THE ROLE OF NUTRITIONAL DEFICIENCY IN MORTALITY

FINDINGS OF THE INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD[1]

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The Inter-American Investigation of Mortality in Childhood, carried out by the Pan American Health Organization in collaboration with the various countries in the years 1968-1972, has for the first time provided an epidemiologic description of mortality due to nutritional deficiency, by age and by type of deficiency, for several areas in Latin America. Material from Chapter IX of the volume Patterns of Urban Mortality in Childhood—Report of the Inter-American Investigation of Mortality in Childhood *(1) is presented here so as to make this information widely available as a basis for action to improve the health of children and thus of families, communities, and countries of the Americas.*

Introduction

The overall objective of the Inter-American Investigation of Mortality in Childhood was to carry out in selected communities of the Americas research projects designed to establish death rates for infancy and early childhood that would be as accurate and complete as possible, taking into account biological as well as nutritional, sociological, and environmental factors. The field work of the Investigation was directed by the principal collaborators in 15 projects widely distributed over the Hemisphere, as shown on the map appearing as frontispiece to this issue. Six of the projects (indicated on the map by circles) were carried out only in cities while the other nine (shown by squares) were conducted in suburban or rural areas as well as a central city. Deaths over a period of 24 consecutive months[4] were investigated in accordance with standard procedures developed during the Investigation's planning phase in 1966-1968. The initial phases of the work as well as the specific projects were described in an earlier paper (*2*).

Although the basic sources of information were the registered deaths in the two-year period, non-registered deaths were included as well. Many neonatal deaths were discovered through searches of delivery records and obstetrics records in hospitals.

In each of the projects, the principal collaborator was in charge of a team of physicians, nurses, and social workers who carried out the field work, making visits to the homes of deceased children and to hospitals, clinics, and physicians' offices in order to complete a detailed questionnaire with information regarding the parents, mother's reproductive history, prenatal care, extent of breast feeding, medical attention received, complete clinical record of infant's status at birth if delivered in a hospital, and clinical history of events leading to death, including autopsy findings.

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The report on the findings was prepared with the assistance of those listed in the Appendix to this article.

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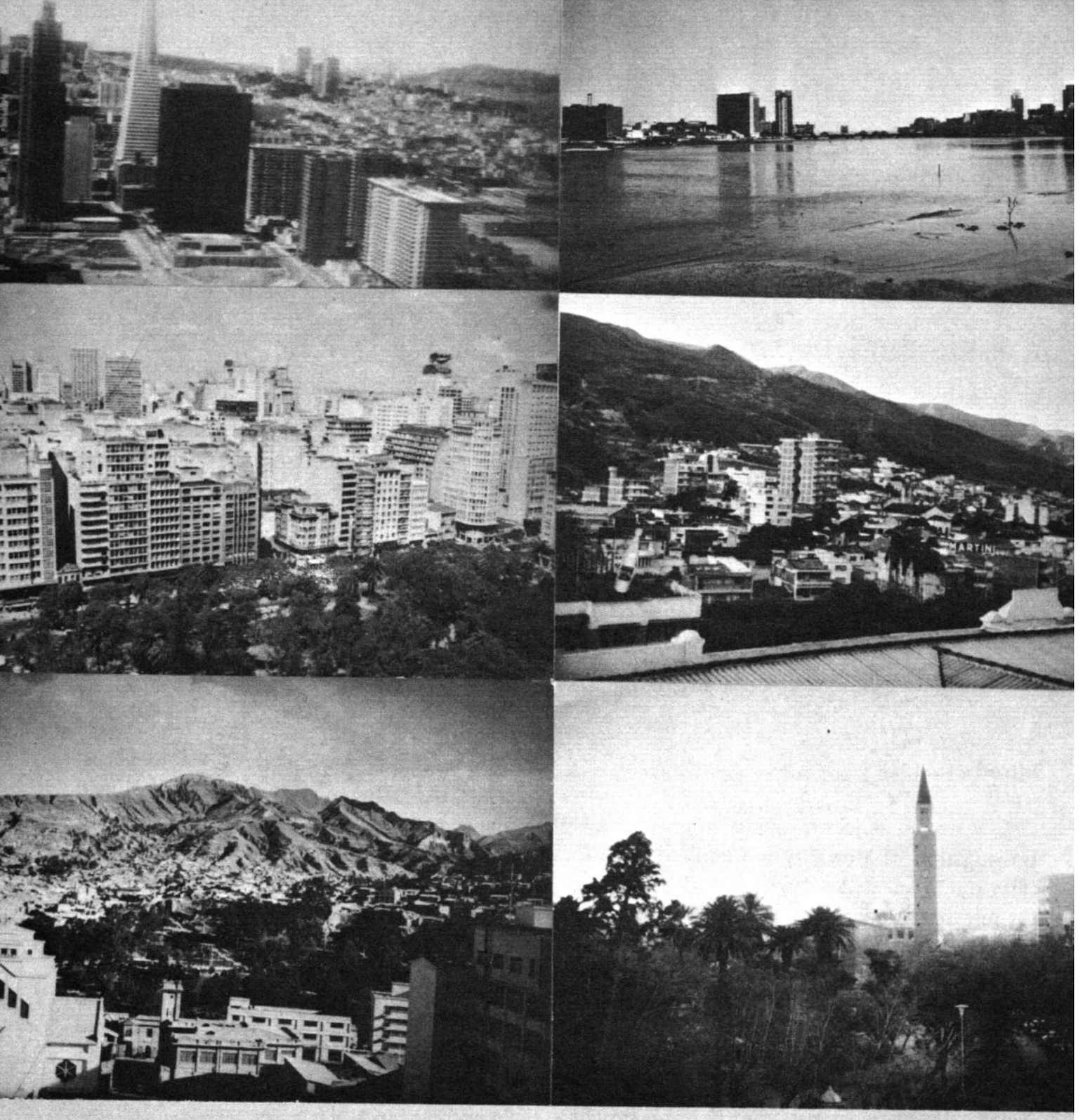
[4]With the exception of the project in California, which covered a one-year period.



A few of the urban centers where the Investigation was conducted, reading clockwise from top left: San Francisco, U.S.A.; Recife, Brazil; São Paulo, Brazil; Cali, Colombia; La Paz, Bolivia; San Juan, Argentina.

The Investigation also covered a number of outlying cities, suburbs, and rural settings, including the ones shown above. Reading clockwise from top left: aerial view of Franca, Riberão Prêto, Brazil; the rural community of Viacha, Bolivia; water supply method in Resistencia, Argentina; open-air market near La Paz, Bolivia; interview at the home of a deceased child in Saint Andrew, Kingston, Jamaica.

The first Inter-American Investigation of Mortality (*3*) in adults (aged 15-74 years) indicated clearly that hospital and autopsy records contained additional information which, when combined with clinical data, made possible more precise definitions of causes of deaths. It was found that the selection of a single cause was often difficult, if not impossible, and that suitable methods for handling multiple causes and combinations of causes needed to be developed. It was recommended, moreover, that modern computer techniques be used, on an experimental basis, for studying the epidemiology of diseases, not as isolated entities but as combinations of pathological states.

The use of the multiple-cause approach in the Investigation of Mortality in Childhood has provided a much greater understanding of the role of immaturity and nutritional deficiency, two causes of death which are assigned as associated causes much more frequently than as underlying causes. Also, important interrelationships such as the synergistic action of infectious diseases and nutritional deficiency and the effects of complications of pregnancy on the product of gestation, as measured by weight and condition of the newborn, have been clarified.

Analysis of the findings of the Investigation, in which extensive data were collected on 35,095 deaths, has uncovered and measured health problems for which solutions must be sought. The patterns of mortality in each of the 25 areas of the 15 projects appeared to be distinct; no two areas had the same type or size of problems. Thus the information provided for each area constitutes a unique contribution to knowledge of conditions and problems in the city, state, province, and country in which the area is situated, as well as adding to the understanding of health problems of the Hemisphere and of the world. Nutritional deficiency was found to be the outstanding and most serious health problem uncovered in the Investigation, as measured by its involvement in mortality.

Fortunately, the *International Classification of Diseases* (*4*), for the first time in the 1965 Revision, includes a group for "Avitaminoses and Other Nutritional Deficiency" (categories 260-269). Whereas in earlier Revisions some of the deaths due to nutritional deficiency were assigned to nutritional maladjustment (category 772) in the section on "diseases of early infancy," the new grouping brings together in one section all deaths from these important causes, and thus facilitates measurement of the size of the problem.

Classification and Diagnostic Evidence

All the information available from the clinical histories, autopsy findings, and medical interviews in the home was used to assess the nutritional state of the deceased infants and young children and the role of nutritional deficiency as underlying or associated cause of death (Table 1). Autopsy findings provided valuable supportive evidence of malnutrition in areas where the size of this important health problem had not previously been recognized.

Weights at birth and in successive age periods were also used whenever available on records. For grading the nutritional state of the deceased child, the Gómez classification and scale (*5*, *6*), based on the weight/age relationship, was applied to the weight standards developed at the Harvard School of Public Health (*7*). Since these standards are utilized widely and others differed only slightly from them, they appeared to be the most satisfactory for use in the Investigation.

When a child was classed as having had Grade I malnutrition according to the Gómez scale (i.e., when its weight was 75-89 per cent of the standard) the nutritional deficiency was not considered a cause of death. When clinical or autopsy data provided a diagnosis of nutritional deficiency and the child's weight was 60-74 per cent of the standard, the deficiency was classed as Grade II, while deficits below 60 per cent placed it in Grade III. Grades II and III deficiency or their equivalents (moderate and severe, from clinical or autopsy findings) were considered as causes of death, but only Grade III (severe) forms were accepted as underlying causes.

TABLE 1—Evidence for diagnosis of nutritional deficiency as underlying or associated cause of death in children under 5 years of age in 13 Latin American projects.

Project	Total deaths	Clinical information and autopsy		Clinical information no autopsy		Autopsy without clinical information		Medical interview only		Death certificate or other record	
		No.	%	No.	%	No.	%	No.	%	No.	%
Total	11,913	1,036	8.7	7,158	60.1	629	5.3	2,735	23.0	355	3.0
ARGENTINA											
Chaco Province	661	48	7.3	374	56.6	41	6.2	168	25.4	30	4.5
San Juan Province	607	65	10.7	475	78.3	7	1.2	37	6.1	23	3.8
BOLIVIA project	1,532	15	1.0	1,048	68.4	5	0.3	438	28.6	26	1.7
BRAZIL											
Recife	1,679	230	13.7	590	35.1	376	22.4	455	27.1	28	1.7
Ribeirão Prêto	405	79	19.5	258	63.7	43	10.6	15	3.7	10	2.5
São Paulo	1,313	126	9.6	1,054	80.3	84	6.4	42	3.2	7	0.5
CHILE project	669	87	13.0	504	75.3	11	1.6	43	6.4	24	3.6
COLOMBIA											
Cali	593	32	5.4	411	69.3	4	0.7	105	17.7	41	6.9
Cartagena	561	131	23.4	326	58.1	21	3.7	73	13.0	10	1.8
Medellín	570	28	4.9	347	60.9	—	—	139	24.4	56	9.8
EL SALVADOR project	1,525	25	1.6	675	44.3	6	0.4	810	53.1	9	0.6
JAMAICA											
Kingston-St. Andrew	370	117	31.6	149	40.3	25	6.8	67	18.1	12	3.2
MEXICO											
Monterrey	1,428	53	3.7	947	66.3	6	0.4	343	24.0	79	5.5

For coding and classification purposes, category 267 (protein malnutrition) of the *International Classification of Diseases* was assigned for deaths in which the clinical history of illness due to nutritional deficiency or the clinical or pathologic examination clearly revealed the so-called "pluricarential syndrome" or "kwashiorkor," characterized by low weight and the presence of edema, among other signs. This form (even when weight was not available) was always graded as severe.

Nutritional marasmus (category 268) was assigned when the clinical history specified that the deceased child was marasmatic, cachetic, or emaciated (with or without gradation by weight). Severe forms of nutritional deficiency in infants under 6 months of age frequently fell in this category. Category 269.9 (other nutritional deficiency, unspecified) was used for all deaths in which Grade II deficiency or equivalent was found, in those for which data were not available for assigning a Grade III deficiency to a more specific type, and in those for which no type or grade was indicated in the records.

In projects where high proportions of deaths occurred in hospitals (as in San Juan Province in Argentina, Ribeirão Prêto and São Paulo in Brazil, and the project in Chile), 90 per cent or more of the diagnoses of nutritional deficiency were supported by clinical or autopsy evidence. In Cartagena, Colombia, 85.2 per cent of the deaths had such evidence. In several projects (as in El Salvador), the medical interviews conducted in the homes provided the basic data for assignment of nutritional deficiency as underlying or associated cause in many deaths.

In areas where clinical data from hospital records were limited, special caution was exercised in assigning nutritional deficiency as a cause, and thus the rates in those areas may be too low because of the lack of supportive evidence. This appeared to be the case in the Bolivia project.

Only low proportions of the deaths were assigned to nutritional deficiency without satisfactory evidence from autopsy, clinical records, or medical interviews with families—that is, on the basis of death certificate or other record only (last column of Table 1). The percentages,

in fact, were usually much lower than for other causes of death, because of the special caution exercised. In the 13 Latin American projects combined, the assignment to nutritional deficiency was based solely on the death certificate or other record for only 3.0 per cent of the deaths, while the percentage for all causes in the Latin American projects was 7.1. The findings, therefore, should be interpreted with care, as the problem may well be more serious in some areas than can be measured at this time. This confirms once again the need to improve the quality of clinical data and to strengthen education in disciplines such as pediatric pathology in many areas of Latin America.

The group "Avitaminoses and Other Nutritional Deficiency" (260-269) of the *International Classification* provides categories for specific avitaminoses (vitamin A deficiency 260, thiamine deficiency 261, etc.) and for the multiple deficiency syndromes (protein malnutrition 267, nutritional marasmus 268, and other nutritional deficiency states 269). In the Investigation only 15 deaths were found to be due to a single vitamin deficiency within categories 260-266, and these categories are therefore grouped in this report under the general heading of vitamin deficiency within the overall section 260-269, which in this report has been more properly named "nutritional deficiency," because of the relative unimportance of the avitaminoses. For future revisions of the *Classification* the group should be renamed "nutritional deficiency" to give more weight to the multiple deficiency syndromes, which are of major importance in many countries.

As for categories 267-269, whenever diagnostic evidence was sufficient the assignment was made to specific conditions (protein malnutrition, nutritional marasmus), though in many areas high proportions of the deaths had to be classified in the miscellaneous group (269). The methods for diagnosing nutritional deficiency syndromes have improved considerably since the description of kwashiorkor (in Spanish *síndrome pluricarencial infantil*) was clarified by Autret and Béhar (*8*), but wider application of this knowledge and better recording of diagnostic data are required if these deficiency states are to be properly identified and studied.

Nutritional Deficiency and Immaturity

Analysis of the interrelationships of nutritional deficiency and immaturity–both of which reflect deficits in the growth and development of the child–is essential to an understanding of the impact of these two important causes of death.

Of the 35,095 deaths under 5 years of age in the 15 projects, 19,994 or 57.0 per cent were due to these two conditions as underlying or associated causes (Table 2). In several areas two-thirds of the deceased children had such evidence of increased vulnerability to disease and high risk of death.

Immaturity and low birth weight, which indicate deficient growth and development at the time of birth, were found to be unusually frequent in infants dying in the neonatal period in several areas. These conditions are believed to be attributable at least in part to the poor nutritional state of the mother, as has been pointed out by Lechtig *et al.* (*9*) and Birch (*10*), though immaturity may be due to other hazards in pregnancy as well.

The assignment of immaturity (category 777) as associated cause was made when the clinical diagnosis showed immaturity and the birth weight was 2,500 grams or less for infants dying in the neonatal period. Birth weights were not available for infants born at home or in several hospitals; therefore in these cases (17.9 per cent of the total) the classification of immaturity was made on the basis of clinical information alone.

Immaturity was assigned as underlying cause only when other clinical information was limited or lacking and no cause other than immaturity was stated. Immaturity was assigned for very few deaths occurring after the first month of life.

If both the birth weight and weights at subsequent periods were available, the infant's growth was evaluated and the assignment was

TABLE 2–Mortality[a] from nutritional deficiency and immaturity as underlying or associated cause in children under 5 years of age in 24 areas of 15 projects.

Project and area	Total deaths		Nutritional deficiency and immaturity		Nutritional deficiency		Immaturity		% of total deaths		
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	Both	Nutritional deficiency	Immaturity
Total	35,095	1,672.1	19,994	952.6	11,969	570.3	8,025	382.3	57.0	34.1	22.9
ARGENTINA											
Chaco Province											
Resistencia	864	2,070.0	537	1,286.5	346	828.9	191	457.6	62.2	40.0	22.1
Rural departments	837	2,387.3	429	1,223.6	315	898.5	114	325.2	51.3	37.6	13.6
San Juan Province											
San Juan (city)	326	1,291.6	174	689.4	66	261.5	108	427.9	53.4	20.2	33.1
Suburban departments	780	2,194.7	451	1,269.0	214	602.1	237	666.9	57.8	27.4	30.4
Rural departments	1,050	2,403.8	576	1,318.7	327	748.6	249	570.1	54.9	31.1	23.7
BOLIVIA											
La Paz	4,115	2,660.0	1,958	1,265.7	1,483	958.6	475	307.0	47.6	36.0	11.5
Viacha	161	4,806.0	66	1,970.1	49	1,462.7	17	507.5	41.0	30.4	10.6
BRAZIL											
Recife	3,635	2,933.6	2,413	1,947.4	1,679	1,355.0	734	592.4	66.4	46.2	20.2
Ribeirão Prêto											
Ribeirão Prêto (city)	464	1,088.4	324	760.0	160	375.3	164	384.7	69.8	34.5	35.3
Franca	434	1,942.7	278	1,244.4	158	707.3	120	537.2	64.1	36.4	27.6
Communities	228	1,300.6	152	867.1	87	496.3	65	370.8	66.7	38.2	28.5
São Paulo	4,312	1,769.3	2,537	1,041.0	1,313	538.8	1,224	502.2	58.8	30.4	28.4
CANADA											
Sherbrooke	371	407.4	179	196.6	12	13.2	167	183.4	48.2	3.2	45.0
CHILE											
Santiago	2,489	1,298.7	1,381	720.6	589	307.3	792	413.3	55.5	23.7	31.8
Comunas	225	1,395.8	120	744.4	80	496.3	40	248.1	53.3	35.6	17.8
COLOMBIA											
Cali	1,627	1,607.7	914	903.2	593	586.0	321	317.2	56.2	36.4	19.7
Cartagena	1,255	1,459.3	815	947.7	561	652.3	254	295.3	64.9	44.7	20.2
Medellín	1,348	1,444.8	835	895.0	570	610.9	265	284.0	61.9	42.3	19.7
EL SALVADOR											
San Salvador	2,738	2,636.2	1,487	1,431.7	1,018	980.2	469	451.6	54.3	37.2	17.1
Rural *municipios*	1,082	5,049.0	593	2,767.1	507	2,365.8	86	401.3	54.8	46.9	7.9
JAMAICA											
Kingston-St. Andrew	1,903	1,038.5	1,125	613.9	370	201.9	755	412.0	59.1	19.4	39.7
MEXICO											
Monterrey	3,953	1,813.8	2,153	987.9	1,428	655.2	725	332.7	54.5	36.1	18.3
UNITED STATES											
San Francisco	234	543.6	125	290.4	10	23.2	115	267.1	53.4	4.3	49.1
California, suburban	664	413.4	372	231.6	34	21.2	338	210.4	56.0	5.1	50.9

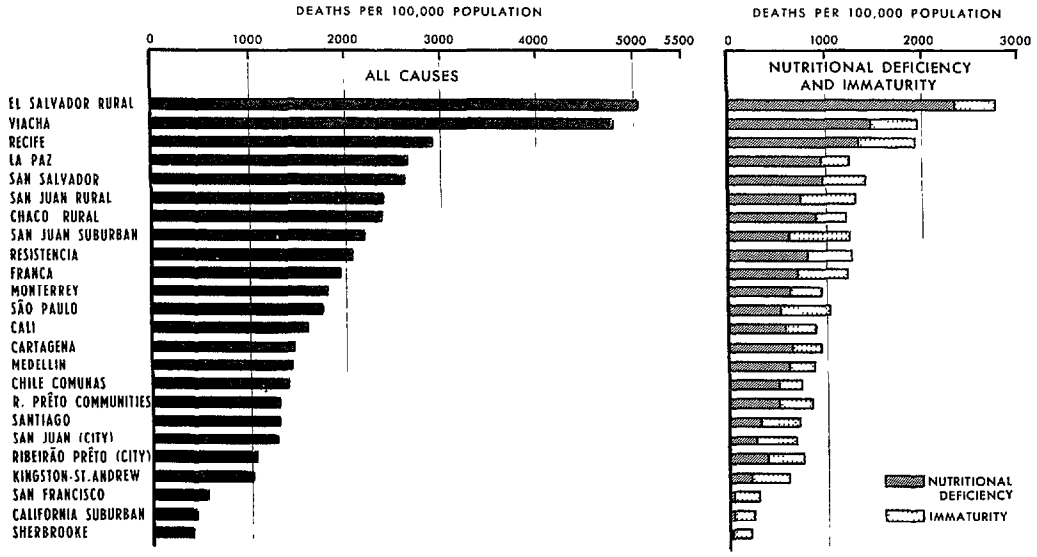
[a] Rates per 100,000 population.

made to nutritional deficiency if both the clinical evidence and the weight indicated a serious deficiency state. Only one assignment, either immaturity (777) or a nutritional deficiency (one of the categories 260-269) was made, and thus the total number of infants and young children with either one of these conditions was obtained.

The seriousness of these two conditions as contributors to mortality is clearly evident in Figure 1, which shows first the death rates from all causes in 24 areas, in descending order, and then the rates for immaturity and nutritional deficiency.

In nearly all the Latin American areas mortality from nutritional deficiency was higher than that from immaturity. In Recife, for example, the rate of 1,355.0 per 100,000 population for this deficiency was over twice the rate of 592.4 for immaturity. Since immaturity is assigned principally as a cause of neonatal deaths, these high rates for nutritional

FIGURE 1–Mortality in children under 5 years of age from all causes and from nutritional deficiency and immaturity in 24 areas of 15 projects.



deficiency indicate that the impact of the lack of growth and development was even greater after the neonatal period.

In a few areas, however, the reverse was true, as in the city of San Juan (San Juan Province, Argentina), where the death rate of 427.9 for immaturity was much higher than that for nutritional deficiency (261.5 per 100,000 population). On the other hand, within this same project in San Juan Province the rural departments had a much higher rate for nutritional deficiency (748.6), thereby indicating the marked difference in these problems of child growth and development in geographic areas of one project. The deficiency in the rural area probably began at birth, as is suggested by the higher rate for immaturity, and thus the health and nutritional state of the mother may be involved.

In the Sherbrooke project in Canada and in the two areas of the California project immaturity was an underlying or associated cause of 45.0, 49.1, and 50.9 per cent respectively of the deaths of children under 5 years of age. Nutritional deficiency was rarely assigned in these areas, which had very low rates from all causes. In these two projects more than 60 per cent of the deaths were in the neonatal period (61.7 per cent in Sherbrooke and 63.5 in California). The situation was thus distinctly different from that found in the Latin American projects.

As can be seen in Figure 1, in areas where the overall death rates for children under 5 years of age were high, the rates were high also for nutritional deficiency. In areas with low death rates, nutritional deficiency was less important and immaturity was assigned in a high proportion of the deaths. Thus reduction of mortality in childhood is dependent on measures to prevent both of these serious conditions.

The data for the Latin American projects suggest that the problem of nutritional deficiency begins with the future mother. There is clearly a need for measures to prevent low birth weights as well as for nutrition programs aimed at promoting normal growth and development.

Age at Death

A full account is given below of mortality

TABLE 3–Deaths under 5 years from all causes in 15 projects, by age group, and deaths from nutritional deficiency as underlying or associated cause in 13 Latin American projects combined.

Age group	Total 15 projects	Northern America, 2 projects	Latin American projects		
			Total	With nutritional deficiency	
				No.	Rate[a]
Total under 5 years	35,095	1,269	33,826	11,913	660.3
Infant	27,602	1,094	26,508	7,701	1,867.6
Neonatal (−28 days)	12,674	799	11,875	401	97.2
Postneonatal (28 days-11 mos.)	14,928	295	14,633	7,300	1,770.4
1 year	4,361	53	4,308	2,589	687.5
2–4 years	3,132	122	3,010	1,623	155.8

[a] Rates under 1 year of age per 100,000 live births; others per 100,000 population.

from nutritional deficiency by age at death. This is the first time that such data for specific geographic areas have become available to permit an epidemiologic description of this important health problem. The study of deaths with this deficiency as an underlying or as an associated cause provides an excellent measure of the impact of this condition on mortality.

In the two projects in Northern America (Sherbrooke in Canada, and the California project) nutritional deficiency was underlying or associated cause of only 56 deaths (4.4 per cent) and the following analysis is therefore confined to the 13 Latin American projects. Table 3 shows, by age group, the conversion from 35,095 deaths in all 15 projects to 33,826 in the 13 Latin American projects which are analyzed in the remainder of this paper.

Of the 33,826 deaths of children under 5 years of age in the 13 projects, 11,913 or 35.2 per cent had nutritional deficiency as underlying or associated cause. This represents an overall rate of 660.3 per 100,000 population. If neonatal deaths (under 28 days of age) are excluded, 11,512 deaths out of 21,951, or 52.4 per cent, had this deficiency state as a cause.

Table 3 reveals clearly the seriousness of the problem among infants under one year of age. Infant deaths with nutritional deficiency as underlying or associated cause numbered 1,867.6 per 100,000 live births–or by the standard unit for infant mortality, 18.7 per 1,000 live births–a rate higher than the total infant death rate in several countries of the world.

The problem is particularly severe in the postneonatal period (28 days-11 months of age) and during the second year of life. The onset of severe forms of malnutrition early in the first year of age in several projects, as reflected by this exceedingly high death rate in the postneonatal period, has very serious implications. Winick and Rosso (*11*) have shown that nutritional deficiency occurring in early stages of rapid growth may have more permanent effects on the child than that occurring during periods of slower growth.

In Table 4 and Figure 2 mortality from nutritional deficiency is shown for three age groups (under 1 year, 1 year, and 2-4 years) for 21 areas of the 13 projects. The rates for infants (as underlying or associated cause) exceeded 2,000 per 100,000 live births in 10 areas. In nine others they were in excess of 1,000. Only in the city of San Juan, Argentina, and in Kingston-St. Andrew, Jamaica, were the rates less than 1,000 per 100,000 live births.

Although in all areas mortality from nutritional deficiency was higher in the first year of life than in the age groups 1-4 years, rates were nearly as high in the second year in the rural areas of Bolivia and El Salvador. High rates in the second year were also found in the cities of Recife, Brazil, La Paz, Bolivia, and San Salvador, El Salvador, in the three cities in Colombia, and in rural Chaco Province in Argentina.

TABLE 4–Mortality[a] from nutritional deficiency as underlying or associated cause, by age group, in 21 areas of 13 Latin American projects.

Project and area	Under 5 years		Under 1 year		1 year		2-4 years	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate
Total 13 projects	11,913	660.3	7,701	1,867.6	2,589	687.5	1,623	155.8
ARGENTINA								
Chaco Province								
Resistencia	346	828.9	270	2,755.1	52	581.7	24	101.7
Rural departments	315	898.5	215	2,756.4	75	1,071.4	25	120.3
San Juan Province								
San Juan (city)	66	261.5	55	945.0	8	158.1	3	19.8
Suburban departments	214	602.1	187	2,361.1	20	279.3	7	32.6
Rural departments	327	748.6	269	2,796.3	35	396.8	23	86.7
BOLIVIA								
La Paz	1,483	958.6	746	2,029.4	489	1,477.3	248	285.1
Viacha	49	1,462.7	25	2,941.2	19	2,676.1	5	267.4
BRAZIL								
Recife	1,679	1,355.0	1,080	3,552.6	354	1,319.9	245	355.1
Ribeirão Prêto								
Ribeirão Prêto (city)	160	375.3	116	1,246.0	20	227.0	24	96.5
Franca	158	707.3	119	2,337.9	21	451.6	18	139.5
Communities	87	496.3	64	1,666.7	9	249.3	14	136.7
São Paulo	1,313	538.8	1,062	1,826.0	146	269.7	105	78.2
CHILE								
Santiago	589	307.3	494	1,229.5	66	177.8	29	24.7
Comunas	80	496.3	66	1,941.2	9	288.5	5	50.6
COLOMBIA								
Cali	593	586.0	306	1,450.2	169	836.6	118	194.4
Cartagena	561	652.3	278	1,553.1	197	1,145.3	86	166.7
Medellín	570	610.9	308	1,587.6	154	828.0	108	192.9
EL SALVADOR								
San Salvador	1,018	980.2	597	2,330.2	262	1,146.6	159	278.0
Rural *municipios*	507	2,365.8	198	3,666.7	147	3,259.4	162	1,345.5
JAMAICA								
Kingston-St. Andrew	370	201.9	243	593.3	90	230.1	37	35.4
MEXICO								
Monterrey	1,428	655.2	1,003	1,892.1	247	548.6	178	142.6

[a] Rates under 1 year of age per 100,000 live births; others per 100,000 population.

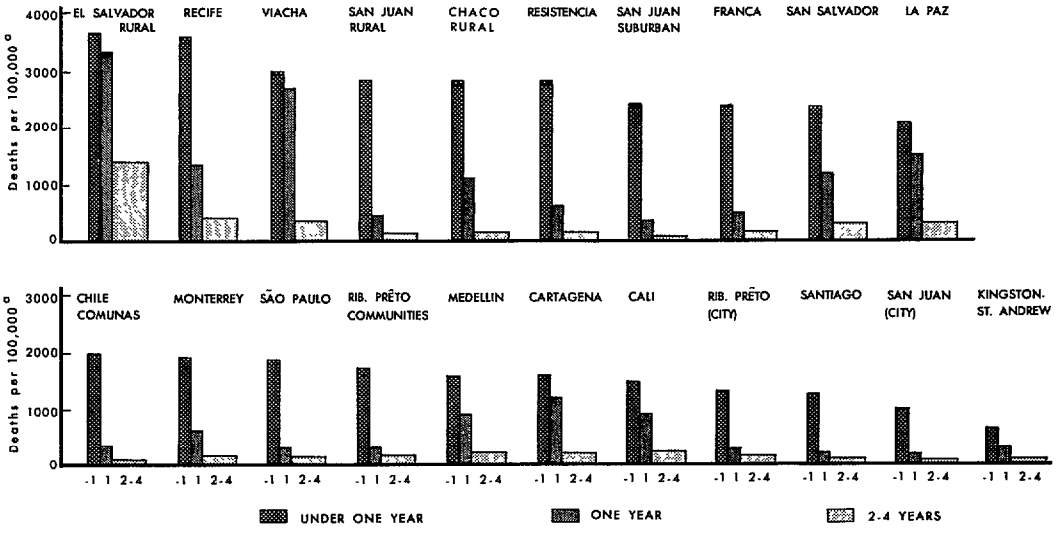
Rates in the group aged 2-4 years were much lower and thus further subdivision is not shown for that age group.

A comparison within projects shows that mortality was much higher in rural areas than in cities. For example, the rural areas (*municipios*) of El Salvador had the highest death rate in infancy and appear in first place in Figure 2, while the city of San Salvador (appearing ninth) had much lower rates. The very low rates in the city of San Juan, Argentina (shown second from the last) are in distinct contrast to those in rural and suburban San Juan (appearing in fourth and seventh place). In the Bolivia project, the rates for the rural community of Viacha for the first two years of life were much higher than those for the city of La Paz. This evidence of higher rates in rural areas than in the neighboring cities is of key importance for health planning and for further research. Health problems such as this in rural areas must be brought fully to light so that solutions may be sought.

To give a clearer picture of the problem, mortality by age at death was analyzed by month for the first two years of life and for six-month periods thereafter.[5] Nutritional deficiency caused excessive mortality principally in the first year of life in six projects: San Juan

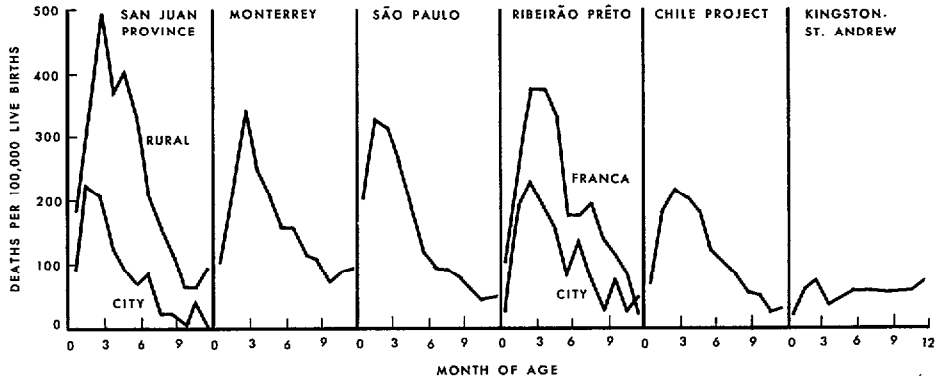
[5] Table 91 in the volume *Patterns of Mortality in Childhood* (*1*) gives the numbers of deaths according to these age distributions.

FIGURE 2–Mortality from nutritional deficiency in children under 5 years for three age groups in 21 areas of 13 Latin American projects.



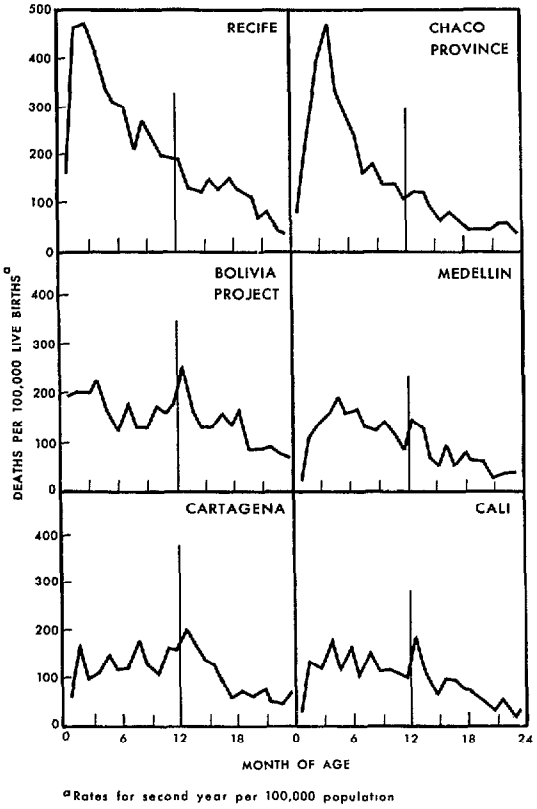
a Under 1 year per 100,000 live births; other rates per 100,000 population.

FIGURE 3–Mortality from nutritional deficiency by month of age for first 12 months of life in six projects.



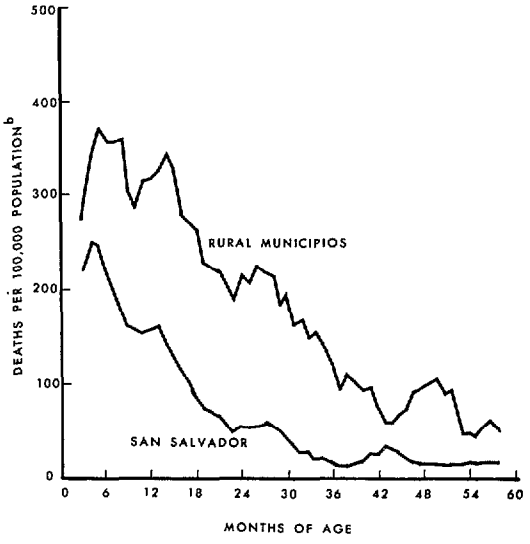
Province, Argentina; Monterrey, Mexico; São Paulo and Ribeirão Prêto, Brazil; Chile; and Kingston-St. Andrew, Jamaica (Figure 3). The rates continued to be relatively high in the first two years of life in six other projects: Recife, Brazil; Chaco Province, Argentina; Bolivia; and Medellín, Cartagena, and Cali in Colombia (Figure 4). In the rural areas of El Salvador the rates continued to be relatively high throughout the first five years of life, as can be seen in Figure 5, which shows both the rural rates and those for the city of San Salvador.

FIGURE 4–Mortality from nutritional deficiency by month of age for first 24 months of life in six projects.



[a]Rates for second year per 100,000 population

FIGURE 5–Mortality from nutritional deficiency by month[a] of age for first 5 years in San Salvador and rural areas (*municipios*) of El Salvador.



[a]Five-month averages
[b]Rates for under 1 year per 100,000 live births

The patterns of mortality from nutritional deficiency varied widely among the areas. In San Juan Province, São Paulo, Monterrey, and Ribeirão Prêto (Figure 3) mortality was excessive principally in very young infants. In San Juan Province, where the rural rates were much higher than those in the city, the highest rates in both areas were in the first six months of life. In the Ribeirão Prêto project in Brazil, the rates were much higher in the interior city of Franca than in the city of Ribeirão Prêto, and in both the problem affected principally early infancy. Although a similar pattern of high mortality in early life was seen in the project in Chile, the rates were much lower.

In the six projects shown in Figure 4 there appeared to be two different patterns. Recife, Brazil, and Chaco Province, Argentina, had exceedingly high rates in early infancy and mortality continued to be relatively high in the second year of life; the rates per 100,000 live births reached 480.3 for infants 2 months of age in Recife and 477.3 for those aged 3 months in Chaco. On the other hand, in the projects in Bolivia and in Medellín, Cartagena, and Cali in Colombia mortality did not appear to be concentrated in early infancy, though rates were between 100 and 200 per 100,000 live births for most of the months of infancy. These rates became lower at the end of the first year of life, but deaths from nutritional deficiency continued to occur in the second year (with variations in rates due to small numbers). It is significant to note that in these four last-mentioned areas breast feeding was practiced much more frequently than in the projects of Brazil.

Although a large proportion of the deceased infants in Chaco Province, Argentina, had been

breast fed, as had a relatively large proportion in San Juan Province, in Argentina, the high death rates there in early life were in distinct contrast to the patterns found in the Bolivia and Colombia projects.

Nutritional deficiency was a particularly serious problem in the El Salvador project (Figure 5). In the city of San Salvador, the rates were very high in early infancy and high mortality continued into the second and third years of life. In the rural areas the death rates were exceedingly high in early infancy and approximately twice as high as those in the city of San Salvador for several of the months of age. In the remainder of the first 5 years they continued to be high, and several times higher than those in San Salvador. In the rural areas 49.7 per cent of the deceased infants (excluding those dying in neonatal period) had been breast fed for one month or longer, while in San Salvador only 34.1 per cent had been breast fed. It therefore seems likely that there are other factors (apart from the lack of breast feeding) that are responsible for excessive mortality from nutritional deficiency in these rural areas. The protective value of breast feeding may vary and be diminished by unfavorable factors that produce mortality from nutritional deficiency.

Until complete data become available on the state of health and nutrition of mothers, on the distribution of births by weight, and on feeding practices in rural as well as urban areas, the reasons for such differences will remain obscure. The relationships of nutritional deficiency to diarrheal disease and to breast feeding are discussed later in this article.

Types of Nutritional Deficiency

The data obtained in the Investigation make it possible, for the first time, to analyze mortality from nutritional deficiency according to type of deficiency as well as age at death. The specific types assigned as underlying or associated causes of 11,913 deaths of children under 5 years of age are given for the 13 Latin American projects combined in Table 5, and by individual projects and age groups in Table 6. The division by type is: vitamin deficiency (260-266); protein malnutrition (267); nutritional marasmus (268); and other nutritional deficiency (269).

TABLE 5—Mortality[a] from nutritional deficiency, by type, in children under 5 years of age in 13 Latin American projects combined.

Type of deficiency	Total	Rate
Total	11,913	660.3
Vitamin deficiency (260-266)	15	0.8
Protein malnutrition (267)	1,562	86.6
Nutritional marasmus (268)	2,544	141.0
Other deficiency (269)	7,792	431.9

[a] Rates per 100,000 population.

Protein malnutrition (267), or kwashiorkor, was assigned as a cause in 1,562 deaths, or 13.1 per cent of the total deaths from nutritional deficiency (11,913). This multiple deficiency syndrome is a severe form of generalized deficiency; it develops as the result of deficits in protein-rich foods over a period of several months or longer. For this reason the finding of this type of deficiency in infants less than one year of age indicates lack of sufficient food and damage by disease early in life. In those suffering from this condition, the changes in body composition and function are profound.

Nutritional marasmus (268), which was assigned in 2,544 deaths (21.4 per cent of the total), is the result of an overall deficit in food intake or utilization and is apt to develop very early in life, that is, in the first few months. Infants suffering from this condition may recover partially or completely or they may develop the more serious kwashiorkor type of protein malnutrition and die from some complication.

In the 13 projects, 7,792 deaths (65.4 per cent of the total) were assigned to category 269, *other nutritional deficiency.* Whenever the clinical evidence was not sufficient to permit a specific assignment to category 267 or 268, or when the deficiency was Grade II or equivalent, the assignment was made to category 269.9 (other and unspecified nutritional deficiency).

TABLE 6—Mortality[a] from specific types of nutritional deficiency in children under 5 years, by age group, in 13 projects.

Project	Total		Vitamin deficiency (260–266)		Protein malnutrition (267)		Nutritional marasmus (268)		Other nutritional deficiency (269)	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
	UNDER 5 YEARS									
Total	11,913	660.3	15	0 8	1,562	86 6	2,544	141 0	7,792	431 9
ARGENTINA										
Chaco Province	661	860 7	—	—	34	44.3	96	125.0	531	691 4
San Juan Province	607	581 1	1	1 0	10	9 6	177	169.4	419	401 1
BOLIVIA project	1,532	969.3	—	—	116	73 4	176	111 4	1,240	784.6
BRAZIL										
Recife	1,679	1,355 0	—	—	322	259.9	499	402.7	858	692 4
Ribeirão Prêto	405	490.9	—	—	31	37.6	113	137.0	261	316.4
São Paulo	1,313	538.8	3	1 2	58	23 8	299	122.7	953	391.0
CHILE project	669	322.0	3	1.4	20	9 6	177	85.2	469	225.7
COLOMBIA										
Cali	593	586.0	2	2 0	130	128.5	138	136 4	323	319 2
Cartagena	561	652 3	—	—	201	233.7	99	115 1	261	303 5
Medellín	570	610.9	4	4.3	94	100.8	107	114.7	365	391.2
EL SALVADOR project	1,525	1,217 2	1	0.8	348	277 8	298	237.8	878	700.8
JAMICA										
Kingston-St. Andrew	370	201 9	1	0.5	58	31 7	83	45 3	228	124 4
MEXICO										
Monterrey	1,428	655.2	—	—	140	64.2	282	129 4	1,006	461 6
	UNDER 1 YEAR									
Total	7,701	1,867.6	10	2.4	325	78.8	1,811	439.2	5,555	1,347.2
ARGENTINA										
Chaco Province	485	2,755.7	—	—	11	62.5	66	375.0	408	2,318.2
San Juan Province	511	2,187 5	1	4 3	2	8.6	158	676.4	350	1,498.3
BOLIVIA project	771	2,050.0	—	—	23	61.2	82	218.0	666	1,770.8
BRAZIL										
Recife	1,080	3,552.6	—	—	79	259.9	340	1,118.4	661	2,174.3
Ribeirão Prêto	299	1,639.3	—	—	3	16 4	89	487.9	207	1,134.9
São Paulo	1,062	1,826.0	1	1.7	14	24.1	255	438.4	792	1,361.8
CHILE project	560	1,285.0	3	6.9	2	4.6	149	341 9	406	931.6
COLOMBIA										
Cali	306	1,450.2	1	4 7	26	123.2	89	421.8	190	900.5
Cartagena	278	1,553 1	—	—	58	324.0	64	357 5	156	871.5
Medellín	308	1,587.6	3	15.5	8	41.2	88	453.6	209	1,077.3
EL SALVADOR project	795	2,562 9	1	3.2	40	128 9	169	544.8	585	1,885.9
JAMICA										
Kingston-St. Andrew	243	593.3	—	—	25	61.0	59	144.0	159	388.2
MEXICO										
Monterrey	1,003	1,892 1	—	—	34	64.1	203	382.9	766	1,445.0
	1 YEAR									
Total	2,589	687.5	3	0.8	696	184.8	478	126.9	1,412	375 0
ARGENTINA										
Chaco Province	127	796.7	—	—	22	138.0	21	131.7	84	527.0
San Juan Province	63	299.4	—	—	4	19.0	12	57.0	47	233.4
BOLIVIA project	508	1,502.5	—	—	66	195.2	60	177.5	382	1,129.8
BRAZIL										
Recife	354	1,319.9	—	—	130	484.7	103	384.0	121	451.2
Ribeirão Prêto	50	292.9	—	—	14	82.0	10	58.6	26	152.3
São Paulo	146	269.7	2	3.7	27	49.9	26	48.0	91	168.1
CHILE project	75	186.3	—	—	12	29.8	18	44.7	45	111 8
COLOMBIA										
Cali	169	836.6	—	—	51	252.5	34	168.3	84	415.8
Cartagena	197	1,145.3	—	—	106	616.3	25	145.3	66	383.7
Medellín	154	828.0	—	—	41	220.4	15	80.6	98	526.9
EL SALVADOR project	409	1,494.9	—	—	134	489.8	96	350.9	179	654.2
JAMAICA										
Kingston-St. Andrew	90	230.1	1	2.6	26	66.5	18	46.0	45	115.1
MEXICO										
Monterrey	247	548.6	—	—	63	139.9	40	88.8	144	319.9
	2–4 YEARS									
Total	1,623	155.8	2	0.2	541	51 9	255	24.5	825	79.2
ARGENTINA										
Chaco Province	49	110 4	—	—	1	2.3	9	20.3	39	87.9
San Juan Province	33	52.3	—	—	4	6.3	7	11.1	22	34.8
BOLIVIA project	253	284.7	—	—	27	30 4	34	38.3	192	216.0
BRAZIL										
Recife	245	355 1	—	—	113	63.8	56	81.2	76	110.2
Ribeirão Prêto	56	116.7	—	—	14	29.2	14	29.2	28	58.3
São Paulo	105	78.2	—	—	17	12.7	18	13.4	70	52.1
CHILE project	34	26 7	—	—	6	4.7	10	7.9	18	14.1
COLOMBIA										
Cali	118	194.4	1	1.6	53	87.3	15	24.7	49	80.7
Cartagena	86	166.7	—	—	37	71.7	10	19.4	39	75.6
Medellín	108	192.9	1	1.8	45	80.4	4	7.1	58	103.6
EL SALVADOR project	321	463 7	—	—	174	251.3	33	47.7	114	164.7
JAMAICA										
Kingston-St. Andrew	37	35.4	—	—	7	6.7	6	5.7	24	23.0
MEXICO										
Monterrey	178	142.6	—	—	43	34 5	39	31.2	96	76.9

[a] Rates under 1 year of age per 100,000 live births; others per 100,000 population.

Only 15 deaths were assigned to a *deficiency of a specific vitamin or to avitaminosis unspecified* (260-266) as underlying or associated cause. Ten of these deaths were due to vitamin D deficiency (265), four to the unspecified group (266.9), and one to ascorbic acid deficiency (264), as can be seen below:

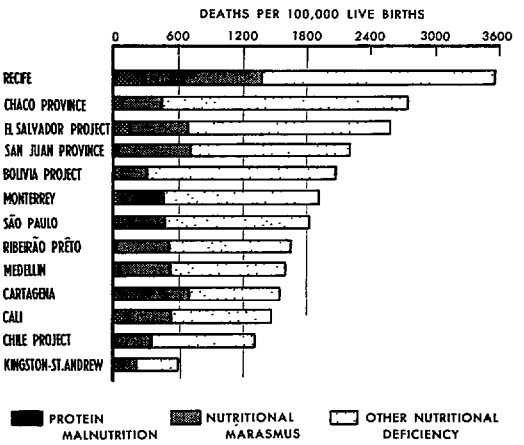
Project	*Age at death*	*Cause*	*Category*
Argentina, rural department, San Juan Province	8 months	Associated	265.0
Brazil, São Paulo	1 year	Underlying	265.0
	1 year	Underlying	265.0
	8 months	Associated	265.0
Chile, Santiago	4 months	Associated	265.0
	3 months	Associated	265.0
	4 months	Associated	265.0
Colombia, Cali	2 years	Associated	265.9
	5 months	Associated	265.0
Colombia, Medellín	3 years	Associated	266.9
	9 months	Associated	266.9
	27 days	Associated	266.9
	4 months	Associated	266.9
El Salvador, rural *municipios*	6 months	Associated	265.0
Jamaica, St. Andrew, rural	1 year	Underlying	264

The overall rate for all types of nutritional deficiency in children under 5 years of age in the 13 projects combined—660.3 per 100,000 population—is indicative of the seriousness of this health problem (Table 5). The combined rate for protein malnutrition was 86.6 per 100,000. In eight of the projects very few deaths were assigned to this category, and the rates there were under 100 per 100,000, but in the other five projects they ranged from 100.8 up to 277.8 (Table 6). The overall rate for nutritional marasmus was 141.0. In all projects except that in Cartagena, Colombia, more than half the nutritional deficiency deaths were assigned to the unspecified group (269), for which the overall rate was 431.9 per 100,000 population.

With regard to infant mortality (under one year) for the 13 projects (Figure 6), nutritional marasmus and unspecified nutritional deficiency states accounted for most of these deaths. Only in the two projects in Recife and Cartagena were the rates for protein malnutrition in this age group relatively high—259.9 and 324.0 per 100,000 live births, respectively.

The rates for children aged one year and 2-4 years (Figure 7) were lower. In five projects (El Salvador, Recife, Cartagena, Cali, and Medellín) protein malnutrition mortality was particularly high in the second year of life, with the rates

FIGURE 6—Mortality in infancy from specific types of nutritional deficiency in 13 projects.



ranging from 220.4 to 616.3 per 100,000 population. In Cartagena more than half the nutritional deficiency deaths in one-year-olds were due to this type. The clinical information for this latter city was of unusually good quality and this fact may account partially for the more frequent assignment to specific types there.

The type of nutritional deficiency was analyzed for 12 projects by three-month age groups in the first two years of life, and for the El Salvador project in the first 5 years.[6]

[6] Tables 94 and 95 in the volume *Patterns of Mortality in Childhood* (*1*) provide this basic information.

FIGURE 7—Mortality from nutritional deficiency, by type, in children one year and 2-4 years of age in 13 projects.

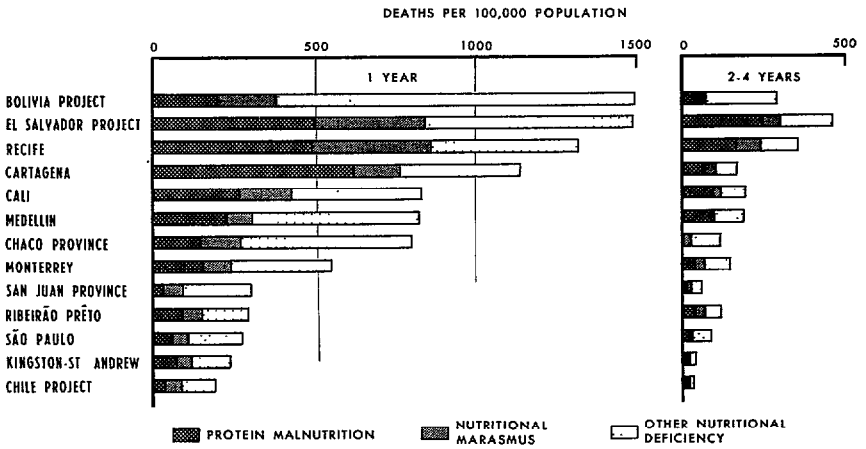
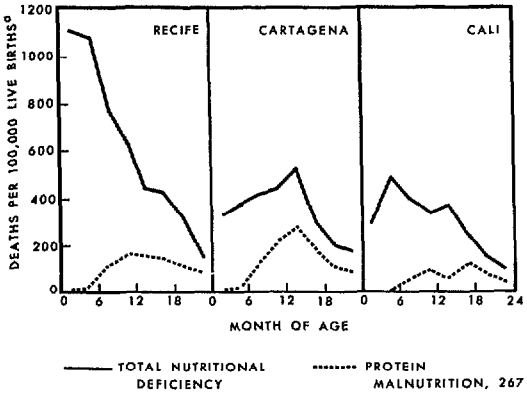


Figure 8 shows the rates for protein malnutrition along with the total rates for nutritional deficiency by three-month age groups for three projects (Recife, Cartagena, and Cali). In Cartagena the peak rates for protein malnutrition occurred among children 12-14 months of age, and in Recife the rates were highest for those aged 9-17 months. In Cali the highest rate was for children 15-17 months old. In all three projects, in the last age group of the two-year period (21 to 23 months) essentially half the deaths from nutritional deficiency were due to protein malnutrition.

FIGURE 8–Mortality from nutritional deficiency and from protein malnutrition for three-month age groups in the first two years of life in three projects.

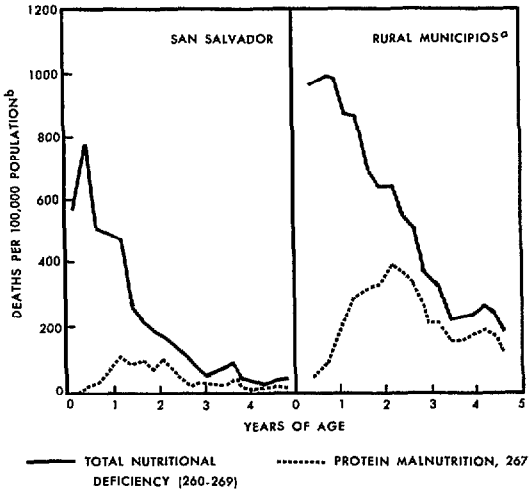


[a]Rates for second year per 100,000 population.

For El Salvador, where nutritional deficiency was a particularly serious problem, the death rates in both urban and rural areas are shown by three-month intervals for the first 5 years of life. In the rural areas protein malnutrition mortality rose to the peak rate of 498.4 in the group aged 27-29 months, and then declined in the older groups. These rates are illustrated in Figure 9. After the second year of life protein malnutrition was the type found in two-thirds of the deaths due to nutritional deficiency (109 out of 162).

For the 13 Latin American projects combined, the role of the various types of nutritional deficiency as underlying or associated cause of death in children under 2 years is

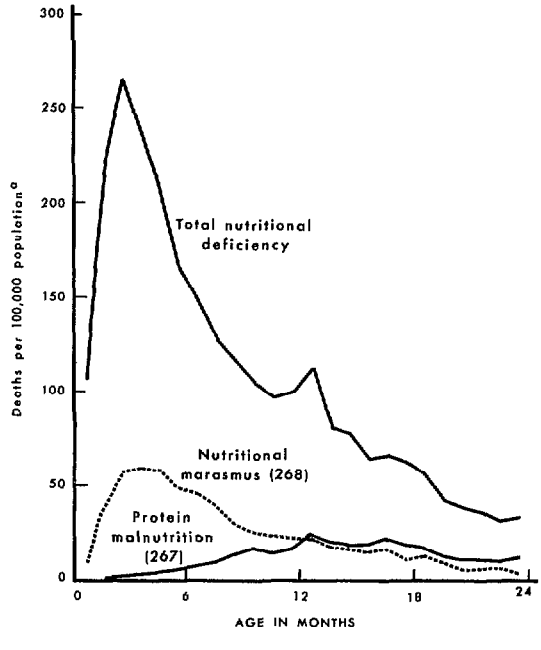
FIGURE 9–Mortality from nutritional deficiency and from protein malnutrition for three-month age groups under 5 years in San Salvador and rural areas (*municipios*) of El Salvador.



[a]Smoothed averages for rural municipios.

[b]Rates for under 1 year of age per 100,000 live births.

FIGURE 10–Mortality from nutritional deficiency, protein malnutrition, and nutritional marasmus by month of age in first two years of life in 13 Latin American projects combined.



[a]Under 1 year of age per 100,000 live births

TABLE 7–Mortality[a] from nutritional deficiency, by type and by month of age, in first two years of life in 13 Latin American projects combined.

Month of age	Total		Avitaminoses (260–266)		Protein malnutrition (267)		Nutritional marasmus (268)		Other deficiency (269)	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
Under 1	439	106.5	1	0.2	—	—	33	8.0	405	98.2
1	904	219.2	—	—	—	—	147	35.7	757	183.6
2	1,086	263.4	—	—	3	0.7	233	56.5	850	206.1
3	969	235.0	1	0.2	5	1.2	237	57.5	726	176.1
4	821	199.1	3	0.7	7	1.7	233	56.5	578	140.2
5	670	162.5	1	0.2	11	2.7	195	47.3	463	112.3
6	607	147.2	1	0.2	25	6.1	182	44.1	399	96.8
7	510	123.7	—	—	35	8.5	153	37.1	322	78.1
8	476	115.4	2	0.5	54	13.1	114	27.6	306	74.2
9	424	102.8	1	0.2	65	15.8	104	25.2	254	61.6
10	393	95.3	—	—	55	13.3	92	22.3	246	59.7
11	402	97.5	—	—	65	15.8	88	21.3	249	60.4
12	413	109.7	—	—	88	23.4	80	21.2	245	65.1
13	297	78.9	—	—	69	18.3	62	16.5	166	44.1
14	283	75.2	2	0.5	68	18.1	56	14.9	157	41.7
15	237	62.9	—	—	67	17.8	50	13.3	120	31.9
16	244	64.8	1	0.3	72	19.1	58	15.4	113	30.0
17	225	59.8	—	—	64	17.0	36	9.6	125	33.2
18	218	57.9	—	—	59	15.7	42	11.2	117	31.1
19	164	43.6	—	—	48	12.7	27	7.2	89	23.6
20	141	37.4	—	—	42	11.2	15	4.0	84	22.3
21	135	35.9	—	—	42	11.2	21	5.6	72	19.1
22	111	29.5	—	—	37	9.8	20	5.3	54	14.3
23	121	32.1	—	—	40	10.6	11	2.9	70	18.6

[a] Rates under 1 year of age per 100,000 live births; others per 100,000 population.

shown in Figure 10 and Table 7. The rates for all types combined were highest at 2 and 3 months of age and then declined in the older groups. Protein malnutrition was diagnosed for three infants at 2 months of age, for five at 3 months, and for seven at 4 months; the frequency then increased steadily until the largest numbers were recorded for children aged 12-16 months, and it decreased thereafter during the latter part of the second year of life. Table 8 shows for the 13 projects combined the protein malnutrition death rates for the group under 5 years as a whole as well as for infants and children 1 year and 2-4 years old. The death rate of 184.8 per 100,000 population for one-year-olds indicates that these children suffered the greatest mortality from this type.

This overall picture combining the rates for all projects does not reveal the gravity of the protein malnutrition problem in certain of the projects. Detailed analyses of the kind made for the El Salvador project are advisable for other areas. For this purpose it is necessary to have available adequate data for rural areas as well as sufficient clinical evidence to distinguish protein deficiency from the non-specific states when assigning the cause. Protein malnutrition is an indicator of a serious health problem whose impact extends far beyond childhood. Research is needed in order to ascertain the effect of damage by protein-calorie malnutrition on future mothers and determine whether there is a relationship to low birth weights in their offspring.

While mortality from protein malnutrition increased to the highest rates in the second year of life, the rates for nutritional marasmus reached a peak at 2 and 3 months of age and then gradually declined (Table 7). Some of the survivors of nutritional marasmus probably later developed protein malnutrition and thus the damage was laid in this early period of life.

It is therefore clear that preventive measures are required very early in life not only to reduce mortality from nutritional deficiency of the intermediate and marasmatic types, but to prevent protein malnutrition in the survivors as well.

Since for all forms of nutritional deficiency combined the highest mortality was in infants 2 and 3 months of age (rates of 263.4 and 235.0, respectively), there is clear evidence of the development of severe forms in early life. This is an important finding, for in the past emphasis has been placed on deficiencies in the second year of life. The full significance of the finding is apparent from the fact that a high incidence of protein-calorie malnutrition at an early age, when the need for rapid growth and development is greatest, can result in irreparable damage to the survivors.

TABLE 8–Protein malnutrition as underlying or associated cause of death under 5 years, by age group,[a] in 13 Latin American projects combined.

Age group	Total	Rate
Under 5 years	1,562	86.6
Under 1 year	325	78.8
1 year	696	184.8
2–4 years	541	51.9

[a] Rates under 1 year of age per 100,000 live births; others per 100,000 population.

The use of the 1965 Revision of the *International Classification of Diseases*, which brought together in one section the various forms of nutritional deficiencies, and the adoption of the multiple-cause approach to the study of mortality in this Investigation, have made it possible to arrive at these analyses and provide an epidemiologic description of nutritional deficiency by type as well as age at death. Such analyses should lay the foundation for new and effective approaches to the study of measures for prevention of such deficiency.

Interrelationships of Causes

The various patterns of mortality due to diarrheal disease as underlying cause in the first year of life were shown elsewhere in the report of the Investigation,[7] while this account has presented similar data for nutritional deficiency as underlying or associated cause. The patterns for these two important diseases of childhood are brought together in Figures 11 and 12, by three-month age groups in the first year of life.[8]

Figure 11 presents the rates for 10 projects. In the first four (Recife, Chaco Province, São Paulo, and Monterrey) diarrheal disease mortality was very high in the first three months of life and decreased sharply in infants 6-8 months and 9-11 months of age. A somewhat different pattern is observed for nutritional deficiency. In Recife and São Paulo the rates were lower than those for diarrheal disease in the first three months but were higher in infants aged 6-8 months and 9-11 months, thereby showing a delayed effect of the nutritional deficiency. Actually, in Recife the total number of infant deaths from nutritional deficiency as underlying or associated cause (1,080) was only slightly less than the number from diarrheal disease (1,141). The same was noted in São Paulo (with 1,062 and 1,149 deaths, respectively). The study of clinical records revealed that in many infants the nutritional deficiency resulted from repeated episodes of diarrheal disease; their deleterious effects caused the deficiency weeks or months after such episodes, and the final episode became fatal for the already malnourished infant. It is thus possible to see the interrelationship of these two causes. In other cases the diarrheal disease resulted in the deaths of very young infants whose poor nutritional states were probably the result of low birth weight, among other determining factors.

In five of the other projects shown in Figure 11 (Cali, Bolivia, Medellín, Cartagena, and Kingston-St. Andrew), different patterns were found. Excessive rates from diarrheal disease were not noted in the first three months of life.

[7] Chapter VIII of *Patterns of Mortality in Childhood* (*1*).

[8] Table 98 of the report (*1*) provides the detailed data for these two diseases.

FIGURE 11–Infant mortality from diarrheal disease and nutritional deficiency by three-month age groups in 10 projects.

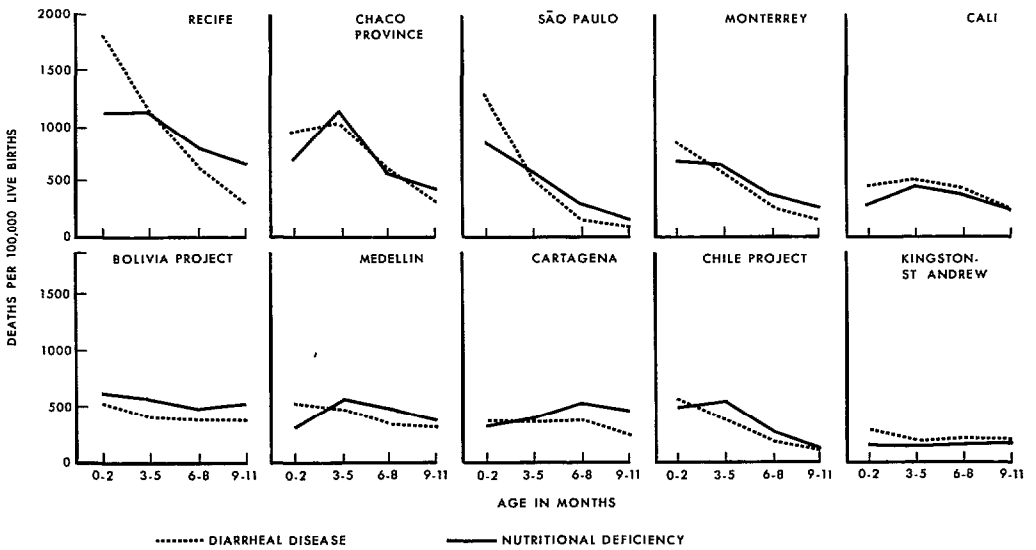
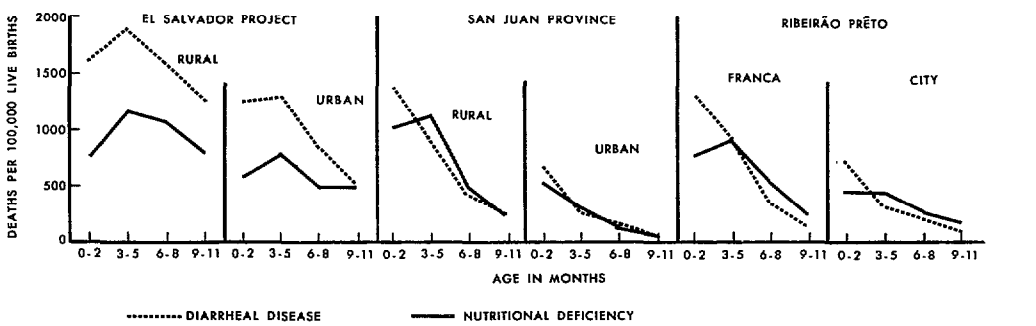


FIGURE 12–Infant mortality from diarrheal disease and nutritional deficiency by three-month age groups in specific areas of three projects.



In these projects breast feeding was more commonly practiced and was continued longer than in the Brazilian projects. The pattern for nutritional deficiency was also different in these projects, showing only small variations. In the project in Chile the patterns for both diarrheal disease and nutritional deficiency were similar to those in Recife and São Paulo, though the rates were much lower.

Two projects–El Salvador and San Juan Province–had sufficient data to illustrate the differences in rates in urban and rural areas, and in Ribeirão Prêto the differences between an interior city (Franca) and the city of Ribeirão Prêto (which had more medical facilities and better environmental conditions) can be shown (Figure 12). Diarrheal disease rates were found to be much higher in rural areas than in the cities, the rural rates being about twice as high in the case of San Juan Province.

Mortality from nutritional deficiency was also greater in rural areas but in general followed a different pattern, the rates being highest among infants 3-5 months of age. The

TABLE 9–Nutritional deficiency as associated cause of death in children under 5 years of age (excluding neonatal deaths) by underlying cause group in 13 projects.

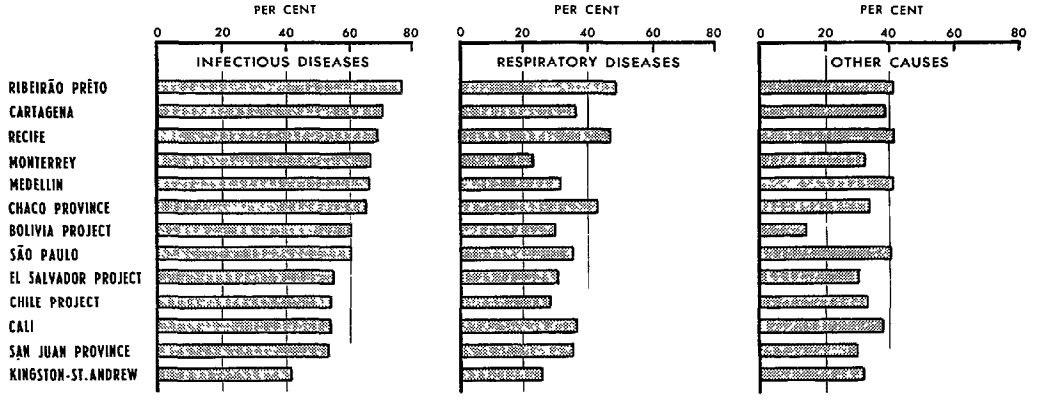
Cause group	Total deaths	With nutritional deficiency		Total deaths	With nutritional deficiency		Total deaths	With nutritional deficiency		Total deaths	With nutritional deficiency		Total deaths	With nutritional deficiency	
		No.	%		No.	%		No.	%		No.	%		No.	%
	ARGENTINA Chaco Province			ARGENTINA San Juan Province			BOLIVIA project			BRAZIL Recife			BRAZIL Ribeirão Prêto		
All causes	1,133	601	53.0	1,250	500	40.0	3,185	1,395	43.8	2,562	1,490	58.2	611	372	60.9
Infective and parasitic diseases	677	443	65.4	579	305	52.7	1,713	1,039	60.7	1,731	1,188	68.6	362	276	76.2
Diarrheal disease	548	365	66.6	410	238	58.0	964	657	68.2	1,122	766	68.3	278	217	78.1
Measles	53	32	60.4	96	34	35.4	578	288	49.8	396	294	74.2	46	31	67.4
Other	76	46	60.5	73	33	45.2	171	94	55.0	213	128	60.1	38	28	73.7
Nutritional deficiency	48			70			69			147			27		
Disease of respiratory system	225	96	42.7	343	119	34.7	1,061	311	29.3	383	177	46.2	91	43	47.3
Other causes	183	62	33.9	258	76	29.5	342	45	13.2	301	125	41.5	131	53	40.5
	BRAZIL São Paulo			CHILE project			COLOMBIA Cali			COLOMBIA Cartagena			COLOMBIA Medellín		
All causes	2,354	1,108	47.1	1,554	592	38.1	1,091	458	42.0	854	438	51.3	965	493	51.1
Infective and parasitic diseases	1,191	710	59.6	593	317	53.5	644	340	52.8	496	346	69.8	555	366	65.9
Diarrheal disease	844	529	62.7	473	252	53.3	486	249	51.2	300	190	63.3	394	249	63.2
Measles	156	74	47.4	21	11	52.4	80	51	63.8	105	91	86.7	89	69	77.5
Other	191	107	56.0	99	54	54.5	78	40	51.3	91	65	71.4	72	48	66.7
Nutritional deficiency	97			55			129			113			72		
Diseases of respiratory system	525	181	34.5	452	125	27.7	149	54	36.2	98	35	35.7	134	41	30.6
Other causes	541	217	40.1	454	150	33.0	169	64	37.9	147	57	38.8	204	86	42.2
	EL SALVADOR project			JAMAICA Kingston-St. Andrew			MEXICO Monterrey								
All causes	2,903	1,317	45.4	913	297	32.5	2,576	1,288	50.0						
Infective and parasitic diseases	2,073	1,123	54.2	420	172	41.0	1,564	1,042	66.6						
Diarrheal disease	1,667	876	52.5	351	148	42.2	933	595	63.8						
Measles	177	126	71.2	9	3	#	297	207	69.7						
Other	229	121	52.8	60	21	35.0	334	240	71.9						
Nutritional deficiency	179			67			90								
Diseases of respiratory system	375	111	29.6	130	32	24.6	503	110	21.9						
Other causes	276	83	30.1	296	93	31.4	419	136	32.5						

Percentage is not calculated when the base is less than 10.

delayed deleterious effect of diarrheal disease was thus clearly evident in this age period. As in the projects shown in Figure 11, the numbers of infant deaths from the two causes (diarrheal disease as underlying and nutritional deficiency as underlying or associated) were practically the same. These data of the Investigation thus indicate the seriousness of this complex of diarrheal disease-nutritional deficiency in rural areas of Latin America and probably in interior cities as well.

The relationship of nutritional deficiency as associated cause of death to three broad groups of underlying causes in the 13 Latin American projects can be seen in Table 9; these groups are infective and parasitic diseases (divided into diarrheal disease, measles, and other), respiratory diseases, and all other causes (excluding nutritional deficiency as underlying cause). Neonatal deaths have been excluded since they have a distinct pattern principally involving immaturity and other conditions present at birth (perinatal causes) and thus do not contribute to this analysis of interrelationships of nutritional deficiency and other causes. As is illustrated clearly in Figure 13, nutritional deficiency was an associated cause of higher proportions of deaths from infectious diseases than of deaths from either of the other groups of causes.

FIGURE 13—Frequency of nutritional deficiency as associated cause of death[a] by underlying cause group in 13 projects.



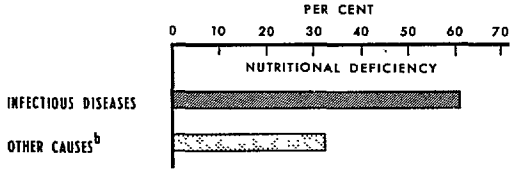
[a]Deaths under 5 years of age excluding neonatal deaths.

When the data for all 13 Latin American projects are combined, the synergistic action of infectious diseases and nutritional deficiency becomes evident (Table 10 and Figure 14).

TABLE 10—Nutritional deficiency as associated cause of death under 5 years of age (excluding neonatal deaths) by underlying cause group in 13 Latin American projects combined.

Underlying cause group	Total deaths	Nutritional deficiency as associated cause	
		No.	%
All causes	21,951	10,349	47.1
Infective and parasitic diseases	12,598	7,667	60.9
Diarrheal disease	8,770	5,331	60.8
Measles	2,103	1,311	62.3
Other	1,725	1,025	59.4
Nutritional deficiency	1,163		
Diseases of respiratory system	4,469	1,435	32.1
Other causes	3,721	1,247	33.5

FIGURE 14—Nutritional deficiency as associated cause of deaths due to infectious diseases and other causes in children under 5 years of age[a] in 13 Latin American projects combined.



[a]Excluding neonatal deaths.

[b]Respiratory diseases and other causes combined.

Nutritional deficiency was associated cause in 60.9 per cent of the deaths from infectious diseases, as compared with only 32.7 per cent of deaths from all other causes. These findings are in accord with previous research indicating the importance of the nutritional state of the host in the development of disease. For example, Schneider (*12, 13*) found that under certain conditions dietary factors were capable of influencing resistance to infectious disease in mice. Recently Scrimshaw, Taylor, and Gordon (*14*) provided a comprehensive review of the interaction of nutrition and infection. The Investigation provides the first extensive series of data on deceased children, based on the study of multiple causes, which show the frequent and serious involvement of nutritional deficiency with infectious diseases and its synergistic effects on those morbid conditions. The role of increased host susceptibility to such diseases can be measured by the degree in which nutritional deficiency is involved as an associated cause of death. As was pointed out in the report of the Investigation,[9] immaturity constitutes a state of high vulnerability particularly during the neonatal period. After this period, nutritional deficiency is an indicator of increased susceptibility to disease, as was shown in regard to measles. Infants and young children

[9]Chapter VI of the report (*1*).

with evidence of immaturity or nutritional deficiency are more susceptible to infection, and thus health programs must center on prevention of both infectious diseases and nutritional deficiency. Since immaturity and nutritional deficiency in infants may be at least partially due to deficient nutrition in the mother, particular emphasis should be placed also on the health of women in the reproductive period, especially during pregnancy. Infants of healthy mothers have better chances to be born with normal weight and with more resistance to infection.

Factors other than those mentioned in this account were also considered in relation to nutritional deficiency. A most important one was breast feeding, which was the subject of detailed analysis.[10] The extent of breast feeding was found to be limited; in three projects in Brazil and in El Salvador less than one half of the infants dying in the postneonatal period had been breast fed for at least one month, the lowest percentage (26.8) being that found in Recife, Brazil. Six months is the minimum period recommended for breast feeding; however, in the 13 Latin American projects combined only 18.4 per cent of the infants dying at 6-11 months of age had been breast fed for six months. The percentages of infants breast fed and never weaned who had nutritional deficiency as underlying or associated cause of death were lower than among infants breast fed not at all or for only limited periods. The high nutritional value of breast milk and the protection it affords against infection make it an important factor in preventing nutritional deficiency. Action at the community level to encourage breast feeding, with the active participation of organized groups and of health authorities, is an urgent need in developing areas. Mothers in those areas should be made to realize that breast feeding their young infants is vital for the child's survival, and for that reason should constitute an integral part of effective reproductive function.

[10] Chapter XIII of the report (*1*).

Discussion

What is now known about nutritional deficiency as well as about low birth weight and immaturity would seem to indicate that the deficient nutritional state of populations is perhaps the most important cause of excessive mortality in developing areas. A kind of vicious cycle is established whereby mothers who have been handicapped since early life by nutritional deficiency and other environmental factors may give birth to low-weight infants. Many of these infants die from infectious diseases because of their increased vulnerability, and those who survive continue being at greater risk of the hazards of the environment and of nutritional deficiency than those born with satisfactory weight. Measured in terms of mortality and reproductive wastage, the effects of inadequate nutrition on communities are exceedingly grave, especially in women who have numerous pregnancies. The consequences of this complex cycle are much more serious when the impact on the child's intelligence and adaptive capacity is taken into account. Evidence of this impact is accumulating (*11*). A review of current knowledge about malnutrition and its effects on brain and behavior was published recently by the Pan American Health Organization (*15*) in a volume incorporating the research papers presented and discussions conducted at a seminar held in Jamaica in January 1972.

Measures to break this vicious cycle through adequate nutrition of future mothers and their offspring and through reduction of biological wastage are mandatory in order to safeguard the health and intelligence of children.

Summary

In the Inter-American Investigation of Mortality in Childhood carried out in 25 different areas in 15 projects in the Hemisphere in the years 1968-1972, 35,095 deaths were in-

vestigated through the study of hospital and autopsy records and through interviews conducted in the homes of deceased children under 5 years of age. The analysis of multiple causes of death proved essential in order to reveal the interrelationships of causes and to gain a fuller understanding of the determinants of excessive mortality in infancy and early childhood.

Of the 35,095 deaths of children under 5 years of age in the 15 projects, 19,994 or 57.0 per cent were found to be due to immaturity or nutritional deficiency as underlying or associated causes. In several areas two-thirds of the deceased children had such evidence of increased vulnerability to disease and high risk of death.

In nearly all the Latin American areas mortality from nutritional deficiency was higher than that from immaturity. Since immaturity is assigned principally as a cause of neonatal deaths, these high rates for nutritional deficiency indicate that the impact of the lack of growth and development was even greater after the neonatal period.

Data on nutritional deficiency in the 13 Latin American projects, presented by age at death, clearly revealed the seriousness of the problem among infants under one year of age. To give a clear picture of mortality by age, death rates were shown by month of age for the first two years of life. In six projects, rates from this cause were excessive, principally in the first year of life. They continued to be relatively high in the first two years of life in six other projects. In the rural areas of El Salvador the rates continued to be relatively high throughout the first five years. Comparisons within projects showed that mortality was much higher in rural areas than in cities, a finding that is of key importance for health planning and further research. Health problems such as this in rural areas must be brought fully to light so that solutions may be sought.

The types of nutritional deficiency responsible for deaths under 5 years of age were analyzed for the first time. Protein malnutrition, or kwashiorkor (category 267 of the *International Classification of Diseases*), was assigned as a cause of 13.1 per cent of the total deaths from nutritional deficiency in the 13 Latin American projects, and nutritional marasmus (category 268) in 21.4 per cent. The roles of the various types of deficiency were shown first for the 13 projects and then for the projects combined. The rates for all types combined were highest at 2 and 3 months of age, and then declined in the older age groups.

While mortality from protein malnutrition increased to the highest rates in the second year of age, the rates for nutritional marasmus reached a peak at 2 and 3 months of age and then gradually declined. Some of the survivors of nutritional marasmus probably later developed protein malnutrition and thus the damage was laid in this early period of life.

Study of the relationship of nutritional deficiency as associated cause of death to three broad groups of underlying causes in the 13 Latin American projects (excluding neonatal deaths) revealed the synergistic action of infectious diseases and nutritional deficiency. The latter was an associated cause of 60.9 per cent of deaths from infectious diseases, compared with 32.7 per cent of deaths from all other causes.

The data obtained on nutritional deficiency as well as on low birth weight and immaturity would seem to indicate that the deficient nutritional state of populations is perhaps the most important cause of excessive mortality in developing areas. Mothers who have been handicapped since early life by nutritional deficiency and other environmental factors probably give birth to low-weight infants; many of these infants die from infectious diseases because of their increased vulnerability, while those who survive continue being at greater risk of the hazards of the environment and of nutritional deficiency. The consequences of this complex cycle are much more serious when the impact on the child's intelligence and adaptive capacity is taken into account. Measures to break this cycle through adequate nutrition of future mothers and their offspring are mandatory in order to protect the health and intelligence of the child population.

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Appendix

List of Persons Who Assisted in the Preparation of the Report of the Inter-American Investigation of Mortality in Childhood

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