have experienced a progressive deterioration of their nutrition and quality of life of older children and adults.

WEIGHT OF PURISCAL INFANTS BORN WITH 2.5 - 2.9 KG

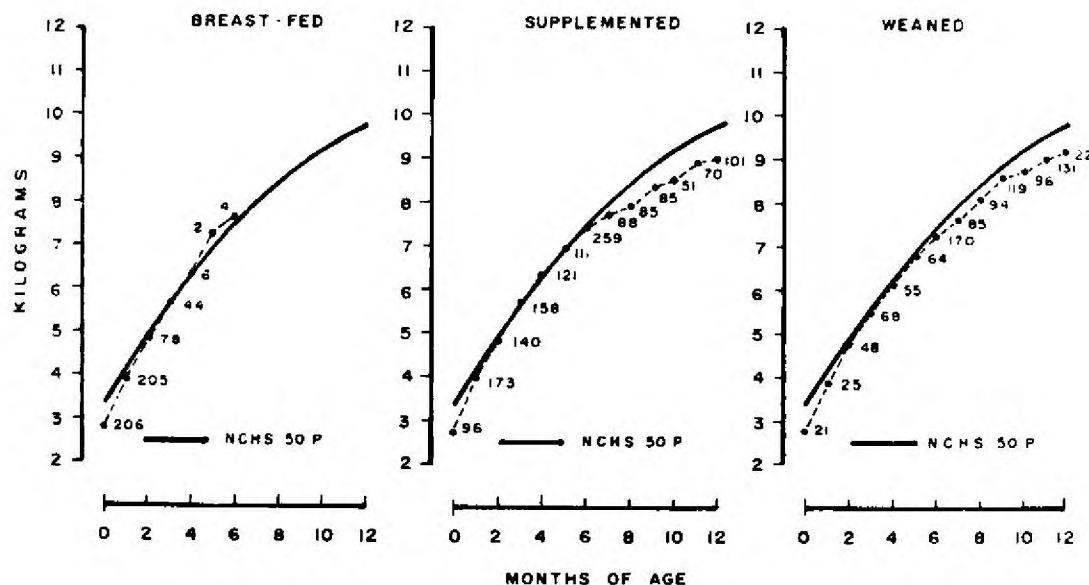


Figure 8 Mean weight curves of three sub-cohorts of Puriscal infants born with 2.5 to 2.9 kilograms (defined by type of feeding) in comparison with the NCHS reference curve, in the first year of life. (Figures in curves indicate number of children measured each time). Small breast-fed infants grew better than supplemented or weaned infants during the first semester of life. Growth seems to falter in the second semester of life.

The Guaymi also have increased their intake of refined sugar, cow's milk, canned food, alcohol and prescription drugs during the course of the present studies (8,9). In transitional societies, where infections have been significantly controlled, breast-fed infants follow the NCHS curves

beyond the first 6 months of life and for as long as two years (43, 60), more closely than weaned infants, indicating that the improvement in the environment is also a *sine qua non* for enhancing child growth.

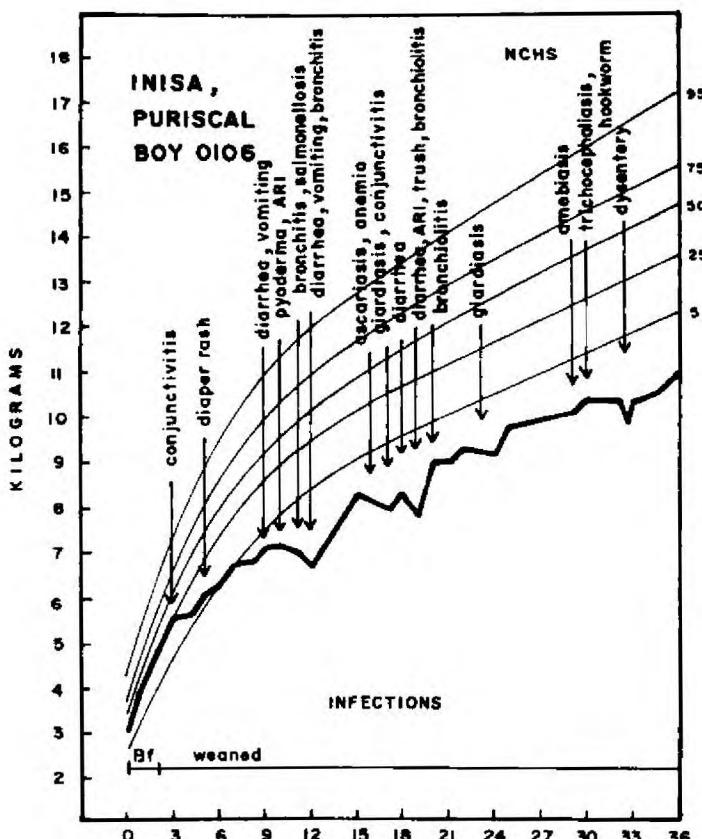


Figure 9 Weight curve and infectious diseases of a Puriscal boy during the first three years of life. Shortly after premature weaning, the child started suffering from episodes of infectious diseases, most of which were associated with weight faltering and weight loss. The child, born with adequate fetal maturity, became definitely malnourished by 9 months of age and was markedly wasted and stunted at age three years.

Human milk contains the nutrients required for optimal growth, development and function. It also has other homeostatic capacities, for instance, in regulation of protein synthesis,

muscle and fat deposit, all determinants of growth. These functions seem mediated by hormones, which might explain the optimal maturation, better nutrient utilization and enhanced resistance to allergens of breast-fed as compared to non-breast-fed infants (1). Infants with low birth weight, prematurity or intrauterine growth retardation, grow well if they are breast-fed (1,5,43). However, exclusively breast-fed infants may grow at a slower rate than supplemented infants in Costa Rica (this work) or in Australia (61). The NCHS curves might not reflect optimal growth, since they derived from a population exposed to an excess of dietary calories. Growth rates of term-adequate-for gestational age (TAGA) infants of Puriscal, follow quite closely the 50th percentile of the NCHS curves during most of the first year of life.

Finally, breast-feeding is an important determinant of child survival, especially in developing countries (45,49, 64-67). The comparison of performance in contrasting ecosystems like Cauqué and Puriscal, show that public health actions should be considered along the promotion of breast-feeding, especially those which aim at the control and prevention of infection (5, 25, 68-70). The Cauqué and Puriscal studies showed that breast-feeding is one of the most important determinants of child health, growth and survival in infancy - especially in the first semester of life. At the same time, those studies revealed that infection is the single most important negative factor of child health and survival in traditional and transitional societies. Consequently, any desired improvement in the health profile of a given country will depend on the control of infection, and this represents investing in environmental sanitation, personal hygiene and primary health care. It has been claimed that such a goal is difficult to attain by the less developed countries. Costa Rica, Chile, Panama, Kerala (India) Sri Lanka and other nations, however, have accomplished much by investing more in social than in economic development, favoring the approach of intersectoral action (71-74)

7. ACKNOWLEDGMENTS

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