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PUBLIC HEALTH IMPLICATIONS OF LOW BIRTH WEIGHT*

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SUMMARY

The present paper interpets the significance of anthropometric data of newborns from a typical Indian village of Guatemala and from the general population of Costa Rica. A good correlation exists between a deficient fetal growth and infant mortality and retarded physical growth. The significance of fetal growth retardation on early and late anomalies and defects is discussed.

The existing information reveals a high incidence of neonates with altered fetal growth and development in Latin America. This circumstance is the main factor associated with the high infant mortality and retarded development observed in many populations of the Subcontinent.

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Certain countries have attained a substantial improvement in the conditions affecting fetal growth, by implementing comprehensive health and development programs with a holistic approach. The interventions that need to be strengthened in order to improve fetal development in our nations are reviewed.

I. INTRODUCTION

Knowledge of the incidence and causality of low birth weight is of singular importance for the formulation of health policies and programs, especially when interventions of great coverage and extension are planned. This condition is particularly true for the developing countries, since in them, fetal growth retardation and premature delivery occur with greater frequency than in the industrialized countries.

As was to be expected, practically no information is available on fetal growth in the developing countries, especially for suburban and rural populations. In general, the existing information is deficient in quality and not representative of the total population. Even in the case of urban areas, information is also scarce and not representative.

These considerations explain why sufficient importance is not given to low birth weight as a health problem in developing countries.

II. STUDY MATERIAL

To illustrate the implications of low birth weight on health, data derived from a prospective study (The Cauqué Study) of a rural community of Guatemala will be employed,[1-3] as well as data from the Instituto Materno-Infantil CARIT (Mother and Child Health Institute CARIT) and from the General Direction of Statistics and Census, both in Costa Rica.[4, 5] The rural community of Guatemala is located at an altitude of 2,000 m above sea level and bolongs to the lingüistic Maya-Cakchiquel group. During the 1964-1973 period careful information was collected for practically the totality of newborn cohorts; these were observed in a prospective form. As a whole, the population consisted of 430 liveborn infants who represented more than 95% of the total births. Among many other determinations,[3] studies included measuring in a prospective way the weight and height, and survival of all the children.

The Costa Rica data correspond to a random sample of 10% of all liveborns in certain years at the CARIT Institute. The study period comprised from 1965 to 1974. During these years, this hospital center provided medical attention to a population representative of all social sectors of the country, including the rural population. Information on infant mortality and birth rate in Costa Rica corresponds to the total population of the country in the stated period.

III. LOW BIRTH WEIGHT IN THE DEVELOPING COUNTRIES

Available information in Latin America reveals a serious fetal growth problem.[6-8] For example, the mean birth weight in the Guatemalan village (Table 1),[9] is one of the lowest registered in the literature and is significantly under that observed in industrialized populations located at similar altitudes than those of the Guatemalan highlands,[10] as well as of Indian groups with better economic situation.[11] Furthermore, the fact that the anthropometric characteristics of the newborn in the Indian village studied did not appear to change during the 10-year period of observation, is suggestive that the factors which determine a deficient fetal growth remained constant during such period.

TABLE 1

WEIGHT OF LIVE NEWBORN COHORTS, SANTA MARIA CAUQUE, GUATEMALA

Year	No. of children	Weight, g Average ± D.E.	% < 2,501 g
1964	37	2,595 ± 360	35
1966	46	2,506 ± 321	46
1968	57	2,510 ± 422	44
1970	67	2,558 ± 412	36
1971	60	2,564 ± 328	48

Classification of the 415 neonates by weight at birth and by gestational age showed that 7% were pre-term and that an additional 34% were term-small-for-gestational age. The ratio "pre-term: term-small-for-gestational age" which was of 1:4.7 in the village contrasts with that observed in more developed societies, where it is generally of 2:1 (Table 2).

A high incidence of low birth weight has been described in pre-industrialized populations, including Latin America.[7, 8, 12-18] Nevertheless, truly representative data for this Region do not exist, particularly in what concerns rural areas; in addition there is no information on fetal maturity due to the difficulties inherent to the collection of information on gestational age.

TABLE 2

FETAL MATURITY OF 415 NEONATES, SANTA MARIA CAUQUE, 1964-1972

Classification	No. %	Birth weight, g	Gestational age, weeks
Term	43 (10.3)	> 3,000	37 – 42
	199 (47.8)	2,501–3,000	37 – 42
	143 (34.4)	< 2,501	37 – 42
Pre-term	6 (1.4)	2,001–2,500	35 – 37
	24 (5.8)	< 2,001	31 – 36

IV. CORRELATION OF LOW BIRTH WEIGHT WITH MORTALITY

The influence of low birth weight and fetal immaturity on the neonatal mortality has been amply demonstrated.[19-23] In the Cauqué Study the correlation between birth weight and infant mortality (Table 3) was so marked as to characterize said variable as the best predictive survival index in similar rural populations. Actually, the indicator is closely correlated with gestational age (Table 4) which also showed a strong association with survival. A birth weight of at least 2,750 g and a gestational age of more than 36 weeks was associated with absolute survival during the neonatal period, and with a relatively good survival during the rest of the first year of life. It must be taken into account that the totality of the neonates who survived the first 48 hours were adequately breast-fed for long periods of time. Definitive weaning takes place during the second or third years of life.[3] Introduction of liquid foods starts at the age of 3 to 6 months, and of solid foods, at 6 to 12 months.

The combination of both variables has been proposed by several authors[24-26] and is shown in Table 5 for the Cauqué Study. The pre-term infants constituted the group with the highest and sustained mortality during all the course of their first year of life. However, the surviving babies showed a high survival during the rest of their preschool period.

The born at-term infants but small for their gestational age (malnourished fetuses) manifested a high mortality during all of the first and second years of life, as well as a high mortality during the rest of the preschool age.

Infants born at term but weighing more than 2,500 g exhibited the lowest neonatal mortality (8 per 1,000) and a post-neonatal infant mortality also relatively low. However, many of these were vulnerable during the preschool years, resulting in a high age-specific mortality in each one of the three preschool years.

TABLE 3

INFANT MORTALITY AND BIRTH WEIGHT, SANTA MARIA CAUQUE, GUATEMALA, 1964-1973

Birth weight, g	No. of children	Age			< 1 year
		< 29 days	29 days-5 months	6-11 months	
< 1,501	5	3 (600)*	1 (200)	0	4 (800)
1,501–1,750	11	2 (182)	3 (273)	1 (91)	6 (545)
1,751–2,000	17	4 (235)	4 (235)	1 (59)	9 (529)
2,001–2,250	47	2 (43)	2 (43)	2 (43)	6 (128)
2,251–2,500	99	3 (30)	0	1 (10)	4 (40)
2,501–2,750	125	2 (16)	3 (24)	2 (16)	7 (56)
2,751–3,000	82	0	2 (24)	2 (24)	4 (49)
3,001–3,250	32	0	0	0	0
3,251–3,500	11	0	0	1 (91)	1 (91)
≤ 3,501	1	0	0	0	0
Total	430	16 (37)	15 (35)	10 (23)	41 (95)

* Figures in parentheses represent deaths and mortality per 1,000 liveborns of said weight.

TABLE 4

INFANT MORTALITY AND GESTATIONAL AGE, SANTA MARIA CAUQUE, GUATEMALA, 1964-1973

Gestational age, weeks	No. of children	Age			
		< 29 days	29 days-5 months	6-11 months	< 1 year
31–32	3	2 (667)*	0	0	2 (667)
33–34	8	3 (375)	3 (375)	0	6 (750)
35–36	20	5 (250)	1 (50)	2 (100)	8 (400)
37–38	47	0	2 (43)	0	2 (43)
39–40	261	6 (23)	7 (27)	8 (31)	21 (80)
41–42	77	0	1 (13)	0	1 (13)
Total	416	16 (38)	14 (34)	10 (24)	40 (96)

* Figures in parentheses represent deaths and mortality per 1,000 livebirths of said gestational age.

TABLE 5

MORTALITY BY FETAL MATURITY, 416 COHORT CHILDREN, SANTA MARIA CAUQUE, GUATEMALA, 1964-1972

Classification	1st year			2nd year	3rd year	4th year
	< 29 days	29 days-11 months	< 1st year			
Pre-term > 37 g	10(323)*	6(286)	16(516)	0	0	0
	31	21	31	15	15	8
Term < 2,501 g	4(28)	8(58)	12(84)	8(76)	3(39)	3(50)
	143	139	143	105	78	60
Term > 2,500 g	2(8)	10(42)	12(50)	9(44)	5(33)	1(8)
	242	240	242	204	153	122
Total	16(39)	24(60)	40(96)	17(52)	8(33)	4(21)
	416	400	416	324	244	190

* Figures in parentheses represent deaths and mortality per 1,000 livebirths at the initiation of the period. The underlined figures under mortality rate indicate number of children in cohort at initiation of period.

The importance of an adequate fetal development to avoid neonatal deaths is obvious when this is compared with infant mortality in two contrasting populations: one of them, the Indian village, and the other a population of the East Coast of the United States of America (Table 6).[27] No differences are noted in neonatal mortality between the Indian community and the North American population if one takes into account the weight category at birth. Consequently, the high neonatal mortality rates observed in the Indian community and in the developing societies are in great measure due to the higher incidence of low birth weight. Rates higher than those observed in the Cauqué Study may be due to the joint action of a deficient diet (particularly during early weaning) and infections.[3, 27-29]

TABLE 6

COMPARISON OF INFANT MORTALITY OF TWO POPULATIONS, BY WEIGHT AT BIRTH

Birth weight, g	Neonatal			Postneonatal			Infantile		
	S.M.C.*	B.	R.**	S.M.C.	B.	R.	S.M.C.	B.	R.
1501–2000	273	210	1.3	303	26	11.7	576	199	2.9
2001–2500	34	45	0.8	34	13	2.6	68	54	1.3
2501–3000	10	10	1.0	43	7	6.1	53	17	3.1
3001–3500	0	5		23	5	4.6	23	10	2.3

* S.M.C. = Santa María Cauqué, Guatemala; B. = Baltimore, USA.[46]

** S.M.C./B ratio.

V. RELATIONSHIP OF LOW BIRTH WEIGHT WITH PHYSICAL GROWTH

The Cauqué Study demonstrated a marked weight and height deficit of the Indian population with respect to accepted standards.[1-3] Other authors have described similar deficiencies.[7, 30, 31] The Cauqué Study also revealed that physical growth deficiencies correlated with the fetal growth.[1-3] Birth weight and gestational age, or both variables combined, showed a good correlation with physical growth of the lactating and preschool child (body weight, height and head circumference). Children with low birth weight exhibited a clear tendency to remain in the lower weight tracks (Figure 1) while those with better birth weight occupied the upper growth tracks.

Correlation with gestational age also was high, but only two populations were noted separated by the limit of 36-37 gestational weeks (Figure 2).

As was to be expected, with regards to fetal maturity, the at-term infants with a birth weight of more than 3,000 g grew better than any other group; the pre-term infants weighing less than 2,001 g grew the worst (Figure 3). However, the pre-term group of children with a birth weight greater than 2,000 g grew as well as the term children.[1]

The relation between birth weight and physical growth has been explored by other authors through retrospective and prospective analyses, who found a positive correlation between both.[32, 33] The few prospective investigations carried out in industrialized countries showed an abnormal growth on the part of pre-term and

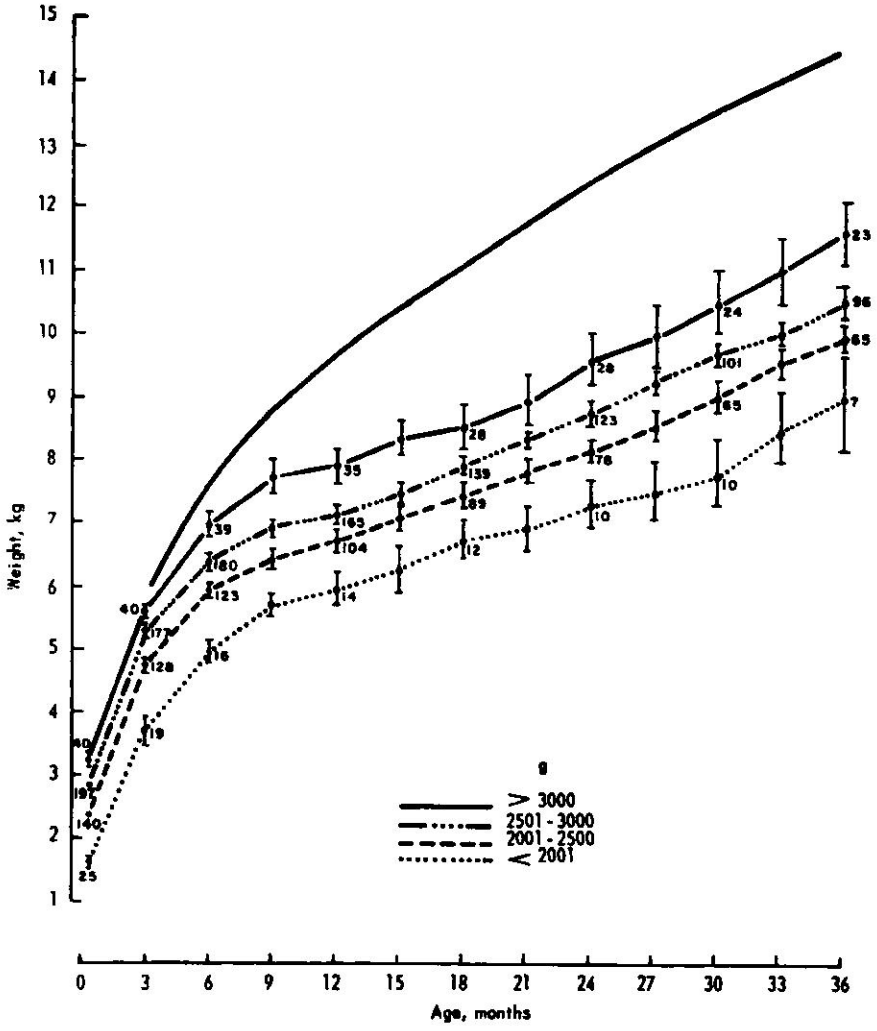

Fig. 1. *Weight curves (average ± 2 E. E.) of four cohorts of children defined by birth weight in comparison with the mean of the Iowa standard curve.*[4,7] *Prospective study, Santa María Cauqué, Guatemala, 1964-1972. Figures in curves are number of children measured.*[2]

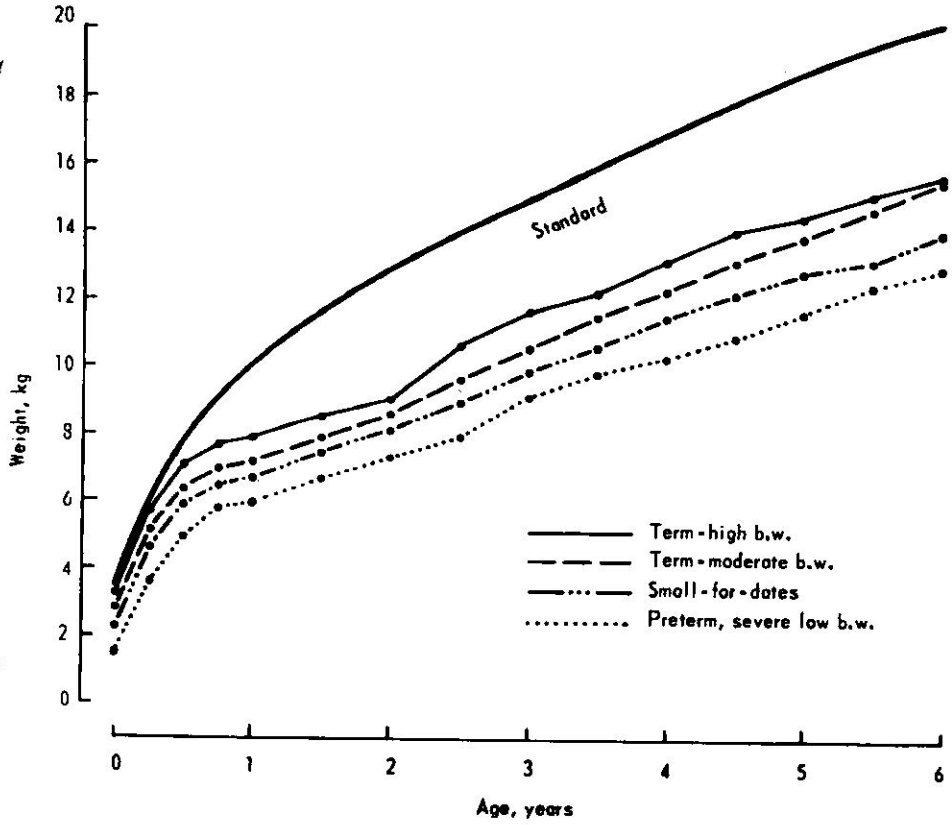

Fig. 3 *Average weight curves of four cohorts of children defined by fetal maturity at birth, in comparison with the mean of the Iowa standard curve. Prospective study, Santa María Cauqué, Guatemala, 1964-1972.*[1]

small-for-gestational age infants,[34, 35] despite the fact that the environment where these children developed was more favorable than is to be expected in develeloping countries, particularly in rural areas.

There are no similar data to those of the Cauqué Study for other developing populations, but a follow-up of Nigerian and Gambian infants showed a deficient weight gain in those with low birth weight.[36, 37]

The correlations between fetal growth and postnatal growth do not imply that the total variability depends mainly from intrauterine growth. Nevertheless, in view of the fact that the observed differences between cohorts defined by birth characteristics are established at an early age (usually in the first months of life), the influence of antenatal events and factors immediately associated with it acquire great importance for understanding the child's growth.

The relationship between birth weight and physical growth is of interest, because neurologic sequelae, suboptimal intelligence and low survival are problems frequently associated to deficient fetal growth and development.[38-42]

VI. OTHER SEQUELAE OF LOW BIRTH WEIGHT

Immediate and late morbidity and sequelae that may result in permanent handicaps are counted among the serious consequences of low birth weight. In pre-term neonates, mortality is fundamentally due to physiologic immaturity, which generates alterations in breathing, in metabolism and in neurological function, as well as in resistance to infections.

Small-for-gestational age infants generally suffer from hypoglycemia and frequently exhibit a similar pathology to that of the pre-term neonate. A chronic deficiency in the quantity and function of the T immunocyte has been described in these infants [39] which could explain their greater susceptibility to infection during infancy and preschool age, as the Cauqué Study has demonstrated.[1-3, 9, 27]

It has been described that low birth weight induces sequalae demonstrable at short and long term intervals, which constitute an important cause of defects and disability.[40-42] Among these are congenital malformations, early infantile malnutrition, infections, sudden death in infancy, alterations of the central nervous system, mental retardation and behavioral disorders.[42]

VII. CHANGES IN FETAL GROWTH AND IN NEONATAL MORTALITY

There is great expectation in learning results obtained from the holistic approach in public health to improve problems such as low birth weight. This approach appears to give excellent results judging by changes recently registered in Cuba and Costa Rica.

In 1920, infant mortality in Costa Rica was around 250 per 1,000 livebirths[5] (Table 7). At that time measures to improve the quality of life were beginning to

TABLE 7

INFANT MORTALITY PER 1,000 LIVEBIRTHS IN COSTA RICA

Year	<29 days	29 days - 11 months	Infants
120			250.0
1965	27.2	48.9	76.0
1967	24.3	38.0	62.3
1969	25.4	41.7	67.1
1970	25.2	36.3	61.5
1971	28.7	27.8	56.4
1972	22.8	31.7	54.4
1973	20.8	24.0	44.8
1974	17.7	19.8	37.6
1975	17.7	19.3	37.1

receive particular attention and the result was a progressive increase in the economic income, education and quality of the environment. In the 1950 and 1960 decades infant mortality became stable around figures of 80 per 1,000. The increment in magnitude and coverage of enrivonmental sanitation, nutrition, and medical care programs, as of 1963 ran parallel with a slow descent in infant mortality which then suffered an even more markedly decrease after 1970, coinciding with the strengthening of maternal and child health, sanitation and nutrition programs.

At that time the Rural Health Program (RHP) was implemented taking advantage of the infrastructure created for the control and prevention of malaria in the past decades. The development of the RHP was escalated since 1972, and its goal for 1978 was to cover 600,000 persons of the rural population dispersed in localities of less than 500 inhabitants. This segment represents approximately 30% of the nation's population. At present (1975) a 70% of the dispersed rural population is being covered by nurse auxiliaries and health assistants who are displaced from the Health and Post Centers by jeep, motorcycle, horse, boat or foot.[43] Their functions are to carry out census; to vaccinate (tuberculosis, measles, poliomyelitis, smallpox, diphteria, whooping cough and tetanus) to treat parasitosis (malaria and intestinal parasites), to promote maternal and child heath, to promote family planning and nutrition; to treat and refer sick persons; to collaborate in environmental sanitation programs; to give education in hygiene and nutrition, and to participate in communitary organization efforts.

Data in Table 7 reflect a marked decline in infant mortality as of 1970 when an increase in the level of life, health and development programs was recorded. The change also reflects in part a decrease in neonatal deaths, notorious after 1971 as a result of improvements achieved in the quality of the matroenvironment. Table 8 summarizes the fetal growth situation in a 10-year period at the Instituto Materno-Infantil Carit. Already in 1965 the average birth weight was relatively good and the registered frequency of low birth weight was only 11%. The situation was maintained rather stable up to 1973 when a fall in the frequency of low birth-weight babies was registered reaching a 9.4% value.

The reasons that seem to explain the decrease in neonatal and postneonatal mortality and in incidence of low birth-weight babies at that date are: a better attention of pregnant women and substantial improvement in family planning. It is quite probable that nutritional changes of secular type which improved the height of the population in a notorious form in the last years[5] also affected the incidence of low birth-weight neonates. These factors are reflected in a decrease in fetal and maternal mortality observed in previous years (Table 9) and in a decrease in mean parity, which, as illustrated in Tables 7 and 8, were parallel to the reduction in birth rates.

VII. CONTROL AND PREVENTION OF LOW BIRTH WEIGHT

Prevention of low birth weight cannot be achieved through unilateral actions oriented, for example, at control of maternal morbidity or towards the improvement of calories consumption during gestation. The diversity of etiologic factors that intervene, usually in a simultaneous way, in the causality of low birth weight, is sufficient reason for planners of health actions to apply the integral (holistic) approach to its prevention. Table 10 succintly summarizes different actions that must be implemented within a holistic approach for the prevention of low birth weight.[42]

Improvements in health and hygiene during childhood are fundamental, particularly in societies where the intergenerational effect of low maternal stature must be reduced, as this reflects a past of malnutrition.[1]

The practice of optimal reproductive patterns is crucial to diminish the incidence of low birth weight due to premature conception. Measures of this type appear to have had a notorious effect on fetal growth in countries that achieved a marked decrease in mortality in the course of a few years, such as China.[44] Antenatal care is another important factor for control and prevention of low birth weight of neonates given the high frequency of abnormalities in "high-risk" pregnant women.[42, 44, 45]

Finally, control and care of the child since early life is fundamental for diagnosis and treatment of present defects and for control and prevention of their sequelae.[42, 45]

TABLE 8

ANTHROPOMETRY OF THE NEWBORN AND PARITY, INSTITUTO MATERNO-INFANTIL CARIT, COSTA RICA, 1965-1974

	1965	1971	1972	1973	1974
Number of cases	409	506	588	551	551
Average weight ± D. E., g	3,106±516	3,090±499	3,089±489	3,071±471	3,109±455
Average height ± D. E., cm	49.7±2.6	50.9±3.0	50.7±3.6	50.2±3.2	50.8±2.7
% with <2,501 g*	11.25	11.07	11.73	9.44	9.21
Average parity	3.9	3.7	3.4	3.0	3.0

* No data for gestational age were obtained.

TABLE 9

BIRTH RATE AND FETAL AND MATERNAL MORTALITY,

COSTA RICA, 1959-1975

Year	Births per 1,000 population	Mortality per 1,000 live births	
		Maternal	Fetal
1959	48	1.26	20.9
1969	34	1.33	15.2
1973	29	0.93	12.0
1974	30	0.50	12.1
1975	29	*	*

* Pending calculation.

TABLE 10

PREVENTION OF LOW BIRTH WEIGHT AND ITS SEQUELAE

1. *Promotion of health in childhood and adolescence*

   - Achievement of good nutrition and hygiene
   - Prevention of infectious diseases
   - Health education on reproduction
   - Promotion of good mental health

2. *Practice of the optimal reproductive pattern*

   - Promotion of conception at optimal ages
   - Increment of interval between pregnancies
   - Prevention of undesired pregnancies

3. *Antenatal care*

   - Treatment and prevention of infectious diseases
   - Promotion of good nutrition and hygiene
   - Education on drugs and stressing agents
   - Identification and control of high-risk factors
   - Education on perinatal events

4. *Care of neonate and child*

   - Control of labor and parturition
   - Perinatal and neonatal care
   - Diagnosis and control of sequelae
   - Child care
   - Strengthening of infrastructure and recording systems

IX. COMMENT

It is estimated that around 20 million children are born with low birth weight in the world every year; approximately a million and a half of these correspond to Latin America. Low birth weight is the main cause of perinatal mortality and of morbidity and long-term sequelae. Consequently, the control and prevention of low birth weight must constitute one of the higher priorities for national health and development planning programs, particularly in nations that still have high infant mortality rates.

The effects of low birth weight detectable in the field are a high infant mortality (particularly neona tal) and a deficit in physical growth of infants and preschool children.

Studies in a community of the Guatemalan highlands demonstrated that if birth weight is at least 2,750 grams and the child is breast-fed during the first months of life, neonatal survival approaches 100%. The high neonatal mortality observed in underdeveloped areas is therefore due more to the greater number of low birth-weight neonates, than to environmental deficiencies. In effect, neonatal mortality figures observed in the rural community in question, adjusted for weight at birth, were not different from those of an industrial population of a much higher socioeconomic development. Such observation questions the need for creating special resources for the care of premature and fetally malnourished infants in developing countries, in excess of true demands, while it favors the recommendation of measures of preventive nature.

Experience registered in other countries suggests that the holistic approach is the best possible solution for the low birth-weight problem. This approach comprises actions of different nature leading to improve the nutritional status and health of the child and of the future mother, to improve the maternal environment during gestation, and to favor those circumstances which permit an optimal care of the pregnant and lactating mother and of the neonate and preschool child, for the purpose of guaranteeing a corrective and preventive action of defects and sequelae associated to low birth weight. Such appears to be the reason to explain a chievements observed in Costa Rica and Cuba, where health programs have received prioritary attention. This position is contrary to the recommendation of isolated measures or interventions whether these are maternal and child health programs or of food supplementation of pregnant mothers, or of any other kind.

A more in-depth analysis of existing information in developing countries is required in regard to benefits derived from different actions and changes in fetal growth. It is also necessary that holistic health and communitary development plans be structured, comprising actions and recommendations necessary to promote optimal fetal development.

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RESUMEN

IMPLICACIONES DE BAJO PESO AL NACER PARA LA SALUD PUBLICA

El presente estudio interpreta la significación de las características antropométricas del recién nacido de una aldea indígena típica del altiplano de Guatemala y de la población general de Costa Rica. Se ilustra la correlación que existe entre las deficiencias del crecimiento fetal y la mortalidad infantil y el retardo del crecimiento físico. Se discute la significación del retardo del crecimiento fetal en el desarrollo de anomalías y defectos demostrables a corto y a largo plazo.

La información existente indica una alta incidencia de niños con alteraciones de crecimiento y desarrollo fetal en Latinoamérica. Esta circunstancia parece ser la causa principal de la alta mortalidad infantil y del retardo en el desarrollo de muchas poblaciones del Subcontinente.

Algunos países han logrado mejoras substanciales en las condiciones que promueven un adecuado crecimiento fetal mediante la implementación de programas en forma integral (holística). Se proponen las áreas de acción en salud necesarias para lograr un desarrollo fetal adecuado en nuestros países.

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