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BIRTHWEIGHT, MATERNAL AGE, AND BIRTH ORDER:

Three Important Determinants in Infant Mortality

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PAN AMERICAN HEALTH ORGANIZATION
Pan American Sanitary Bureau, Regional Office of the
WORLD HEALTH ORGANIZATION

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BIRTHWEIGHT, MATERNAL AGE, AND BIRTH ORDER: THREE IMPORTANT DETERMINANTS IN INFANT MORTALITY

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SPECIFIC AREAS, METHOD OF SELECTION OF DEATHS, TIME PERIOD, AND ESTIMATED POPULATION BASES FOR TWO YEARS[a] FOR 15 PROJECTS[b] OF THE INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD

Country, central city, and other area	Selection of deaths of residents	Time period[a]	Estimated population base (two years)				
			Under 5 years	1–4 years			Live births
				Total	1 year	2–4 years	
ARGENTINA							
1. Chaco Province Project—Total			76,800	60,320	15,940	44,380	17,600
Resistencia (urban), San Fernando Department	All	Aug. 1968—July 1970	41,740	32,530	8,940	23,590	9,800
Rural departments: Comdte. Fernández, Genl. Donovan, Libertad, Presidencia de la Plaza, 1 de Mayo, Quitilipi	All	Aug. 1968—July 1970	35,060	27,790	7,000	20,790	7,800
2. San Juan Province Project—Total			104,460	84,180	21,040	63,140	23,360
San Juan (urban), Capital Department	All	Aug. 1968—July 1970	25,240	20,220	5,060	15,160	5,820
Suburban departments: Chimbas, Rawson, Rivadavia, Santa Lucia	All	Aug. 1968—July 1970	35,540	28,620	7,160	21,460	7,920
Rural departments: Rest of Province	All	Aug. 1968—July 1970	43,680	35,340	8,820	26,520	9,620
3. BOLIVIA Project							
La Paz (urban)	All	July 1968—June 1970	154,700	120,100	33,100	87,000	36,760
Viacha (rural community)	All	July 1968—June 1970	3,350	2,580	710	1,870	850
BRAZIL							
4. Recife Project—Three urban districts: Beberibe, Casa Amarela, Encruzilhada	All	July 1968—June 1970	123,910	95,810	26,820	68,990	30,400
5. Ribeirão Prêto Project							
Ribeirão Prêto (city)	All	July 1968—June 1970	42,630	33,670	8,810	24,860	9,310
Franca (interior city)	All	July 1968—June 1970	22,340	17,550	4,650	12,900	5,090
Communities (suburban-rural): Batatais, Brodosqui, Cravinhos, Jardinópolis, Sertãozinho	All	July 1968—June 1970	17,530	13,850	3,610	10,240	3,840
6. São Paulo Project (urban)	1 in 4.25	June 1968—May 1970	243,710	188,400	54,140	134,260	58,160
CANADA							
7. Sherbrooke Project[c]	All	Jan. 1970—Dec. 1971	91,060	74,320	17,000	57,320	16,970
8. CHILE Project							
Santiago (urban)	1 in 5 1 in 3	July 1968—Feb. 1969 Mar. 1969—June 1970	191,650	154,500	37,130	117,370	40,180
Comunas (suburban-rural): Colina, Lampa, Quilicura, Til-Til	All	July 1968—June 1970	16,120	13,000	3,120	9,880	3,400
COLOMBIA							
9. Cali Project (urban)	1 in 2 1 in 3	July 1968—June 1969 July 1969—June 1970	101,200	80,900	20,200	60,700	21,100
10. Cartagena Project (urban)	All	July 1968—June 1970	86,000	68,800	17,200	51,600	17,900
11. Medellín Project (urban)	1 in 3	July 1968—June 1970	93,300	74,600	18,600	56,000	19,400
12. EL SALVADOR Project							
San Salvador (urban)	All	Sept. 1968—Aug. 1970	103,860	80,040	22,850	57,190	25,620
Rural municipios: Apopa, Nejapa, Quezaltepeque	All	Sept. 1968—Aug. 1970	21,430	16,550	4,510	12,040	5,400
JAMAICA							
13. Kingston-St. Andrew Project—Total			183,240	143,570	39,110	104,460	40,960
Metropolitan Kingston (urban)	All	June 1968—May 1970	167,530	131,260	35,770	95,490	37,450
St. Andrew, rural	All	June 1968—May 1970	15,710	12,310	3,340	8,970	3,510
MEXICO							
14. Monterrey Project (urban)	All 2 in 3 1 in 2	Aug. 1968—July 1969 Aug. 1969—Jan. 1970 Feb. 1970—July 1970	217,940	169,820	45,020	124,800	53,010
UNITED STATES							
15. California Project							
San Francisco (urban)	All	June 1969—May 1970	43,050	32,800	8,500	24,300	11,310
Suburban sections of Alameda, Contra Costa, and San Mateo counties	All	June 1969—May 1970	160,610	128,180	31,530	96,650	33,430

[a] Two years, except for the California project (one year).

[b] The 15 projects are listed by the name (shown in bold face in this table) that will be used in referring to them throughout this report. For four projects—the Bolivia project, Chile project, El Salvador project, and California project—these names will be used when reference is made to the combination of urban, suburban, and rural areas included in those projects.

[c] The Sherbrooke project includes a large rural area but the number of deaths is too small for subdivision and the project is included with the cities.

BIRTHWEIGHT, MATERNAL AGE, AND BIRTH ORDER: THREE IMPORTANT DETERMINANTS IN INFANT MORTALITY

Introduction

Identification of the major factors involved in infant mortality was a goal of the Inter-American Investigation of Mortality in Childhood–an undertaking in which more than 35,000 deaths in infants and children under 5 years of age from 15 project areas widely spaced throughout the Americas were carefully studied. In each of the 13 Latin American projects the details related to the deaths occurring over a two-year period in this age group were subjected to intensive examination. Two additional projects, one in the United States and the other in Canada, were added for purposes of comparison. The respective dates covered, together with information on the estimated population base and the deaths investigated, are given in the frontispiece table.

As soon as a death occurred and was known to the project staff, a nurse or social worker made a visit to the home to obtain specific data regarding the parents, the mother's reproductive history, prenatal care, the delivery, breast-feeding, and the medical care received by the child. After this information was obtained, a medical interviewer then sought clinical and pathological data in the hospital, health center, and/or private physician's office where medical attention had been provided. If information was not available or was unsatisfactory, the medical interviewer visited the home to get a history of the child's illnesses.

Usually the death certificate was the starting point, but early in the program deficiencies in the registration of deaths, especially those in the first days of life, became evident. Consequently, intensive searches were initiated to uncover all unregistered deaths so that they might be included in the Investigation. This work resulted in the discovery of 1,667 from the neonatal period and 440 from the postneonatal–a total of 2,107 infant deaths, or 7.6 per cent of all those studied. The important subject of registration, with recommendations for its improvement, is discussed in several of the reports on the Investigation (*22,23,26*). The past medical history and record of the child's fatal illness, including the results of laboratory and other examinations, were sought from all possible sources in order to determine the underlying or associated causes of death–that is to say, the multiple causes.[1]

A full report of the findings from the Investigation was published by the Pan American Health Organization in 1973 (*22*). Its section on reproductive

[1] A full explanation of these procedures is given in the 1973 report of the Investigation (*22*).

patterns presents data on maternal age and birth order for the deceased infants in the 15 projects. Neonatal and infant death rates according to maternal age group were provided for seven projects and according to birth order for four–it only being possible to present them for the projects in which the distribution of live births by maternal age and by birth order was available.

The Investigation produced considerable additional information of value for studies in greater depth of specific subjects such as reproductive patterns, registration problems (*23,26*), the interrelationships of different possible determining factors (*24*), and outcome of pregnancy (*26*). The present paper undertakes, on the basis of the data on deaths in children under 1 year of age, an analysis in depth of three important determinants of infant mortality–namely, birthweight, maternal age, and birth order–for eight of the projects.[2] A tabulation of live births by maternal age group and by birthweight became available for Ribeirão Prêto later in 1973.[3] Also, special cross-tabulations of live births by birth order according to maternal age group prepared in Chile,[4] El Salvador,[5] and California[6] have added to the present analysis of these important factors in combination.

References are made to previous studies in which the three factors have been analyzed–principally those conducted on the United States birth cohorts of 1950 and 1960 (*1,2,3,16,27*) and in New York State (*33*), eight cities of the United States (*29*), and England and Wales (*10,11*). Finally, comparisons are made with the findings reported in a 1973 publication on the 1968 live birth cohort in New York City (*4,13*), which reveal similarities in several aspects with the results from the Inter-American Investigation and clearly support the emphasis that is being placed on these three determinants, especially birthweight.

The data from the Inter-American Investigation definitely indicate the importance of the mother's age and parity as determinants in the survival and future health of the child. Mortality has been observed to be excessive in infants born to mothers at the younger and older ends of the reproductive age range and also to increase in general with ascending birth order (*10,11,29,33*). In several studies the two factors have been combined in evaluating the risks. Birthweight was also analyzed in the valuable U.S. cohort studies for 1950 and 1960 mentioned above. There seems to be no doubt that these three important factors–birthweight, maternal age, and birth order–need to be evaluated in combination in order to understand their relative role in infant mortality with special reference to the Americas.

In order to determine the respective risks of death due to these three specific factors, it is essential to know the distribution of live births in order

---

[2]Chaco Province (R. A. Castro) in Argentina, Ribeirão Prêto (J. R. Teruel) and São Paulo (R. Laurenti) in Brazil, Sherbrooke (L. Munan) in Canada, Chile (A. Legarreta), El Salvador (E. Suárez M.), Monterrey (D. Aceves S.) in Mexico, and California (H. M. Wallace) in the United States of America. (Principal collaborators' names in parentheses.)

[3]J. R. Teruel, principal collaborator for the project, personal communication.

[4]National Health Service, personal communication, 1973.

[5]National Bureau of Statistics and Census, personal communication, 1973.

[6]State Department of Health, personal communication, 1972.

to serve as a basis. With regard to maternal age and birth order, the Inter-American Investigation was able to obtain the necessary information for several of the project areas, as mentioned above. The role of the third, birthweight, was revealed in the analysis of multiple causes, which permitted, among other advantages, the calculation of death rates from immaturity according to both birth order and maternal age. Thus, the relative risks for all three factors in combination could be established.

While immaturity[7] is a measure of growth and development at the time of birth, nutritional deficiency is usually considered evidence of deficits in growth and development after birth (although it can frequently exist during intrauterine life as well). Infant mortality in which these two important causes are involved can now be analyzed in relation to both birth order and maternal age for several project areas of the Investigation. The results are so revealing, and so demonstrative of the value of this approach, that recommendations are made for routine collection of the necessary basic data and their analysis in large maternities as well as in municipal, state, and national services. Knowledge of these risks should be extremely useful in the development of preventive programs.

Infant Mortality by Age of the Mother

Data on live births by age of the mother are available for eight of the projects in the Inter-American Investigation of Mortality in Childhood. For seven of them the information was included in Chapter XII of the 1973 published report on the Investigation (*22*). For the eighth, Ribeirão Prêto, tabulations were completed later in 1973. Consequently it is now possible to analyze neonatal and infant mortality[8] in terms of this important factor.

The eight projects varied widely in their level of birth rates per 1,000 population:

El Salvador project	40.4
Monterrey project	39.8
Chaco Province project	33.7
Ribeirão Prêto project	27.5
Chile project	26.1
São Paulo project	24.8
California project	16.3
Sherbrooke project	15.2

As it can be seen, the U.S. and Canadian projects had the lowest rates, while at the other extreme the rates were high in the Monterrey and El Salvador projects. These marked differences were reflected in the distribution of births by age of the mother.

[7]The definition of *immaturity*–birthweight of 5-1/2 pounds (2,500 grams) or less or specification as "immature" on the basis of clinical diagnosis–is explained fully on page 7.

[8]*Infant mortality*, which refers to death occurring in the first year of life, is divided into *neonatal mortality* (death in the first 27 days of life) and *postneonatal mortality* (28 days through 11 months).

Table 1. Neonatal and infant mortality by maternal age,[a] in eight projects of the Inter-American Investigation of Mortality in Childhood (deaths per 1,000 live births).

Maternal age in years	Chaco Province project	Ribeirão Prêto project	São Paulo project	Sherbrooke project	Chile project	El Salvador project	Monterrey project	California project
	Neonatal mortality							
Total	32.3	28.2	33.7	13.5	26.6	29.6	26.0	12.7
Under 20	53.4	36.2	52.3	16.4	31.7	40.7	33.1	17.2
20-24	28.3	23.9	32.1	12.6	24.2	26.2	23.9	11.7
25-29	26.6	25.3	28.7	12.9	23.2	23.7	20.7	11.3
30-34	31.9	28.8	34.3	16.1	29.9	27.6	27.2	12.7
35 and over	27.1	38.0	37.2	12.8	30.2	34.5	34.1	14.0
	Infant mortality							
Total	80.1	52.6	65.1	18.3	55.2	88.4	60.7	17.5
Under 20	133.5	72.1	104.1	21.2	79.3	116.6	86.3	26.2
20-24	76.6	48.5	67.9	18.6	51.7	84.2	59.7	15.9
25-29	60.5	43.4	53.2	16.5	44.5	72.9	47.0	15.3
30-34	69.4	50.5	61.4	18.3	54.1	81.3	56.8	16.5
35 and over	72.8	68.0	67.4	20.3	59.8	93.6	77.4	17.5

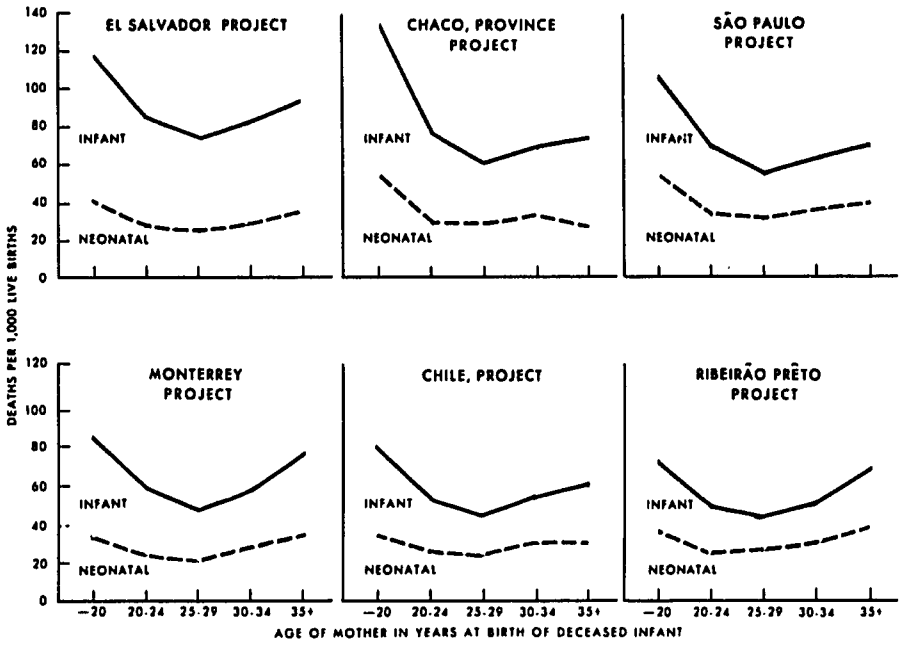
[a]At birth of the deceased infant. Deaths for which the mother's age at the time of birth was not stated have been distributed proportionally in accordance with those for which the maternal age was known.

The bases for the rates—that is, the distribution of live births by age of the mother—were provided in four projects (Chaco Province, São Paulo, Sherbrooke, and Monterrey) from local sources by the principal collaborators as part of the Investigation. For two projects—Chile (*5*) and El Salvador (*7*)—the tabulations by maternal age were available in published form. With respect to the seventh, California, the State Department of Health prepared a table especially for use in the Investigation. Finally, in the case of Ribeirão Prêto the principal collaborator obtained and tabulated data on maternal age and birthweight for 15,867 live hospital births, or 87 per cent of the births in the project area, completing the earlier work done in 1973. Inasmuch as hospitals are routinely used for deliveries there, with 95.1 per cent of the babies dying in infancy having been born in hospitals in the city of Ribeirão Prêto, the distribution is believed to approximate that of all live births. The births for which the maternal ages were not known were distributed in the same proportions as those for which they were known. Although the quality of the information may vary from one project to another, possibly owing in part to inaccuracies in recording the maternal ages, the general consistency of the results bears out the value of the findings.

Neonatal and infant mortality[9] by five maternal age groups is given for the eight projects in Table 1. Figure 1 shows these rates graphically for the six Latin American projects, starting at the top left with the El Salvador one,

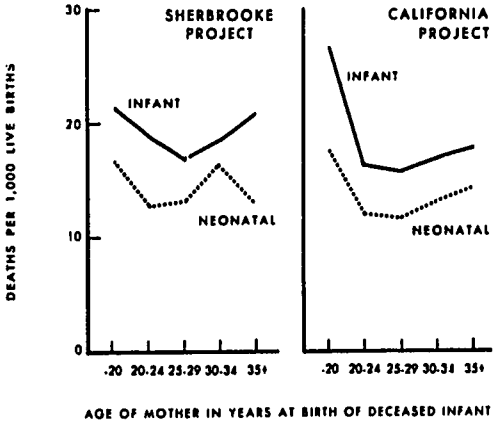
[9]In the Investigation efforts were made to include nonregistered as well as registered deaths. Many of the nonregistered deaths would also be nonregistered births. Although the omission may not be large in terms of the number of live births, the completeness of registration of live births as well as of infant deaths is an important factor to consider in interpreting these rates.

Fig. 1
NEONATAL AND INFANT MORTALITY BY MATERNAL AGE
IN SIX LATIN AMERICAN PROJECTS OF THE INTER-AMERICAN
INVESTIGATION OF MORTALITY IN CHILDHOOD



which had the highest infant death rate (88.4 per 1,000 live births), and proceeding in descending order to Ribeirão Prêto, which had the lowest (52.6), at the bottom right. Figure 2 shows the situation for the Sherbrooke and California projects, where the respective infant death rates were lower than in the six from Latin America. In all eight projects the rates were higher

Fig. 2
NEONATAL AND INFANT MORTALITY BY MATERNAL AGE
IN THE SHERBROOKE AND CALIFORNIA PROJECTS
OF THE INTER-AMERICAN INVESTIGATION
OF MORTALITY IN CHILDHOOD



for young mothers (under 20 years) than for the other four age groups (although in Ribeirão Prêto and Sherbrooke they were only slightly higher than for mothers 35 and over). The lowest rates were for mothers 25-29 years old, and hence this maternal age span would appear to be the most favorable one.

The excessive death rates among infants born to mothers under 20 years of age require further study. These rates, which reached as high a level as 133.5 per 1,000 live births in Chaco Province, are shown below in descending order. The column at the right indicates the percentage of all live births in this age group.

	Infant death rate	*Percentage of live births*
Chaco Province project	133.5	16.0
El Salvador project	116.6	18.3
São Paulo project	104.1	8.1
Monterrey project	86.3	9.9
Chile project	79.3	14.3
Ribeirão Prêto project	72.1	11.8
California project	26.2	15.8
Sherbrooke project	21.2	6.6

As it can be seen, in five of the projects young mothers had more than 10 per cent of the live births. The highest figure is for the El Salvador project, where it was 18.3 per cent, while at the other extreme in the Sherbrooke project it was only 6.6 per cent.

In Figure 1 wide differences between the neonatal and infant death rates are seen for the first four projects. They are due to high mortality in the postneonatal period. The postneonatal death rates (difference between neonatal and infant) were somewhat smaller in the Chile and Ribeirão Prêto projects and much smaller in the Sherbrooke and California projects. In areas where infant death rates were high, the excessive mortality was concentrated mainly in the postneonatal period. Although the excessive postneonatal mortality is usually attributed to unfavorable environmental conditions, some of it could be due to low (2,500 grams or less) or deficient (2,501-3,000 grams) birthweights, with concomitantly reduced frequency of the birthweights most favorable for survival (3,501-4,000 grams). Owing to their biological condition, infants with low or deficient birthweight start extrauterine life with increased susceptibility to infections and nutritional deficiency.

Immaturity and maternal age

It is well known that low-weight births (2,500 grams or less) occur frequently in young mothers (*1,3,16,29*). For two of the projects, Ribeirão Prêto and Sherbrooke, the percentages of low-weight births are now available by maternal age. In each case the data were furnished recently from local sources by the principal collaborators.[10] Table 2 gives these figures for the

[10] J. R. Teruel, personal communication, 1973, and L. Munan, personal communication, 1974.

Table 2. Percentage of low-weight live births by maternal age,[a] Ribeirão Prêto and Sherbrooke projects of the Inter-American Investigation of Mortality in Childhood and United States 1960 birth cohort.

Age of Mother	Ribeirão Prêto project	Sherbrooke project	United States 1960[b]
Total	8.7	7.6	7.8
Under 20	11.7	9.8	10.1
20-24	7.8	7.4	7.5
25-29	8.1	7.1	7.0
30-34	9.2	7.5	7.5
35 and over	9.0	7.9	8.1

[a]At birth of the infant.
[b]Source: H.C. Chase (3).

two projects and also for the United States birth cohort of 1960 (*3*)[11] for purposes of comparison.

The figure of 8.7 per cent for Ribeirão Prêto is the first concrete evidence of a high frequency of low-weight births in one of the Latin American projects, although the distributions of neonatal deaths in hospitals given in the 1973 published report already indicated that low-weight births were occurring more frequently in the Latin American projects than in the United States and European countries. In "low-rate" countries (*2*) such as the Netherlands, Sweden, and New Zealand, infants weighing 2,500 grams or less constitute only 5 per cent of the live births, whereas preliminary tabulations of live births in large maternity services in Recife and San Salvador point to levels of around 15 per cent.

In the Ribeirão Prêto and Sherbrooke projects and in the United States in 1960 births of 2,500 grams or less occurred more frequently among mothers under 20 years of age (11.7, 9.8, and 10.1 per cent, respectively) than in the other age groups. The percentages were markedly lower for births among mothers in the 20-24-year age group (7.8, 7.4, and 7.5 per cent, respectively), following which there was again a slightly rising trend, increasing usually with each successively older group. The differences in the older age groups were not great in Sherbrooke and the United States, but they were consistent with the pattern shown in the large series for the United States.

As it was mentioned earlier, the multiple-causes approach used in the Investigation made it possible to gain an insight into the role of low birthweight in infant mortality. The following definition of immaturity has been given in the WHO International Classification of Diseases (*30*): "For the purpose of this Classification an immature infant is a liveborn infant with a birthweight of 5-1/2 pounds (2,500 grams) or less, or specified as "immature." Immaturity (Category 777 of the International Classification–*31*) was assigned as an underlying or associated cause of death when

[11]Although more recent data on birthweight are available from the U.S. Department of Health, Education, and Welfare's annual publication *Natality*, the distribution for 1960 is used here since other data for the 1960 birth cohort (*3*) are also referred to in the present paper.

the infant was known to be immature clinically and/or according to the WHO definition. Clinical diagnoses of immaturity were frequently available when the birthweights were not. The assignment of immaturity as an underlying or associated cause has revealed the seriousness of the problem of low birthweight.

Table 3 gives the death rates from immaturity as an underlying or associated cause in the eight projects. While these rates were around 10 per 1,000 live births in the California and Canadian projects, they were twice as high in three of the Latin American ones (Ribeirão Prêto, 19.1; São Paulo, 21.0; and Chile, 19.1). Such high death rates from immaturity were

Table 3. Infant mortality due to nutritional deficiency and to immaturity as underlying or associated cause by maternal age,[a] in eight projects of the Inter-American Investigation of Mortality in Childhood (deaths per 1,000 live births).

Maternal age in years	Chaco Province project	Ribeirão Prêto project	São Paulo project	Sherbrooke project	Chile project	El Salvador project	Monterrey project	California project
	Nutritional deficiency							
Total	27.6	16.4	18.3	0.4	12.8	25.6	18.9	0.5
Under 20	47.2	23.4	29.6	-	22.2	29.4	29.5	1.2
20-24	29.5	17.2	20.1	0.2	10.9	25.9	18.0	0.3
25-29	19.6	12.1	13.8	0.4	9.6	22.7	13.8	0.4
30-34	21.0	13.2	16.3	-	11.9	22.8	16.9	0.2
35 and over	23.3	21.3	20.0	1.4	15.1	28.0	26.2	0.4
	Immaturity							
Total	17.3	19.1	21.0	9.8	19.1	17.9	13.7	10.1
Under 20	28.6	25.1	39.0	16.4	24.2	27.8	20.1	15.3
20-24	17.5	16.2	20.0	8.7	18.3	17.5	12.5	8.9
25-29	14.0	16.2	17.0	9.7	16.4	13.3	11.1	8.3
30-34	18.0	23.2	20.7	10.5	19.8	14.1	14.6	10.2
35 and over	10.8	22.6	22.5	9.2	20.1	17.0	15.5	12.5

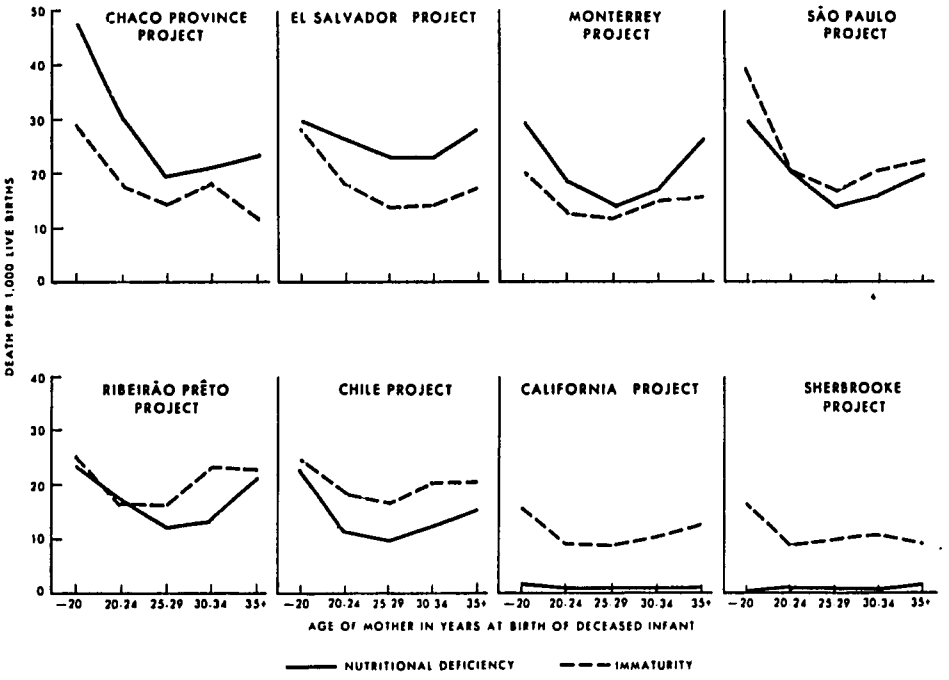
[a]At birth of the deceased infant. Deaths for which the mother's age at the time of birth was not stated have been distributed proportionally in accordance with those for which the maternal age was known.

unexpected. The discovery and inclusion in the Investigation of nonregistered deaths was largely responsible for the uncovering of this serious health problem. An example from the Chile project illustrates the effect of the inclusion of such deaths: in Santiago the neonatal death rate from immaturity as reported in the Investigation (*22*) was 19.7 per 1,000 live births, whereas if only the registered deaths for the same period had been used it would have been 12.2.

Table 3 and Figure 3 also show the breakdown of the rates by age of the deceased infant's mother. In general they were lowest in the 25-29 maternal age group and tended to increase thereafter.[12] In all the projects they were high for mothers under 20 years of age (shown by the broken lines in the figure). Several explanations for these differences in mortality may be given. In the first place, the frequency of immature births may be greater in the

[12]Exceptions were noted in the Chaco Province and Sherbrooke projects, which may be attributed in part to the small numbers involved.

Fig. 3
INFANT MORTALITY DUE TO NUTRITIONAL DEFICIENCY AND TO IMMATURITY AS UNDERLYING OR ASSOCIATED CAUSE BY MATERNAL AGE, IN EIGHT PROJECTS OF THE INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD



case of young mothers because of biologic conditions that interfere with the replenishment of reserves—for example, inadequate development or shorter intergestational intervals. Also, unfavorable social conditions such as unwanted pregnancies, unstable marital unions, inexperience, and less knowledge and/or interest in pre- and postnatal care may be more serious in this age group and thus pose an increased threat to the infant's survival. Finally, the frequency of extremely low-weight births—that is, those of 1,500 grams or less, in which the risk of death is very great—may be higher in young mothers.

The wide variation in mortality from immaturity among infants born to young mothers in the eight project areas—from 15.3 in California to 39.0 per 1,000 live births in São Paulo—is due undoubtedly to differences in the nature and severity of the causes and factors that bear on the frequency of low birthweight, including the availability and quality of medical care during the prenatal, natal, and postnatal periods.

Nutritional deficiency and maternal age

In addition to immaturity, nutritional deficiency is an indicator of deficits in growth and development observed after birth. The presentation of immaturity and nutritional deficiency together in this analysis is advisable for several reasons. Immaturity was assigned as one of the multiple causes of

death (usually an associated cause) when it was clinically evident or when the hospital records indicated a low birthweight. If the birth did not occur in a hospital, if the weight was not recorded immediately, or if there was no clinical evidence of immaturity and yet there was evidence of a deficit in growth and development at the time of death, then one of the categories of nutritional deficiency (260-269) was assigned as the underlying or associated cause. Although the dividing line of 2,500 grams is used in the definition of immaturity, birthweights of from 2,501 to 3,000 grams are still unfavorable for satisfactory growth, development, and survival. The proportion of infants born within this latter range seems to be significantly greater in the Latin American countries, representing a sizable percentage of all live births. These low and deficient weights are probably the result of abnormal maternal conditions, especially poor nutritional state, prior to and during pregnancy. Such weights constitute an important factor which, together with adverse environment, predisposes to nutritional deficiency and probably elevates mortality during the postneonatal period. Thus to some extent immaturity and nutritional deficiency are both measures of the same problem. The data on these causes have been processed with only one assignment for each death, either immaturity (777) or nutritional deficiency (260-269). In the neonatal period the category assigned was usually immaturity, whereas in the postneonatal period it was usually nutritional deficiency.

Infant death rates from nutritional deficiency by maternal age are shown by solid lines in Figure 3, while those from immaturity are indicated with broken lines. In Chaco Province, El Salvador, and Monterrey the rates from nutritional deficiency were higher than those from immaturity, whereas in the other three Latin American projects they were generally lower and in California and Sherbrooke they were insignificant. The differences in these patterns are puzzling. In all the Latin American projects the young mothers had high infant death rates from both nutritional deficiency and immaturity. On the other hand, the rates corresponding to nutritional deficiency were relatively high for all maternal age groups, indicating that the problem is not limited to young mothers. These findings point to serious health problems in infancy which require greater in-depth study of the interrelationships among the different factors that have just been discussed.

Infant Mortality by Birth Order

For five projects of the Investigation it is possible to analyze infant mortality according to birth order.[13] The 1973 published report (*22*) provided the necessary data on the California and Sherbrooke projects and

[13]*Birth order* as used in this paper refers to total birth order—that is, taking into account all products of pregnancy, including fetal deaths as well as live births. Fetal deaths were usually stated in the reproductive histories obtained in the home interviews of mothers of deceased infants. The completeness of inclusion of fetal deaths in the bases depended in part on the instructions in the registration systems in the respective areas. For the California project, however, the base took into account live births only.

Table 4. Neonatal and infant mortality by birth order,[a] in five projects of the Inter-American Investigation of Mortality in Childhood (deaths per 1,000 live births).

Birth order	Sherbrooke project		Chile project		El Salvador project		Monterrey project		California project	
	Neonatal	Infant	Neonatal	Infant	Neonatal	Infant	Neonatal	Infant	Neonatal	Infant
Total	13.5	18.3	26.6	55.2	29.6	88.4	26.0	60.7	12.7	17.5
1	9.6	12.6	19.9	39.4	22.7	60.9	19.5	40.5	8.9	12.8
2	10.7	16.3	22.8	47.8	24.8	72.3	18.9	48.4	12.1	16.7
3	18.8	23.7	27.7	57.8	28.1	81.0	19.4	49.7	16.2	22.0
4	21.1	27.3	32.3	67.0	28.6	86.8	23.9	50.9	21.8	28.9
5 or higher	22.3	30.5	42.4	90.6	48.4	160.3	38.1	90.0	23.5	30.6

[a]Deaths for which the birth order was not stated have been distributed proportionally in accordance with those for which the order was known.

two Latin American ones (Chile and Monterrey). In addition, data on live births by birth order according to maternal age have since been provided for the El Salvador project.[14] The quality of the data made available for the bases could undoubtedly be improved. Some of the differences in rates may be due to discrepancies in the transcription of data from the birth certificates and in the recording of reproductive histories as part of the Investigation.

Table 4 gives the neonatal and infant death rates by birth order for the five projects, while Figure 4 shows them graphically. The rising trend with ascending birth order is evident. The death rate among infants of the fifth or higher birth orders was more than double what it was for first products or pregnancy. In the Sherbrooke and California projects the infant death rates were very low for first births (12.6 and 12.8 per 1,000 live births respectively.) Moreover, in these two projects the birth rates were low, and a high proportion of the births were the woman's first -40.4 per cent in Sherbrooke and 43.2 per cent in California. Death rates for the postneonatal period were also low in these two projects, infant mortality being only 36 and 38 per cent higher than neonatal alone. In contrast, the postneonatal rates were high in the three Latin American projects, as evidenced by the wide gap between neonatal and total infant mortality shown by the broken and solid lines, respectively, in Figure 3. Among fifth and higher-order births the infant death rates were 90.0 per 1,000 live births in Monterrey, 90.6 in Chile, and 160.3 in El Salvador.

Table 5 and Figure 5 also focus on the factor of birth order, with the data presented according to nutritional deficiency or immaturity as the underlying or associated cause of death. In the case of immaturity, the infant death rates in general rose progressively from low levels for first births to higher ones for those of the fifth or subsequent orders, doubling themselves in the three Latin American projects and being nearly three times as great in the California and Canadian ones. The rates from nutritional deficiency

[14]National Office of Statistics and Census, personal communication, 1973. The distribution of live births by birth order and age of the mother for the Department of San Salvador, which could only be tabulated for 1972, was applied to the distribution of live births by age of the mother for 1969 in order to obtain the estimated bases for these rates.

(shown by the solid lines in Figure 5) rose even more markedly with ascending birth order in the three Latin American projects. For fifth or subsequent births in the El Salvador, Monterrey, and Chile projects they were three to four times greater than for first births (55.9, 30.5, and 28.2 per 1,000 live births as opposed to 14.0, 10.9, and 7.4, respectively). In the Latin American projects the increases observed in infant death rates from immaturity and nutritional deficiency when they are considered in relation to rising birth order point to the importance of this factor in excessive mortality.

These observations bring up the question: Why do the infant death rates rise with ascending birth order when at the same time mortality tends to be high among infants born to young mothers and the frequency of low-birthweight babies is greatest for young mothers? How can these

Fig. 4
NEONATAL AND INFANT MORTALITY BY BIRTH ORDER, IN FIVE PROJECTS OF THE INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD

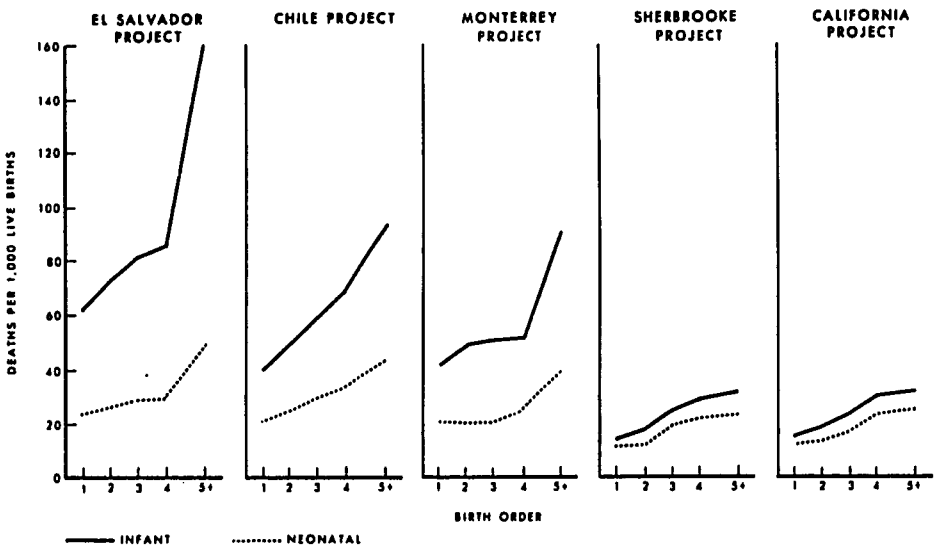
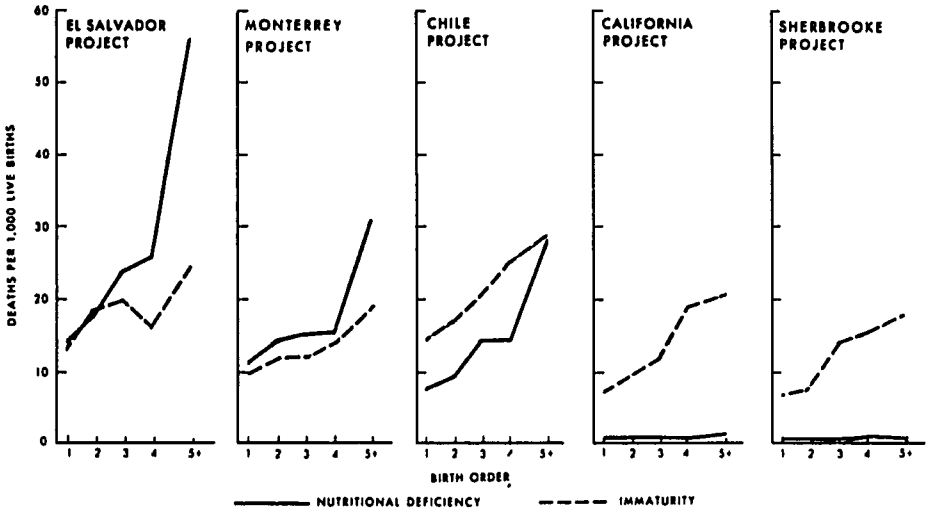


Table 5. Infant mortality due to nutritional deficiency and to immaturity as underlying or associated cause by birth order,[a] in five projects of the Inter-American Investigation of Mortality in Childhood (deaths per 1,000 live births).

Birth order	Sherbrooke project		Chile project		El Salvador project		Monterrey project		California project	
	Nutritional deficiency	Immaturity	Nutritional deficiency	Immaturity	Nutritional deficiency	Immaturity	Nutritional deficiency	Immaturity	Nutritional deficiency	Immaturity
Total	0.4	9.8	12.8	19.1	25.6	17.9	18.9	13.7	0.5	10.1
1	0.2	6.6	7.4	14.2	14.0	13.6	10.9	9.4	0.2	7.1
2	0.5	7.7	9.1	16.8	18.0	18.5	13.8	11.7	0.5	9.4
3	-	13.7	14.0	20.3	23.4	19.3	14.9	11.8	0.9	11.8
4	1.0	15.3	14.0	25.1	25.6	16.1	15.0	13.5	0.4	18.4
5 or higher	0.6	17.8	28.2	28.7	55.9	24.2	30.5	18.6	1.4	20.6

[a]Deaths for which the birth order was not stated have been distributed proportionally in accordance with those for which the order was known.

Fig. 5
INFANT MORTALITY DUE TO NUTRITIONAL DEFICIENCY AND TO IMMATURITY AS UNDERLYING OR ASSOCIATED CAUSE BY BIRTH ORDER, IN FIVE PROJECTS OF THE INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD



apparently conflicting findings be explained? Analysis of the factors of maternal age, birth order, and birthweight in combination helps to give the answer.

Infant Mortality by Birth Order According to Age of the Mother

Ideally, infant mortality should be analyzed by birth order according to maternal age. In only two Latin American projects (El Salvador and Chile) can this be done at the present time. Cross-tabulations especially prepared for the present purpose in 1973 by the Salvadorean National Bureau of Statistics and Census and the Chilean National Health Service's Bureau of Biostatistics have made it possible to study these relationships. To estimate the bases of live births by these two factors for the period of the Investigation, it was necessary to apply distributions from 1972 cross-tabulations to those available for 1969 (the mid-period of the study). In the Province of Santiago the distribution of births by birth order and maternal age is undergoing marked changes, no doubt owing in large part to family planning. Similar although smaller shifts are now occurring in San Salvador. Omissions in the registration of infant deaths and live births have been pointed out (*15,22,23*), and this problem, as well as other difficulties, may have affected the bases of the rates presented. Cross-tabulations were also provided by the California State Health Department in 1972. The data made available in this form served for the present study of infant death rates by birth order according to the age of the mother.

Table 6 and Figure 6 present neonatal and infant mortality by birth order for five maternal age groups for the El Salvador project. The numbers of births and/or deaths were small in several of the groups. Although a much

larger experience is desirable, the rates are given here to point up the relationships under discussion, especially the increases by birth order.

The death rate for infants born to mothers under 20 years of age was very high–116.6 per 1,000 live births. Even for first births in this maternal age group it was high–89.6. For second births it was 161.5, and it rose to more than 300 for third births.

In the next age group, 20-24 years, the rate for first births was much lower–44.0 per 1,000 live births–but it also increased with the higher birth orders, reaching a level in excess of 300 with the fifth. This maternal age group accounted for the largest proportion of live births (31.5 per cent).

Infant mortality was lowest for the 25-29-year maternal age group, the rate for first births (30.8) being much lower than for the younger mothers (89.6 and 44.0, respectively). In this age group it was also relatively favorable in the low birth orders, but, as in the two younger groups, it gradually increased to more than 300–although not until the seventh birth.

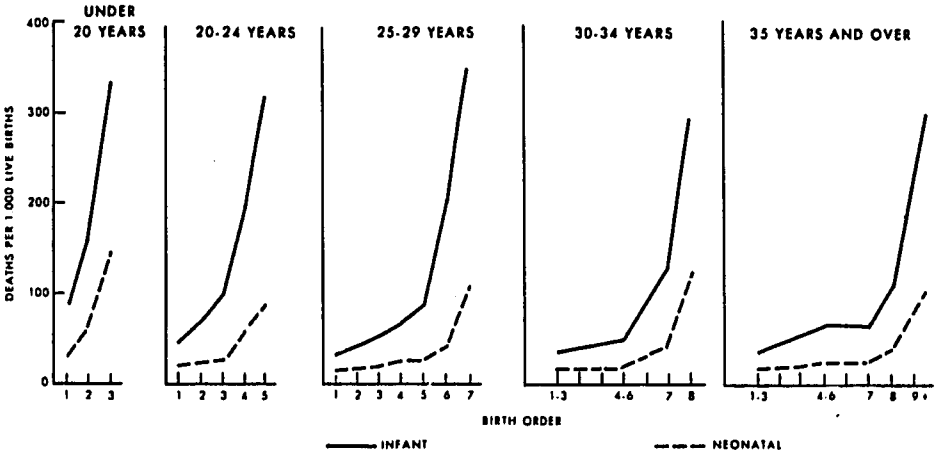
The experience with 30-34-year-old mothers was limited, since only 14.6 per cent of the live births occurred in this age period and these were distributed over many birth orders. Still infant mortality for first and second births was very low (26.8 and 24.0 per 1,000 live births), and an increase by birth order was noted, going up to a high of nearly 300 in the case of the eighth birth.

Table 6. Neonatal and infant mortality by birth order according to maternal age,[a] El Salvador project, Inter-American Investigation of Mortality in Childhood.

Birth order	Total	Under 20 years	20-24 years	25-29 years	30-34 years	35 years and over
	Neonatal deaths per 1,000 live births					
Total	29.6	40.7	26.2	23.7	27.6	34.5
1	22.7	30.1	18.4	13.2	14.8[b]	24.2[b]
2	24.8	58.2	21.3	15.2	12.1[b]	7.3[b]
3	28.1	144.3	26.1	20.7	20.4	22.5[b]
4	28.6		60.6	23.7	18.1	10.0[b]
5	25.9		91.1	25.2	12.0[b]	21.0
6	36.6			41.6	20.2	39.2
7	42.9			108.3	41.0	22.6
8	80.8				123.7[c]	41.2
9 or higher	129.7					104.0
	Infant deaths per 1,000 live births					
Total	88.4	116.6	84.2	72.9	81.3[d]	93.6[e]
1	60.9	89.6	44.0	30.8	26.8	42.5[b]
2	72.3	161.5	69.3	40.3	24.0	18.0[b]
3	81.0	334.8	101.5	52.9	45.8	41.8
4	86.8		196.4	67.8	36.9	45.0
5	96.6		317.5	85.6	57.4	75.3
6	127.4			203.9	73.6	78.7
7	137.1			349.2	130.9	60.5
8	220.3				292.3[c]	109.6
9 or higher	427.0					300.8

[a]At birth of the deceased infant.
[b]Less than 10 deaths.
[c]Based on 100-199 live births.
[d]For birth orders 1-3 and 4-6 the rates were 34.0 and 52.9 per 1,000 live births, respectively, for infant deaths and 16.3 and 16.5 for neonatal deaths.
[e]For birth orders 1-3 and 4-6 the rates were 34.5 and 67.0 per 1,000 live births, respectively, for infant deaths and 18.2 and 23.6 for neonatal deaths.

Fig. 6
NEONATAL AND INFANT MORTALITY BY BIRTH ORDER ACCORDING TO MATERNAL AGE, EL SALVADOR PROJECT, INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD



Similarly, the experience with mothers 35 and over was very small. However, as with all the other age groups, the infant death rates became very high only with high birth orders.

Table 6 and Figure 6 also present neonatal death rates for the El Salvador project. The variations are in general smaller, although the pattern is similar. Immaturity as an underlying or associated cause was the important determinant of mortality in this age period.

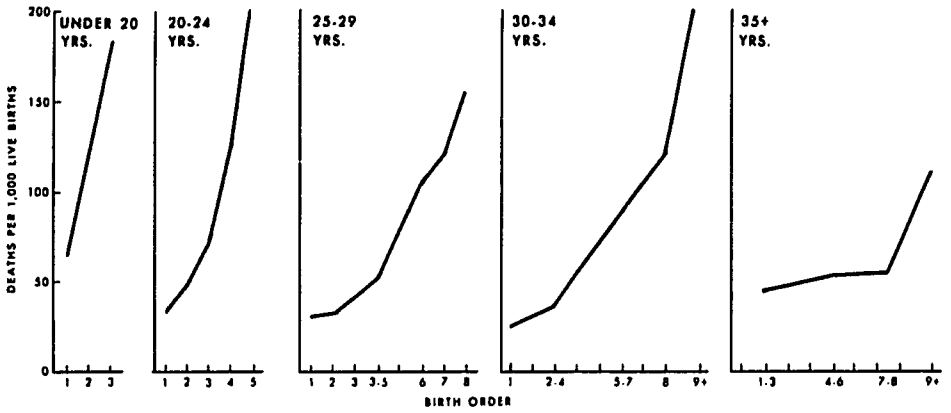
Infant death rates by birth order and maternal age group are presented for the Chile project in Table 7 and Figure 7. As in the El Salvador project, the death rates were very high for young mothers, with definite increases with rising birth order. In the next age group, 20-24 years, the rate for first births (32.2 per 1,000 live births) was much lower than the figure for the younger mothers (60.6), and it likewise increased with each additional birth. Although in general the Chile project's rates did not attain the high levels noted in the El Salvador one, they still rose significantly on reaching the third birth in the case of mothers under 20, the fifth birth with the 20-24

Table 7. Infant mortality by birth order according to maternal age,[a] Chile project, Inter-American Investigation of Mortality in Childhood (deaths per 1,000 live births).

Birth order	Total	Under 20 years	20-24 years	25-29 years	30-34 years	35 years and over
Total	55.2	79.3	51.7	44.5	54.1	59.8
1	39.4	60.6	32.2	28.4	27.0	25.6
2	47.8	116.4	47.2	29.6	19.8	45.7
3	57.8	182.2	70.9	42.8	40.4	54.5
4	67.0		120.9	59.9	45.2	47.4
5	71.6		241.7[b]	53.1	61.2	55.2
6	89.9			100.9	92.5	52.7
7	90.2			114.7	137.5	47.7
8	91.0			153.8	117.6	62.1
9 or higher	129.6				210.4[b]	109.7

[a]At birth of the deceased infant.
[b]Estimated base of live births may be too small.

Fig. 7
INFANT MORTALITY BY BIRTH ORDER ACCORDING TO MATERNAL AGE, CHILE PROJECT, INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD



Note: Data for birth orders in Table 7 combined as follows: 25-29 years, 3-5 birth orders (50.1); 30-34 years, 2-4 birth orders (34.2) and 5-7 birth orders (85.4); 35 years and over, 1-3 birth orders (42.8), 4-6 birth orders (52.0), and 7-8 birth orders (54.1).

age group, the eighth birth among 25-29-year-olds, and the highest order of birth given for those in the 30-34 group.

In the California project the number of infant deaths was small (784), even though the base (44,740 live births) was larger than that for either the El Salvador (31,020) or Chile (43,580) projects. Home interviews were not conducted in this project and hence reproductive histories were not available. Live births only were used in determining birth order. The data were sufficient to show the rates per 1,000 live births for the under-20 and the 20-24-year maternal age group by birth order:

Birth order	*Under 20 years*	*20-24 years*
1	20.2	12.5
2	46.1	17.0
3	86.3	21.7
4		34.1

There is the same marked increase in death rates noted for the El Salvador and Chile projects, with ascending birth order among young mothers. For the 20-24 age group there was nearly a threefold rise, from 12.5 per 1,000 live births for the first birth to 34.1 for the fourth.

The infant death rates by maternal age group in the El Salvador and Chile projects clearly became high for third births for mothers under 20 years of age, for fifth births for those 20-24 years, for seventh or eighth births for those 25-29 years, and for higher birth orders for those 30 years and over. Mothers having their third product of pregnancy when they were under 20 years of age could not have had sufficiently long intervals in between. By the same token, many in the next age group having their fifth product must have also had short intervals between their pregnancies. In the other maternal age groups the rates became higher only in the seventh, eighth, and subsequent birth orders, where likewise the intervals would have been shorter. The

grouping together of data on all births of the fifth and higher orders, as is often done, fails to reveal that probably the important factor in understanding the roles of birth order and of maternal age is the length of the interval between births. However, the detailed breakdowns provided for the present purposes for the El Salvador and Chile projects have indeed shown the pattern of differences by maternal age group for high-order births. The subject of birth intervals is explored more fully in a later section.

Thus the first half of the question raised earlier can now be answered: infant mortality increases with ascending birth order in each maternal age group; at the same time, among young mothers it is already excessive with the first birth and rises to even higher rates with subsequent ones.

No doubt another of the factors contributing to infant mortality in young mothers is their marital status. In all three projects relatively high proportions of the young mothers under 20 years were single—namely, 39.0, 29.6, and 34.6 per cent in the El Salvador, Chile, and California projects, respectively. In El Salvador approximately half the mothers were living in common-law unions. Table 8 gives infant deaths in the under-20 maternal age group by marital status of the mother and according to first and second-or-higher birth order. In the Chile project a notably smaller percentage of the mothers were single in the case of higher-order births (14.0 per cent) than for first births (40.4 per cent). Similarly, in El Salvador there was a drop of from 47.1 to 28.3 per cent. In the California project there was only a slight change.

Table 8. Marital status of mothers under 20 years of age at birth of the deceased infant by birth order, in three projects of the Inter-American Investigation of Mortality in Childhood.

Marital status	Total		First birth		Higher birth order		Order unknown
	No.	%[a]	No.	%	No.	%	No.
El Salvador project							
Total	646	100.0	363	100.1	270	100.0	13
Single	245	39.0	169	47.1	76	28.3	-
Married	62	9.9	33	9.2	29	10.8	-
Common-law union	313	49.8	155	43.2	158	58.7	-
Separated, etc.	8	1.3	2	0.6	6	2.2	-
Unknown	18		4		1		13
Chile project							
Total	477	99.9	260	99.9	207	99.9	10
Single	131	29.6	97	40.4	27	14.0	7
Married	257	58.1	115	47.9	140	72.5	2
Common-law union	49	11.1	25	10.4	24	12.4	-
Separated, etc.	5	1.1	3	1.2	2	1.0	-
Unknown	35		20		14		1
California project							
Total	182	100.0	108	100.0	71	99.9	3
Single	56	34.6	35	36.8	21	32.8	-
Married	101	62.3	59	62.1	39	60.9	3
Separated, etc.	5	3.1	1	1.1	4	6.2	-
Unknown	20		13		7		-

[a]Percentage based on distribution of those for whom the status was known.

Several of the factors considered in the Inter-American Investigation of Mortality in Childhood were also taken into account in reports published in 1973 (*4,13*) of an excellent study on infant mortality in a cohort of 142,017 live births registered with the New York City Health Department in 1968. Since information on education of the mother, prenatal care, birthweight, age of the mother, and birth order was provided on the New York City birth certificates, these basic data were available for use in analysis of infant mortality. Although the infant death rate was low (21.9 per 1,000 live births), the variation according to birth order in maternal age groups was similar to the patterns reported for the projects in El Salvador and Chile. For example, among mothers 15-19 years of age the infant death rate for first births was 24.1 per 1,000 live births and for the second order, 49.5. Although the base became small as it reached the fourth birth, the rate nevertheless rose to 62.2. For mothers in the 20-24-year group the rates went from 15.6 per 1,000 live births for first births to 53.3 for births of the sixth or higher order. For the next maternal age group, 25-29 years, the rate for first births was the lowest, 14.2. The consistency of these rates with those given in the Investigation bears out the value of the latter data, even though for the Latin American projects the bases were estimated.

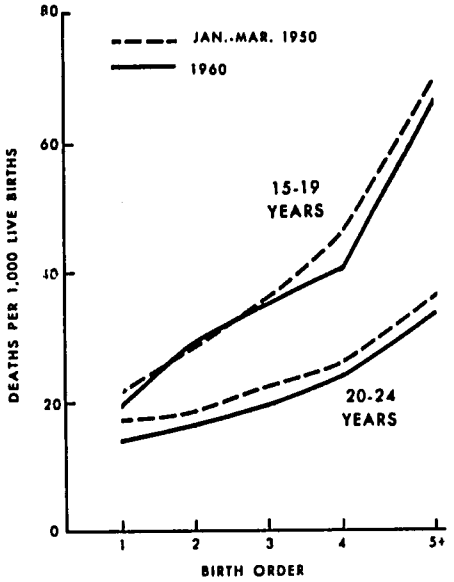
Studies by birth order and age of the mother of combined fetal and neonatal mortality conducted by Yerushalmy (*33*) in New York State (exclusive of New York City) in 1936-1938 based on 251,348 live births likewise revealed marked increases in death rates for the higher birth orders. For example, for mothers under 20 years of age the combined infant loss (including stillbirths) was 61.6 per 1,000 first births, while it rose to 82.4 for the third order and 164.2 for the fourth. The rate for mothers 20-24 years was lowest for the second (42.1) and increased for the fifth (69.4) and sixth or higher order (92.1).

Similarly, in an analysis of neonatal mortality by birth order according to maternal age in the 1950 and 1960 United States birth cohort studies (*3,16*) the rates increased with birth order for births to mothers 15-19 and 20-24 years of age for both cohorts (Figure 8).

In the studies of social and biological factors in infant mortality conducted in England and Wales in 1949 and 1950, Heady and co-workers (*10*) commented on the increase in death rates as follows: "For postneonatal deaths . . . there is a steady rise with increasing parity in each age group, witness the low rates for first children . . . and the high rates for fourth or later children. . . . The rise is sharper for the younger mothers–those under 25 years of age–than for the older mothers."

Thus the findings from the Investigation are consistent with those of other studies in indicating excessive infant death rates for young mothers and increases with ascending birth order. The analyses presented here demonstrate the tremendous value of having tabulations available of live births by birth order according to the age group of the mother. If birth certificates provide space for recording this information (as they do in El Salvador, Chile, and the United States of America), such tabulations can be prepared routinely. In those countries where provision has not yet been made on the

Fig. 8
NEONATAL MORTALITY BY BIRTH ORDER ACCORDING TO TWO MATERNAL AGE GROUPS, UNITED STATES BIRTH COHORTS, 1950 AND 1960



SOURCE: J. LOEB (16) AND H. C. CHASE (3).

birth certificates, it is recommended that steps be taken in this direction so as to permit future analysis. Meanwhile, it is urged that studies of mortality by birth order and maternal age be conducted in large maternities.

Infant Mortality from Immaturity and from Nutritional Deficiency by Birth Order and Maternal Age

The third important determinant in infant mortality, birthweight, can now be considered in relation to the other two, maternal age and birth order. Death rates from immaturity (as an underlying or associated cause) by birth order according to maternal age serve to reflect at least partially the frequency of low birthweight. Similarly, the rates from nutritional deficiency reveal to some extent the effect of low and deficient birthweight in these groups.

Infant mortality due to immaturity and to nutritional deficiency as an underlying or associated cause is given by birth order according to maternal age group for the El Salvador and Chile projects in Table 9. For first births the death rates from immaturity were 18.4 and 21.0 per 1,000 live births for the under-20 maternal age group in the El Salvador and Chile projects, respectively. For second births among these same young mothers they rose to 42.8 and 30.3, and for those of third or subsequent orders they were still higher—119.9 and 43.1. In the California project among mothers under 20 years of age they were 11.5 for first births, 27.5 for second, and 53.0 for third and higher orders, while for the next maternal age group they were 7.2 for the first, 8.8 for the second, 12.2 for the third, and 21.9 for the fourth

Table 9. Infant mortality due to nutritional deficiency and to immaturity as underlying or associated cause by birth order according to maternal age,[a] El Salvador and Chile projects, Inter-American Investigation of Mortality in Childhood (deaths per 1,000 live births).

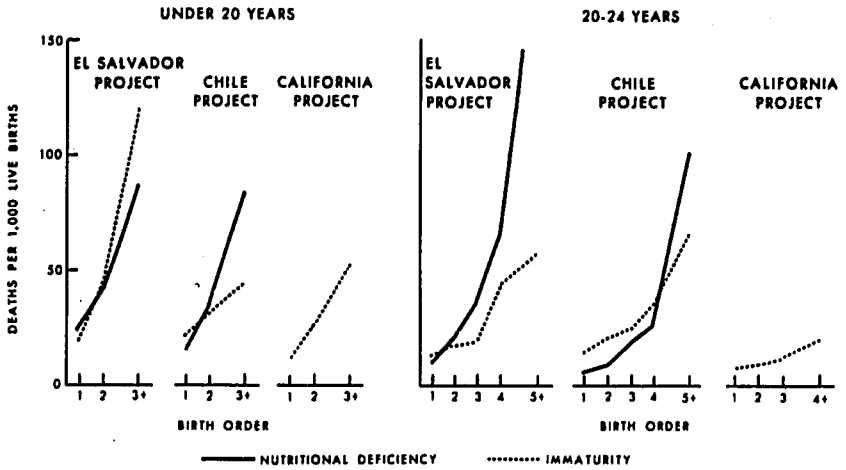
Birth order	El Salvador project		Chile project	
	Nutritional deficiency	Immaturity	Nutritional deficiency	Immaturity
	Under 20 years			
Total	29.4	27.8	22.2	24.2
1	22.8	18.4	14.6	21.0
2	41.4	42.8	33.4	30.3
3 or higher	86.1	119.9	82.8	43.1
	20-24 years			
Total	25.9	17.5	10.9	18.3
1	8.5	11.6	4.5	12.3
2	18.8	16.4	7.9	19.0
3	34.4	17.4	17.9	22.7
4	64.3	42.1	26.7	35.6
5 or higher	214.5	56.2	100.8	65.3
	25-29 years			
Total	22.7	13.3	9.6	16.4
1-4	11.8	10.3	6.0	13.9
5 or higher	72.2	26.9	26.8	28.5
	30-34 years			
Total	22.8	14.1	11.9	19.8
1-4	5.7	8.2	4.9	14.1
5-7	24.9	8.0	20.9	25.3
8 or higher	167.0	99.7	55.3	60.9
	35 years and over			
Total	28.0	17.0	15.1	20.1
1-7	15.4	9.9	9.8	17.1
7 or higher	51.5	30.3	25.6	25.9

[a]At birth of the deceased infant.

and higher orders. Figure 9 shows these data for the El Salvador, Chile, and California projects in graphic form. Clearly, these death rates from immaturity among young mothers are not only high but increase with ascending birth order as well.

The death rates from immaturity can be used to estimate the frequency of low-weight births in a particular category of birth order. For example, the figure of 27.5 per 1,000 live births for second births of under-20 mothers in the California project means, in other words, that 2.75 per cent of the live births resulted in deaths due to immaturity as an underlying or associated cause. In the California project the neonatal death rate for those weighing 2,500 grams or less was 129.9 per 1,000—in other words, 1 in every 8 low-birthweight infants died. If this ratio is used and 8 is multiplied by the percentage who died in the particular birth order (2.75 in the case of second births), the result is the estimated frequency of low-weight births in that category (22.0 per cent). The death rate among low-weight babies is probably even higher in this maternal age group. If a higher death rate were taken, the estimated percentage of low-weight births would be lower.

Fig. 9
INFANT MORTALITY FROM IMMATURITY IN THREE PROJECTS AND FROM NUTRITIONAL DEFICIENCY IN TWO PROJECTS, BY BIRTH ORDER ACCORDING TO TWO MATERNAL AGE GROUPS, INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD



Although these data indicate that there is probably a marked increase in the frequency of low-weight births (as with immaturity) by birth order in a specific maternal age group, there are distinct differences in the three projects, suggesting that other determinants are involved as well.

Another factor for consideration is the distribution of birthweight within the group of births of 2,500 grams or less, since the distribution in the low-weight group affects the death rate and the ratio of deaths to births in each of the categories. In the California project the deaths from immaturity among young mothers were in very low-weight products: half of them weighed 1,000 grams or less at birth and 31 per cent weighed 1,100-1,500 grams. The frequency of such low-weight births must have been high, especially among the third and higher orders, to have resulted in such high death rates from immaturity. In the El Salvador and Chile projects the distribution of birthweights of the deceased infants was distinctly different, with relatively few in the lowest weight group. Some of the deaths in the lowest weight group in these two Latin American projects may have occurred before delivery or been classed as fetal deaths by the attendant at birth. Also, there are differences in the availability of medical services. Infants born to mothers under 20 years of age should be considered to be at great risk of dying from immaturity.

In the 20-24-year maternal age group the death rates from immaturity were relatively low for first births (11.6, 12.3, and 7.2 per 1,000 live births in the El Salvador, Chile, and California projects, respectively). The rates increased with ascending birth order. For fifth or higher-order births the infant death rates were 56.2 and 65.3 in the El Salvador and Chile projects. If one out of five low-birthweight babies died, the frequency of low-weight births would be 28 and 33 per cent, respectively, in these high birth orders. In the California project the death rate for fourth and higher-order births was three times that for first births (21.9 per 1,000 live births as against 7.2).

With regard to nutritional deficiency as an underlying or associated cause, in the El Salvador and Chile projects the infant death rates became very high for third and higher-order births to under-20 mothers and for fifth and higher-order births in the 20-24-year age group. With the exception of the under-20 maternal age group in the El Salvador project, the increases in death rates by birth order were much greater for nutritional deficiency than for immaturity. In the other three maternal age groups the data were grouped for the different birth orders so as to have sufficient numbers with which to calculate rates for the two projects. Although there were puzzling differences, the death from immaturity as an underlying or associated cause were consistently more elevated for the higher-order births in the El Salvador and Chile projects. At the same time, mortality from nutritional deficiency was much greater among fifth and higher-order births to mothers in the 25-29 and 30-34-year brackets in El Salvador than it was for these same groups in Chile.

The increases in death rates from nutritional deficiency with rising birth order can depend on the condition of the child at birth, which in turn is related to the health of the mother. The effect of birth order by age of the mother on birthweight should be clarified. Infants born with deficient weights (3,000 grams or less) who survive the neonatal period are at great risk of dying from nutritional deficiency.

The fact that the young mothers have such excessive infant losses involving immaturity and nutritional deficiency in the higher birth orders raises questions as to their own health. In a later section of this report it will be seen that the mothers in the younger age brackets had short intervals between births in the higher orders. Thus it is likely that they did not recuperate sufficiently from repeated pregnancies to give the essential nutrients to their babies—another subject that deserves greater exploration.

Birthweight

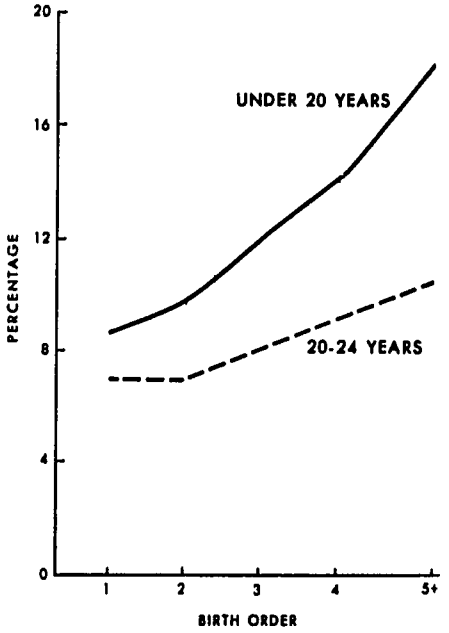
Information regarding birthweight, especially in Latin American areas, would contribute to an understanding of these relationships. The role of birthweight, as observed principally from data from the United States, is considered briefly below.

The 1950 birth cohort study conducted in the United States also included birthweight by birth order according to maternal age group (*16*). For the under-20 and 20-24 year groups the frequency of low-weight births (2,500 grams or less) by birth order was as follows:

Birth order	*Under 20 years*	*20-24 years*
1	8.6	6.9
2	9.6	6.9
3	12.0	8.0
4	14.0	9.1
5 and higher	18.3	10.5

As it can be seen, the percentages are higher for the younger maternal age group, and there is a general pattern of increasing frequency as the birth order rises in both age groups. Figure 10 shows these increases graphically. Similar or even greater increases probably occurred in the El Salvador and Chile projects, if one judges by the death rates in which immaturity was an associated or underlying cause.

Fig. 10
PERCENTAGE OF LIVEBORN INFANTS WITH BIRTHWEIGHTS OF 2,500 GRAMS OR LESS, BY BIRTH ORDER ACCORDING TO TWO MATERNAL AGE GROUPS, UNITED STATES BIRTH COHORT, 1950



SOURCE: J. LOEB (15).

An answer may now be given to the second part of the question raised at the end of the discussion on infant mortality by birth order. Young mothers have a higher frequency of low-weight births, and this frequency increases with rising birth order. Similar evidence is presented from the death rates with immaturity as an underlying or associated cause. Mortality due to immaturity was especially high for young mothers, and increases occurred as the birth order rose. Thus, in studies of infant mortality these important factors should be considered in combination.

In the United States in 1960 (*3*) the frequency of very low-weight births (1,500 grams or less) was higher for mothers under 20 than for those in the older age groups. The percentages for three age groups were as follows:

Birthweight (in grams)	*Under 20 years*	*20-24 years*	*25-29 years*
1,000 or less	0.76	0.53	0.52
1,001-1,500	0.95	0.62	0.56
1,501-2,000	1.98	1.37	1.25
2,001-2,500	6.41	4.95	4.65

Since over 90 per cent of the babies in the lowest weight group and also a high proportion in the 1,001-1,500-gram group die, there is no question that these higher frequencies of low-weight births have a definite effect on mortality in infants born to young mothers.

In this same study the distribution of birthweight in general differed notably with maternal age. For five weight groups the percentage distribution according to the five age groups was as follows:

Birthweight (in grams)	*Under 20 years*	*20-24 years*	*25-29 years*	*30-34 years*	*35 years and over*
2,500 or less	10.1	7.5	7.0	7.5	8.1
2,501-3,000	21.4	19.1	17.8	17.0	16.4
3,001-3,500	39.5	39.5	38.0	36.0	34.1
3,501-4,000	23.2	26.3	27.7	28.2	28.4
4,001 and more	5.8	7.7	9.5	11.2	13.0

Hence, in addition to the higher proportion of low-weight births among young mothers, births with deficient weights of 2,501-3,000 grams were also more frequent for young mothers than for those 25-29 years of age or in the older groups. These birthweights are not considered satisfactory, and it is a fact that the death rate is higher in this group than among infants weighing more than 3,000 grams.

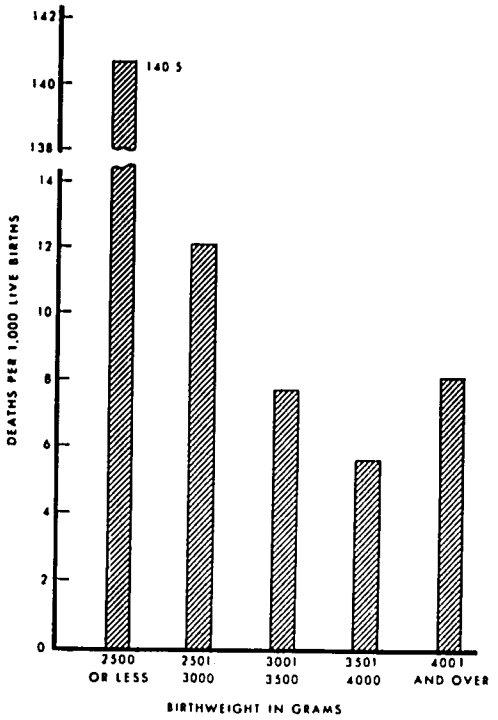
In the New York City study mentioned earlier (*13*), the infant deaths per 1,000 live births were as follows for the same five weight groups:

Birthweight (in grams)	*Rate*
2,500 or less	140.5
2,501-3,000	12.1
3,001-3,500	7.7
3,501-4,000	5.6
4,001 and more	8.0

In this experience (shown graphically in Figure 11) the death rate for babies weighing 2,501-3,000 grams was more than twice that for the group with lowest mortality—namely, those weighing 3,501-4,000 grams. Although the excessive mortality in the low-weight group (2,500 grams or less) is well known, actually the number of births in this category was relatively small in the New York City study (14,160 live births out of 142,017). In the next weight group (2,501-3,000 grams) the figure was more than twice as great (33,977). Even though mortality was much lower, this group represents a large proportion of the infants with deficient weight. The number and frequency of births in these weight groups is undoubtedly important, and such data may be especially significant in Latin America.

Neonatal mortality by birthweight can now be presented for two projects of the Investigation, namely Ribeirão Prêto and California. For Ribeirão Prêto it was necessary to apply the weight distribution for 15,172 births to the estimated total of 18,240, and thus the resulting base is an approximation. For the California project the weight distribution given by the State Health Department for 47,613 live births in San Francisco and the counties

Fig. 11
INFANT MORTALITY BY BIRTHWEIGHT,
NEW YORK CITY BIRTH COHORT, 1968



Source: Kessner et al (12)

of Alameda, Contra Costa, and San Mateo in 1969 was applied to the 44,740 births which served as the population base for the study of infant mortality in the Investigation. The resulting breakdown of neonatal death rates is present in Table 10 and Figure 12. Similar data for the live birth cohort of 1960 in the United States (*3*) are included for comparison. Although the patterns of the death rates are similar, the levels differ markedly.

A very high proportion of babies weighing 1,000 grams or less died in the first month of life. In the California project and in the United States 1960 live birth cohort it was over 90 per cent. While it was lower in Ribeirão Prêto, this difference may be because some of the very low-weight births were registered as fetal deaths or were not registered at all.

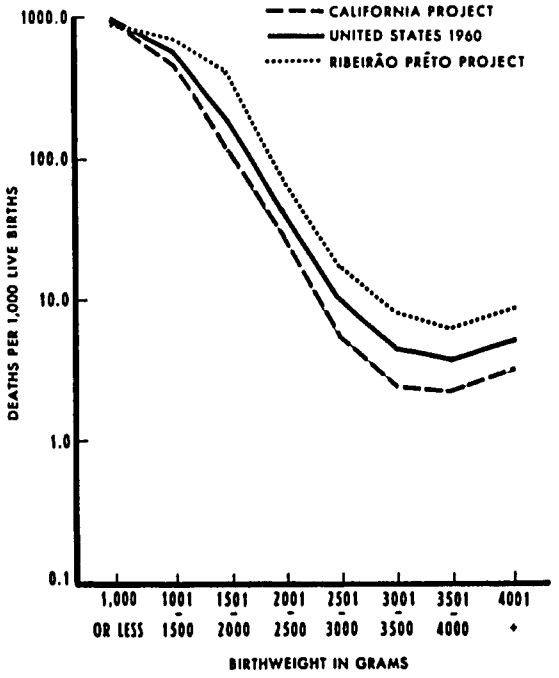
Neonatal mortality declined as birthweight increased, being lowest for babies weighing 3,501-4,000 grams in all three experiences. In view of this evidence, as well as the findings from the New York City study (*4,13*), this weight group has been termed the "most favorable." For low-weight babies (2,500 grams or less) the rates ranged from 129.9 per 1,000 live births in the California project to 215.7 in Ribeirão Prêto. For infants in the deficient weight group (2,501-3,000 grams) they were more than twice as high as for those in the most favorable weight group, hence amply justifying the designation of "deficient."

Table 10. Neonatal mortality by birthweight, Ribeirão Prêto and California projects, Inter-American Investigation of Mortality in Childhood and United States 1960 birth cohort (deaths per 1,000 live births).

Birthweight in grams	California project 1969-1970	Ribeirão Prêto project 1968-1970	United States birth cohort 1960
Total	12.7	28.2	18.4
1,000 or less	940.0	890.6	912.8
1,001-1,500	434.8	696.3	521.5
1,501-2,000	106.9	391.0	180.6
2,001-2,500	28.2	68.1	41.4
2,500 or less	129.9	215.7	171.6
2,501-3,000	5.4	16.8	9.9
3,001-3,500	2.5	8.5	4.7
3,501-4,000	2.2	6.0	3.6
4,001 and more	3.1	8.7	5.0
2,501 and more	3.1	10.0	5.5

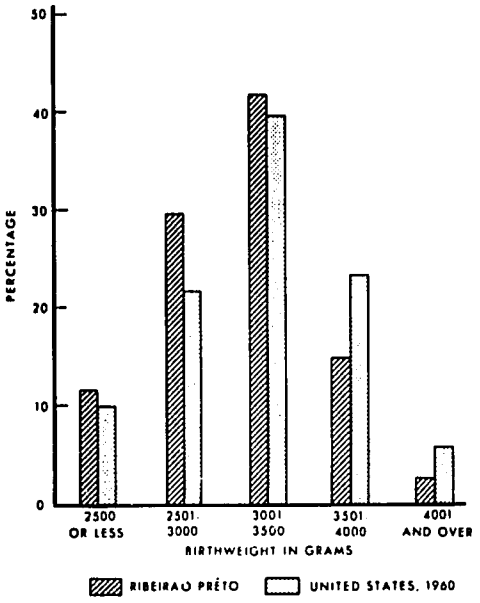
Source for United States data: Chase (3).

Fig. 12
NEONATAL MORTALITY BY BIRTHWEIGHT, RIBEIRÃO PRÊTO AND CALIFORNIA PROJECTS, INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD, AND UNITED STATES BIRTH COHORT, 1960



Source of United States data: H.C. Chase[3].

Fig. 13
PERCENTAGE DISTRIBUTION OF BIRTHWEIGHT AMONG INFANTS BORN TO MOTHERS UNDER 20 YEARS OF AGE IN RIBEIRÃO PRÊTO, INTER-AMERICAN INVESTIGATION AND UNITED STATES, 1960 BIRTH COHORT



Source of data for United States, Chase (3)

Although the neonatal death rates for babies weighing 4,001 grams and more were slightly higher than for those in the 3,501-4,000 range, the number of births in the higher weight group, especially in Latin American areas, was very small in comparison with that in the deficient weight group–and in Ribeirão Prêto and hospitals in Mexico City and San Salvador (*26*) it was smaller than the number of low-weight births.

The pattern of these neonatal death rates by birthweight and that of infant death rates in New York City (*13*) again bear out the importance of satisfactory birthweight for survival–and of the need for actions to prevent low and deficient birthweight.

Although infant mortality by birthweight and maternal age group is not known for the Latin American projects, the data on live births for Ribeirão Prêto clearly indicate that young mothers in this project gave birth to a higher proportion of infants weighing 3,000 grams or less than did their counterparts in the United States (Figure 13). For the five weight categories the respective distributions for mothers under 20 were as follows:

Birthweight (in grams)	*Ribeirão Prêto*	*United States 1960*
2,500 or less	11.7	10.1
2,501-3,000	29.5	21.4
3,001-3,500	41.7	39.4
3,501-4,000	14.5	23.2
4,001 and more	2.6	5.8

In Ribeirao Prêto 41.2 per cent of the liveborn infants weighed 3,000 grams or less, whereas in the United States the corresponding percentage was 31.5. Only 14.5 per cent of the births in Ribeirão Prêto were in the 3,501-4,000-gram group, which is the one that had the lowest mortality in New York City. Thus it is reasonable to assume that some of the excessive infant mortality in the Latin American projects may be due to the high frequency of low-weight births. It is hoped that data will become available, at least in selected areas, to clarify these problems in Latin America.

The authors of the publications on the New York City study—Kessner et al. (*13*) and Chase (*4*)—make the important statement that infant mortality varied more according to birthweight than to any other maternal or infant characteristic.

Birth Intervals

Increased knowledge on length of birth intervals would contribute to the interpretation of infant mortality by birth order and maternal age and also of the differences observed between one project and another. Unfortunately, birth intervals have rarely been analyzed and reported as an important factor in infant mortality. However, an analysis (*12*) from a 14-hospital collaborative perinatal study supported by the United States National Institute of Neurological Diseases and Stroke bears out the importance of having data on sibling intervals. In this research Holley and co-workers matched a series of 251 children close in age to their next previous sibling (less than 12 months) with others having longer sibling intervals (24-60 months) on the basis of race, sex, social class, and other factors and observed that the short-interval group had had lower birthweights.

Woodbury (*29*), in his classic study of infant mortality in eight cities, found in Baltimore that the infants with the shortest intervals from the previous birth (one year) had the highest death rate (146.7 per 1,000 live births), whereas those born four or more years after the preceding birth had the lowest (84.9). He commented on the relatively short intervals for second and third births to mothers under 20 years of age. Also, he found that a considerably larger proportion of the short-interval births were premature as compared with those in the other groups.

In the United States, Potter (*20*) arrived at the following estimates of existing average birth intervals in the absence of contraception and pregnancy wastage: 18 months for nonlactating mothers and 27 months for those with prolonged lactation. Much more needs to be learned regarding birth intervals in Latin America. In the Khanna study in India (*21*) the intervals between live births were observed to increase by about six months between the 20-24 and the 35-39 maternal age groups. In that area of India where breast-feeding is usual, the birth interval averaged slightly more than 30 months (*32*).

In the discussion that follows below, birth intervals are analyzed for mothers of the deceased infants studied in the Investigation taking into account birth order and maternal age group. The interval which has been

used is the average obtained by taking the difference between the mother's age in completed years at the time of delivery of her first product of pregnancy and her age at the birth of the deceased infant and dividing it by the number of products in this period.[15] This is believed to be the most satisfactory interval to use in relating the factors of birth order and age. Several pregnancies, not the preceding one alone, affect the condition of the mother. With pregnancies at short intervals the depletion process is cumulative. Consideration of the entire reproductive period provides much more data for studying birth intervals and for measuring the additive effect of pregnancies.

In the El Salvador project the reproductive histories were obtained for the mothers of nearly all the deceased infants. Infant deaths numbered 2,742, and maternal ages and birth orders were known for 2,646 (96.5 per cent). Of the deceased infants, 584 were first births, and the remaining 2,062 were second or higher-order births. Information on birth intervals was available for 1,974 of them, or 95.7 per cent. There were five other projects in the Investigation with more than 2,000 infant deaths: the Recife and São Paulo (Brazil), Monterrey (Mexico), Bolivia, and Chile projects. In the Bolivia and Chile projects unregistered deaths—many of low-birthweight babies—were discovered by the Investigation's collaborators just as their work was being completed, and for these it was not possible to get reproductive histories through home interviews (*23*). In Monterrey it was also impossible to obtain histories for some of the deaths. Thus, only the findings for the remaining two projects, Recife and São Paulo, have been compared with those for the El Salvador one.

The average intervals in the El Salvador project are given by birth order and maternal age group in Table 11. For mothers under 20 the average interval up to the second birth (the child who died) was 1.7 years. The average intervals corresponding to the third and fourth births were even shorter—1.6 and 1.5 years, respectively.

In the next maternal age group, 20-24 years, the average interval from the first product to the second (the deceased infant) was 2.4 years—much longer than that for the younger mothers (1.7 years). The short average interval of 1.5 years noted for the fourth birth among mothers under 20 was not found until the sixth order in this age group.

For the older mothers the average intervals were much longer for lower-order births. For example, for the third birth they were 2.9, 3.8, and 6.6, respectively, for mothers 25-29, 30-34, and 35 and over. In these three age groups the average intervals decreased, but they were still at least 2.0 years for the sixth, ninth, and twelfth births. These intervals, of course, were taken from the reproductive histories of the mothers of deceased infants. It is likely that for the mothers of all the babies—those who survived infancy as well as those who died—the patterns would be similar, though the intervals

[15]The total number of years is divided by the number of products. For example, for an infant of the third birth order the total years would be divided by 2, since the period counted is from delivery of the first product to the birth of the deceased child.

Table 11. Average interval between products of pregnancy[a] by birth order according to maternal age,[b] El Salvador project, Inter-American Investigation of Mortality in Childhood.

Birth order	Under 20 years	20-24 years	25-29 years	30-34 years	35 years and over
2	1.7	2.4	4.2	...	...
3	1.6	2.1	2.9	3.8	6.6
4	1.5	1.9	2.5	3.0	4.4
5		1.7	2.4	2.8	3.5
6		1.5	2.0	2.6	3.2
7			1.9	2.2	2.7
8			1.8	2.1	2.5
9				2.0	2.3
10				1.8	2.2
11				1.7	2.1
12					2.0

[a]Average intervals calculated by taking the total time elapsed from delivery of the first product and birth of deceased infant and dividing it by the number of products after the first. Average figures are given for those birth orders for which there were at least 15 deaths.

[b]At birth of the deceased infant.

...Fewer than 15 deaths.

might be longer. Unfortunately, such data for intervals are not available for all births. Although reproductive histories were obtained for mothers in the sample of living children in the Investigation, the number of such infants included in a project was small (less than 400), and hence the data are not sufficient for this type of subdivision and analysis.

The length of the intervals probably has an important relationship to infant mortality, especially in the areas of Latin America under discussion. For mothers under 20 the intervals are necessarily short for third, fourth, and fifth births. The increasing mortality by birth order in all five maternal age groups (Figures 6 and 7) is no doubt related to the shorter intervals in the higher birth orders. The average reproductive period for mothers 25-29 years would only be around 10 years (from 17 to 27), and thus for sixth or higher-order births the average interval would usually be 2.0 years at the very most.

Similar data on birth intervals for mothers of deceased infants in the Recife project are given in Table 12. The average intervals were shorter in Recife than in the El Salvador project, reaching a low of 1.2 for third births among under-20 mothers, for seventh births among those 20-24 years, and for tenth births for the 25-29 age group. Birth rates were high in both the Recife and El Salvador projects (41.6 and 40.4 per 1,000 population, respectively), and thus these intervals were unlikely to have been affected by family planning.

In São Paulo, the third project with sufficient data for a discussion of birth intervals, the birth rate was much lower–24.8 per 1,000 population (Table 13)–and family planning could have affected the intervals. However, the average intervals here appeared to follow the same general pattern by birth order and maternal age group as they did in Recife and El Salvador (except among mothers under 20).

In these three projects breast-feeding was limited. Only 26.8 per cent of the infants who died in the first year of life, excluding those dying in the

neonatal period, were breast-fed for one month or longer in Recife, while the figures were 35.5 per cent in São Paulo and 37.9 per cent in the El Salvador project. Thus a possible effect of breast-feeding as reported in the Khanna study in India (*21*) would not be seen. In that study it was observed that for mothers who breast-fed their children for an average (median) period of 26 months, postpartum amenorrhea averaged 10.8 months. By maternal age groups, this period increased from 7.4 months for mothers 15-19 years of age to 12.9 months for those 35-39 years.

For the three projects–El Salvador, Recife, and São Paulo–the average intervals by birth order for the five maternal age groups are shown in Figure 14. Although the intervals are based only on the period from delivery of the

Table 12. Average interval between products of pregnancy[a] by birth order according to maternal age,[b] Recife project, Inter-American Investigation of Mortality in Childhood.

Birth order	Under 20 years	20-24 years	25-29 years	30-34 years	35 years and over
2	1.3	1.7	2.8	...	...
3	1.2	1.6	2.2	2.6	...
4		1.5	1.9	2.8	...
5		1.4	1.8	2.3	3.0
6		1.3	1.6	2.0	3.0
7		1.2	1.5	1.9	2.3
8			1.4	1.8	2.1
9			1.3	1.4	2.0
10			1.2	1.5	1.8
11				1.5	1.7
12					1.6
13					1.5

[a]Average intervals calculated by taking the total time elapsed from delivery of the first product and birth of the deceased infant and dividing it by the number of products after the first. Average figures are given for those birth orders for which there were at least 15 deaths.

[b]At birth of the deceased infant.

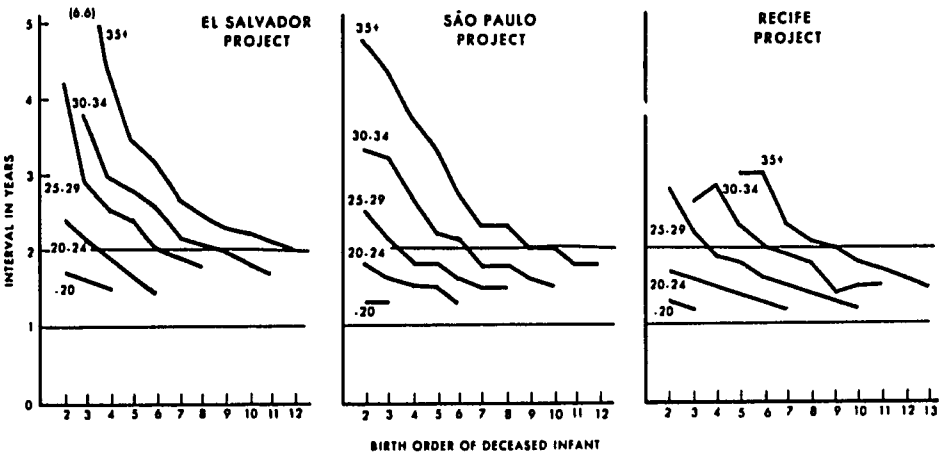
Table 13. Average interval between products of pregnancy[a] by birth order according to maternal age,[b] São Paulo project, Inter-American Investigation of Mortality in Childhood.

Birth order	Under 20 years	20-24 years	25-29 years	30-34 years	35 years and over
2	1.3	1.8	2.5	3.3	4.7
3	1.3	1.6	2.1	3.2	4.3
4		1.5	1.8	2.7	3.7
5		1.5	1.8	2.2	3.3
6		1.3	1.6	2.1	2.7
7			1.5	1.8	2.3
8			1.5	1.8	2.3
9				1.6	2.0
10				1.5	2.0
11					1.8
12					1.8

[a]Average interval calculated by taking the total time elapsed from delivery of the first product and birth of deceased infant and dividing it by the number of products after the first. Average figures are given for those birth orders for which there were at least 15 deaths.

[b]At birth of the deceased infant.

Fig. 14
AVERAGE INTERVAL BETWEEN PRODUCTS OF PREGNANCY[a] BY BIRTH ORDER AND MATERNAL AGE, EL SALVADOR, SÃO PAULO, AND RECIFE PROJECTS, INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD



[a]Average intervals calculated by taking the total time elapsed from delivery of the first product and birth of deceased infant and dividing it by the number of products after the first. Average figures are given for those birth orders for which there were at least 15 deaths.

first product to the birth of the deceased infant, the marked patterns that prevail definitely add to the interpretation of infant mortality by birth order and maternal age. There is no doubt that when birth intervals are short infant mortality is greater. Similar data for the mothers of liveborn infants as well would be useful for further evaluating the risks.

Outcome of Previous Pregnancies

In the Inter-American Investigation the reproductive history taken by the public health nurse or social worker in the home interview provided data for studying mortality in the mother's previous products of pregnancy according to birth order and by maternal age group. Information was obtained on fetal deaths (early and late) and all past live births, including the age at death of those siblings who died before the child under study. Naturally, the completeness of the data depended on recollection of these events by the mother or other person interviewed. Cross-checking with the list of siblings given in the roster of members of the household helped to improve the accuracy of the histories.

The survival of previous products of the mothers of the deceased children studied in the Investigation has been analyzed according to maternal age and birth order for the El Salvador project. As was done in the section on birth intervals, the data for the two other projects in which the number of deaths included was large enough to permit such subdivision—namely, Recife and São Paulo—are provided for purposes of comparison. It should be pointed out that here the mothers of all the deceased children investigated—not the infants only, as in the rest of this paper—have been taken into consideration.

The previous products[16] numbered over 10,000 in each of the three projects (13,743 in Recife, 11,928 in El Salvador, and 10,814 in São Paulo). Reproductive losses, both fetal deaths and deaths of those born alive, were considerable in all three: 33.5 per cent in El Salvador, 38.3 per cent in Recife, and 29.2 per cent in São Paulo. Table 14 shows the total previous products and the breakdown by fetal deaths and deaths of liveborn children in the same five maternal age groups by birth order for these three projects. (In this table the birth order refers to that of the deceased child, and all previous products are grouped together in a single figure.) Figure 15 shows the percentages from Table 14 in graphic form.

In the El Salvador project fetal deaths among previous products of pregnancy (shown by the lower portions of the bars in Figure 15) were proportionally less than in Recife and São Paulo. This may be due in part to the incomplete reporting of abortions and stillbirths (fetal deaths) as well as to actual differences in the frequencies of such losses. In general the percentage of the previous products dead increased with ascending birth order in the five maternal age groups. The greatest frequencies were noted for the highest birth-order category in each of the age groups[17] (fourth-plus for under-20 mothers, sixth-plus for the next age group, and so on). Thus reproductive losses increased as the intervals became shorter. The pattern in Recife was similar to that in El Salvador. In both projects over 40 per cent of the previous products had died in the highest birth-order groups. Such high percentages are evidence of excessive pregnancy losses. These mothers constitute a group of women who are vulnerable to disease and conditions unfavorable for survival of the product.

In São Paulo, where the birth rate and infant mortality are lower than in Recife and El Salvador, the pattern was less clear for mothers in the 35-and-over age group. Older mothers had had losses over a long period during which infant mortality was apparently higher than it was at the time of the Investigation. However, older mothers with many pregnancies may have forgotten some of their losses.

Infant mortality in previous products, presented in Table 15 and Figure 16, in general followed patterns similar to those shown for the El Salvador and Chile projects in the course of the Investigation (Tables 6, 7 and Figures 5, 6). However, the rates themselves were much higher for the past products. For example, in the El Salvador project for first births in previous products they were 160.6, 111.5, 102.2, 69.9, and 94.8 per 1,000 live births for the respective maternal age groups, whereas the comparable rates during the Investigation were 89.6, 44.0, 30.8, 26.8, and 42.5. Many mothers in the older age groups having their second product (the deceased child in the Investigation) may have had their first product several years before, when infant mortality was greater.

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[16] All histories have been used, and hence the numbers are slightly larger than those given in the 1973 report on the Investigation (*22*, chapter XII).

[17] In the 35 and over maternal age group it was necessary to combine birth orders 2 through 5 owing to the small numbers involved.

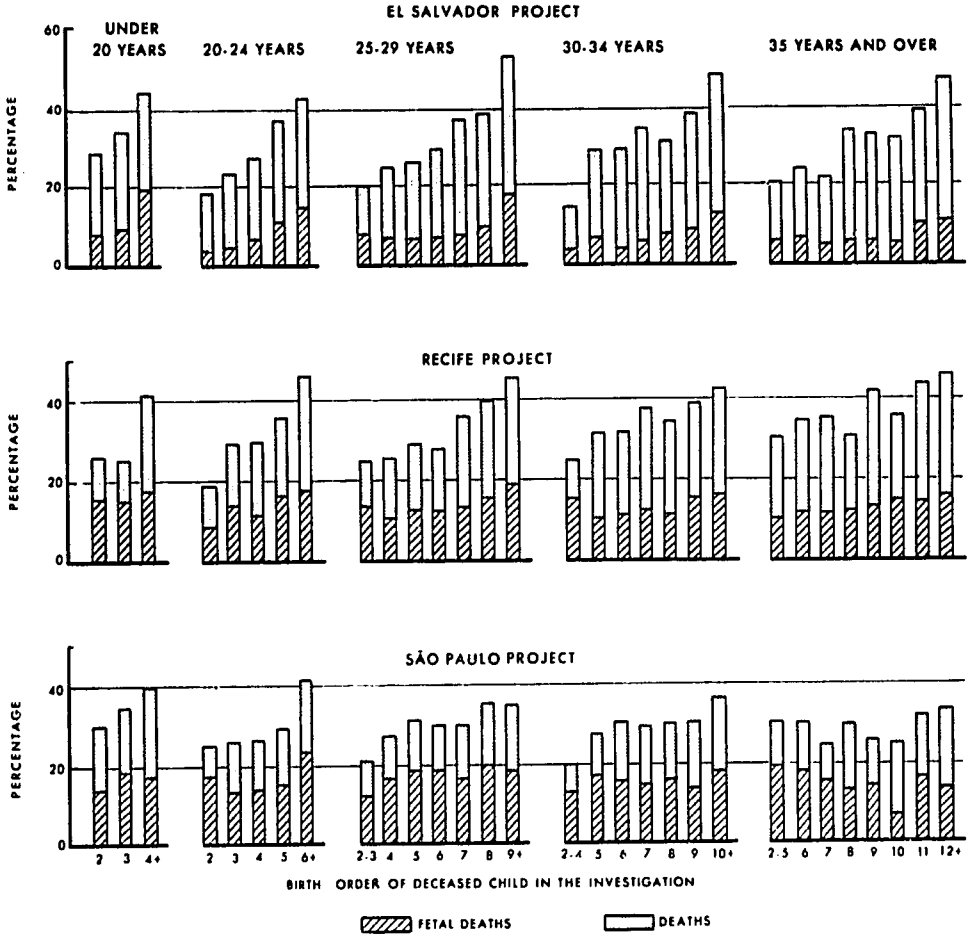
Table 14. Number and percentage of deaths among previous products of pregnancy[a] of mothers of the deceased children under 5 years of age in the study, by birth order according to maternal age,[b] El Salvador, Recife and São Paulo projects, Inter-American Investigation of Mortality in Childhood.

Maternal age and birth order	El Salvador project							Recife							São Paulo						
	Total previous products	Products death						Total previous products	Products death						Total previous products	Products death					
		Total		Fetal deaths		Deaths			Total		Fetal deaths		Deaths			Total		Fetal deaths		Deaths	
		No.	%	No.	%	No.	%		No.	%	No.	%	No.	%		No.	%	No.	%	No.	%
Total	11,928	3,991	33.5	887	7.4	3,104	26.0	13,743	5.267	38.3	1,997	14.5	3,270	23.8	10,814	3,163	29.2	1,635	15.1	1,528	14.1
-20 years (total)	507	166	32.7	47	9.3	119	23.5	423	128	30.3	65	15.4	63	14.9	331	108	32.6	52	15.7	56	16.9
2	235	66	28.1	16	6.8	50	21.3	148	38	25.7	22	14.9	16	10.8	157	45	28.7	21	13.4	24	15.3
3	188	63	33.5	15	8.0	48	25.5	154	39	25.3	22	14.3	17	11.0	114	39	34.2	21	18.4	18	15.8
4 or higher	84	37	44.0	16	19.0	21	25.0	121	51	42.1	21	17.4	30	24.8	60	24	40.0	10	16.7	14	23.3
20-24 years (total)	2,161	634	29.3	159	7.4	475	22.0	2,052	742	36.2	299	14.6	443	21.6	1,882	544	28.9	294	15.6	250	13.3
2	291	52	17.9	9	3.1	43	14.8	171	32	18.7	14	8.2	18	10.5	340	86	25.3	58	17.1	28	8.2
3	504	116	23.0	20	4.0	96	19.0	320	92	28.8	43	13.4	49	15.3	486	124	25.5	61	12.6	63	13.0
4	591	159	26.9	34	5.8	125	21.2	396	115	29.0	44	11.1	71	17.9	426	113	26.5	58	13.6	55	12.9
5	368	135	36.7	38	10.3	97	26.4	344	123	35.8	54	15.7	69	20.1	324	94	29.0	47	14.5	47	14.5
6 or higher	407	172	42.3	58	14.3	114	28.0	821	380	46.3	144	17.5	236	28.7	306	127	41.5	70	22.9	57	18.6
25-29 years (total)	2,512	812	32.3	196	7.8	616	24.5	3,725	1,329	35.7	537	14.4	792	21.3	2,574	730	28.4	422	16.4	308	12.0
2 or 3	295	59	20.0	20	6.8	39	13.2	217	53	24.4	29	13.4	24	11.1	480	101	21.0	57	11.9	44	9.2
4	342	83	24.3	20	5.8	63	18.4	306	77	25.2	32	10.5	45	14.7	393	105	26.7	64	16.3	41	10.4
5	364	95	26.1	20	5.5	75	20.6	427	119	27.9	51	11.9	68	15.9	428	131	30.6	75	17.5	56	13.1
6	504	145	28.8	29	5.8	116	23.0	605	166	27.4	68	11.2	98	16.2	465	133	28.6	82	17.6	51	11.0
7	396	148	37.4	29	7.3	119	30.1	486	173	35.6	64	13.2	109	22.4	336	99	29.5	55	16.4	44	13.1
8	301	117	38.9	26	8.6	91	30.2	567	229	40.4	83	14.6	146	25.7	210	73	34.8	41	19.5	32	15.2
9 or higher	310	165	53.2	52	16.8	113	36.5	1,117	512	45.8	210	18.8	302	27.0	262	88	33.6	48	18.3	40	15.3
30-34 years (total)	3,020	1,073	35.5	224	7.4	849	28.1	3,475	1,343	38.6	495	14.2	848	24.4	3,126	941	30.1	468	15.0	473	15.1
2, 3 or 4	238	35	14.7	8	3.4	27	11.3	178	45	25.3	27	15.2	18	10.1	379	75	19.8	45	11.9	30	7.9
5	248	71	28.6	14	5.6	57	23.0	164	53	32.3	16	9.8	37	22.6	296	79	26.7	47	15.9	32	10.8
6	290	83	28.6	10	3.4	73	25.2	235	75	31.9	26	11.1	49	20.9	420	126	30.0	64	15.2	62	14.8
7	426	145	34.0	22	5.2	123	28.9	282	107	37.9	33	11.7	74	26.2	306	88	28.8	43	14.1	45	14.7
8	546	170	31.1	37	6.8	133	24.4	462	157	34.0	52	11.3	105	22.7	336	99	29.5	50	14.9	49	14.6
9	488	190	38.9	38	7.8	152	31.1	280	110	39.3	43	15.4	67	23.9	376	114	30.3	50	13.3	64	17.0
10 or higher	784	379	48.3	95	12.1	284	36.2	1,874	796	42.5	298	15.9	498	26.6	1,013	360	35.5	169	16.7	191	18.9
35 years + (total)	3,728	1,306	35.0	261	7.0	1,045	28.0	4,068	1,725	42.4	601	14.8	1,124	27.6	2,901	840	29.0	399	13.8	441	15.2
2, 3, 4 or 5	348	70	20.1	16	4.6	54	15.5	137	42	30.7	14	10.2	28	20.4	404	119	29.5	78	19.3	41	10.1
6	275	65	23.6	16	5.8	49	17.8	200	70	35.0	23	11.5	47	23.5	180	52	28.9	30	16.7	22	12.2
7	282	62	22.0	11	3.9	51	18.1	198	71	35.9	24	12.1	47	23.7	336	81	24.1	49	14.6	32	9.5
8	392	130	33.2	19	4.8	111	28.3	294	91	31.0	35	11.9	56	19.0	280	82	29.3	35	12.5	47	16.8
9	416	135	32.5	19	4.6	116	27.9	344	143	41.6	46	13.4	97	28.2	376	94	25.0	48	12.8	46	12.2
10	441	137	31.1	20	4.5	117	26.5	378	138	36.5	53	14.0	85	22.5	270	66	24.4	16	5.9	50	18.5
11	389	151	38.8	39	10.0	112	28.8	400	177	44.2	56	14.0	121	30.2	250	80	32.0	41	16.4	39	15.6
12 or higher	1,185	556	46.9	121	10.2	435	36.7	2,117	993	46.9	350	16.5	643	30.4	805	266	33.0	102	12.7	164	20.4

[a] Those prior to birth of the deceased child in the study.

[b] At birth of the deceased child.

Fig. 15
PERCENTAGE OF DEATHS AMONG PREVIOUS PRODUCTS OF PREGNANCY OF MOTHERS OF THE DECEASED CHILDREN UNDER 5 YEARS OF AGE IN THE STUDY, BY BIRTH ORDER ACCORDING TO MATERNAL AGE, EL SALVADOR, RECIFE, AND SÃO PAULO PROJECTS, INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD



In the El Salvador and São Paulo projects the infant death rates of previous products were especially high among young mothers.

From the data presented it would appear that the mothers of the decesased children studied in the Investigation suffered excessive reproductive losses in the past and that their infants were at greater risk of death than those in the population at large of the areas in question (that is, including the mothers of all liveborn infants as well). These mothers therefore probably constitute a group at greater risk of reproductive loss. The factors of early maternal age, high birth order, and low birthweight would also have been determinants of excessive mortality in the past. Low and deficient birthweights might have been even more frequent, and thus immaturity and nutritional deficiency may have been even more serious problems than they were during the period of the Investigation. In any case, then, as now, the causes and factors responsible for high infant death rates were multiple.

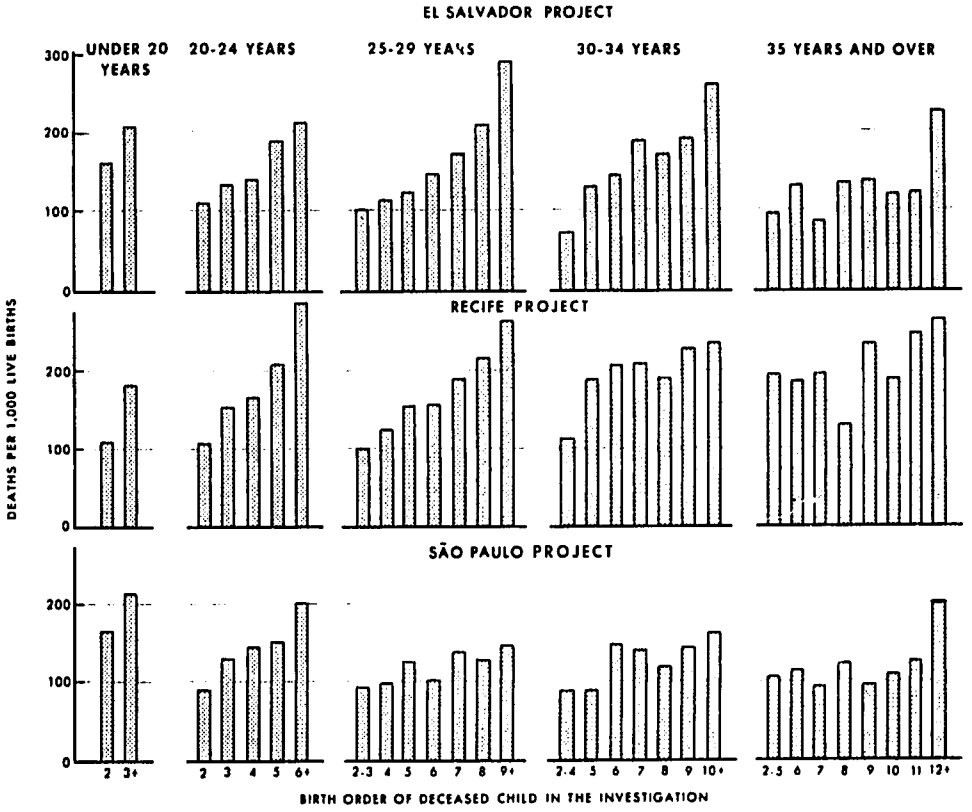
Table 15. Infant mortality among previous products of pregnancy[a] of mothers of the children under 5 years of age in the study, by birth order according to maternal age,[b] El Salvador, Recife, and São Paulo projects, Inter-American Investigation of Mortality in Childhood (deaths per 1,000 live births).

Maternal age and birth order of deceased child	El Salvador project			Recife			São Paulo		
	Live births	Infant deaths No.	Infant deaths Rate	Live births	Infant deaths No.	Infant deaths Rate	Live births	Infant deaths No.	Infant deaths Rate
Total	11,001	1,809	164.4	11,649	2,416	207.4	9,087	1,169	128.6
-20 years (total)	459	86	187.4	357	54	151.3	279	52	186.4
2	218	35	160.6	125	13	104.0	136	22	161.8
3 or higher	241	51	211.6	232	41	176.7	143	30	209.8
20-24 years (total)	1,997	309	154.7	1,738	363	208.9	1,586	216	136.2
2	278	31	111.5	155	16	103.2	282	24	85.1
3	484	64	132.2	269	41	152.4	423	53	125.3
4	557	78	140.0	352	56	159.1	368	51	138.6
5	330	62	187.9	286	58	202.8	277	41	148.0
6 or higher	348	74	212.6	676	192	284.0	236	47	199.2
25-29 years (total)	2,307	371	160.8	3,151	590	187.2	2,142	238	111.1
2 or 3	274	28	102.2	188	18	95.7	419	38	90.7
4	319	37	116.0	272	32	117.6	328	31	94.5
5	344	42	122.1	374	56	149.7	352	43	122.2
6	473	70	148.0	536	81	151.1	383	38	99.2
7	364	62	170.3	421	78	185.3	277	37	133.6
8	275	57	207.3	484	102	210.7	169	21	124.3
9 or higher	258	75	290.7	876	223	254.6	214	30	140.2
30-34 years (total)	2,784	517	185.7	2,958	619	209.3	2,619	343	131.0
2, 3 or 4	229	16	69.9	150	16	106.7	331	28	84.6
5	234	31	132.5	148	27	182.4	249	21	84.3
6	280	41	146.4	208	42	201.9	356	51	143.3
7	402	76	189.1	249	51	204.8	263	36	136.9
8	502	87	173.3	409	75	183.4	278	33	118.7
9	449	86	191.5	229	51	222.7	326	45	138.0
10 or higher	688	180	261.6	1,565	357	228.1	816	129	158.1
35 yrs.and over (total)	3,454	526	152.3	3,445	790	229.3	2,461	320	130.0
2,3,4 or 5	327	31	94.8	123	24	195.1	326	34	104.3
6	259	34	131.3	177	32	180.8	150	17	113.3
7	271	23	84.9	174	34	195.4	281	25	89.0
8	373	51	136.7	259	33	127.4	245	29	118.4
9	397	55	138.5	298	69	231.5	327	30	91.7
10	417	50	119.9	314	59	187.9	254	27	106.3
11	348	44	126.4	343	83	242.0	209	26	124.4
12 or higher	1,062	238	22[illegible]1	1,757	456	259.5	669	132	197.3

[a]Those prior to birth of the deceased child in the study.

[b]At birth of the deceased child.

Fig. 16
INFANT MORTALITY AMONG PREVIOUS PRODUCTS OF PREGNANCY OF MOTHERS OF THE DECEASED CHILDREN UNDER 5 YEARS OF AGE IN THE STUDY, BY BIRTH ORDER ACCORDING TO MATERNAL AGE, EL SALVADOR, RECIFE, AND SAO PAULO PROJECTS, INTER-AMERICAN INVESTIGATION OF MORTALITY IN CHILDHOOD



DISCUSSION

In the 1973 report of the Inter-American Investigation of Mortality in Childhood (*22*) nutritional deficiency—a condition frequently coupled with low weight at birth—was stated to be the most serious health problem uncovered. The two conditions combined, nutritional deficiency and low birthweight, are endangering the survival and hampering the growth of infants and young children and probably of future mothers. Whereas in the past it was considered that full brain growth in the human organism was attained by the fifth month after birth, recent evidence (*6*) suggests that the process may not be completed until about the third birthday. Hence sustained nutritional deficiency beginning with low or insufficient birthweight and worsened by adverse environment and inadequate food intake

may have an even more serious impact on the mental development of infants and young children than has been thought before. The mother's own low birthweight is believed to contribute at least in part to her poor nutritional state as an adult. Likewise, the infants who die from nutritional deficiency may be those who had unsatisfactory birthweights (3,000 grams or less). It is crucially important to break this vicious cycle.

The very high infant death rates corresponding to the maternal age groups in which birth intervals are short suggests that mothers fail to recover sufficiently between one pregnancy and the next. Analyses (*18,28*) of data from the collaborative perinatal study supported by the National Institute of Neurological Diseases and Stroke point to the importance of studying the relationship between birthweight, on the one hand, and prepregnancy weight and weight gain during pregnancy, on the other.

A study (*25*) is underway in New York City "to establish and then to plan strategies to prevent its occurrence [low birthweight] and sequelae." In the same vein, a recommendation by the National Academy of Sciences study (*13*) calls for refining the delineation of risk categories and directing the woman to the appropriate services that will help her to decrease the chances of giving birth to a low-weight or nonviable infant. A research program has been undertaken at the Institute of Nutrition of Central America and Panama (*14*) in which a food supplement of 20,000 calories or more given over the course of a woman's pregnancy appears to have resulted in a mean weight gain of from 2,960 to 3,220 grams.

The importance of weight at birth is receiving increasing attention in the literature. Hardy (*9*) refers to the longer-range as well as the immediate significance in the following statement: "The weight of an infant at birth is an important development milestone. In conjunction with gestational age, it provides a useful index of intrauterine growth (*8,17,19*). Intrauterine growth not only reflects the developmental experience of the fetus but also predicts fetal outcome–both immediate and longer range."

The Inter-American Investigation has shown how much can be learned about infant mortality through the use of new approaches such as the study of multiple causes and the evaluation of these three determining factors–birthweight, maternal age, and birth order. It has indicated many actions that might be undertaken by health authorities and medical educators to help improve the health of infants and young children and prevent mortality. Recommendations are given in the final chapter of the 1973 report (*22*).

Specific recommendations are now made in regard to the future analysis and study in greater depth of infant mortality taking into account the three factors that have been emphasized here.

The large maternities in Latin America could provide the basic data for analysis at the hospital level. An individual "outcome of pregnancy" form (Appendix 1) should be completed for each admission to the obstetric service and should include the following information: age of the mother, history of previous products of pregnancy, outcome of delivery, weight and condition of the newborn at birth, and condition on discharge from the pediatric service. Coordination between the obstetric and pediatric services

would be necessary in order to ensure that the form is properly filled out. The data so derived could be analyzed at the hospital level in regard to the frequency of low-weight births and the distribution of births by birthweight, maternal age, and birth order. Similarly, the facts on birthweight, maternal age, and birth order are needed on birth certificates as well. For this purpose the cooperation of hospital and health authorities is likewise necessary. The requirement of these data for calculation of death rates for the first day of life would be valuable for promoting the application of standard definitions as well as for identifying problems and evaluating progress. In the event of death, the "outcome of pregnancy" form should include, in addition, the multiple causes involved, the condition of the mother, and complications of pregnancy and delivery – thus making it possible to specify the underlying as well as contributory causes of death. The completeness and quality of the data on death certificates, as on the "outcome of pregnancy" forms, will depend on cooperation between the obstetric and pediatric services.

In Chile and El Salvador spaces are provided on birth certificates for the age of the mother and the number of previous products of pregnancy. The addition of one more item, weight at birth, would be desirable. In Canada and the United States of America such information is recorded routinely on birth certificates, although special cross-tabulations are usually necessary for analysis of the relationships. It is recommended that these items be added to birth certificates in the Latin American countries and that tabulations be prepared routinely.

The subject of registration of births and deaths in accordance with the WHO definition has been discussed in a paper prepared for a United Nations meeting on demographic statistics (*23*). Registration of all births and deaths in accordance with standard definitions is essential. Recommendations and actions at the international level are advisable. Since hospitals are being used for an increasingly large proportion of all deliveries, the routine establishment of registration offices on the premises would simplify procedures and help greatly to ensure that all the vital events occurring in hospitals are certified.

The foregoing analysis demonstrates clearly that the factors of birthweight, maternal age, and birth order are very important in determining the survival of the newborn. The marked increase of infant death rates with ascending birth order in the young maternal age groups would indicate that the short interval between pregnancies has a direct relationship to excessive mortality in childhood. But the increasing available evidence on the frequency of low and deficient birthweights in Latin America implicates birthweight as probably the most important of all these three factors. The problem of nutritional deficiency in early life may well be closely related to low and deficient weights at birth. At the same time, deficits in birthweight independent of the length of gestation are probably a function of unsatisfactory health, including inadequate nutritional state, of the mother.

In the Latin American areas nutritional deficiency and immaturity (low birthweight) contribute greatly to excessive infant mortality as underlying or associated causes. Furthermore, both these conditions represent deficits in

growth and development. Emphasis on their prevention is essential not only in order to increase the chances of survival but also to improve the biological, social, and mental quality of future generations.

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Appendix 1

SUGGESTED FORM FOR MINIMUM INFORMATION ON OUTCOME OF PREGNANCY FOR USE IN HOSPITALS

(Name of hospital)

OUTCOME OF PREGNANCY

1. MOTHER: Name _____ Number _____

Residence _____

Age in completed years _____ Number of years of education _____

Number of previous products of pregnancy (abortions, fetal deaths, and live births) _____

Weeks of gestation _____ Date and hour of delivery _____

Complications _____

2. PRODUCT: Outcome of pregnancy [a] _____ Sex _____ Multiple [b] _____

Name _____ Weight at birth _____

Height _____ Condition _____

Congenital anomalies _____

_____

Death: Date and hour _____ Age: Days ___ hours ___ minutes ___ Fetal death: ___

Underlying cause _____

Associated causes _____

Live birth: Discharge [c] _____ Date _____

Condition _____ Age: Days ___ Hours _____

[a] Live birth, fetal death, or abortion.
[b] If multiple, order of birth and separate record for each one.
[c] Type of discharge and destination, such as home or other hospital.

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