Nutrition and Infection Field Study in Guatemalan Villages, 1959-1964

IV. Deaths of Infants and Preschool Children

Werner Ascoli, MD, and Miguel A. Guzmán, PhD, Guatemala City, and Nevin S. Scrimshaw, MD, and John E. Gordon, MD, Cambridge, Mass

THIS study was designed to demonstrate the differential effect of experimentally introduced programs of supplemental feeding and integrated medical services in separate Guatemalan highland villages, a third community serving as a control.[1] A choice was made to work with populations sufficiently large to give significant results for cases of infectious disease and nutritional disorder and yet of necessity too small to permit judgment by the deaths which occurred.[2]

The reasons for this decision were several. The intent was to emphasize quality of data. A study assuring significant numbers of deaths and still obtaining detailed information on cases was beyond practical limitations on staff and finances. Existing information on the frequency of disease was far less than for deaths. Granted that numbers of deaths from malnutrition and infectious disease in developing countries are not well defined, some facts had been established.[3] Furthermore, cases of disease with their varying degrees of severity have a broader usefulness in understanding the ecologic interplay of nutrition and infection.[4]

The original plan was to present a simple record of the deaths which occurred during the study, attempting neither analysis nor evaluation. The situation changed subsequently when the Institute of Nutrition of Central America and Panama (INCAP) under the auspices of the Nutrition Section of the US Office of International Research (OIR) made a comprehensive field study of deaths in 40 rural villages and small towns of Guatemala as a part of a larger and general nutritional survey of sampled populations from each of the Central American countries.

Deaths in the present investigation were carefully studied by prospective field methods described earlier.[5] The proportion of deaths at various times within the first year of life, some findings about death rates in the second year, and causes of death in a rural child population of a developing country were highly suggestive of a synergism between nutrition and infection. As anticipated, the numbers were too few to be conclusive. The results of the larger INCAP-OIR survey served usefully to confirm the suggestive findings about deaths in early childhood.

The two studies covered the same years except that the INCAP-OIR investigation included the year preceding the prospective observations. The collection of data in the INCAP-OIR study was retrospective and from the official registers maintained in local jurisdictions, instead of prospectively and by direct observation of events, as in the present investigation. Both studies were organized by the same field epidemiologist (Dr. Ascoli). In scope, the INCAP-OIR study exceeded any known investigation of

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Submitted for publication May 9, 1967; accepted May 15.

From the Institute of Nutrition of Central America and Panama (INCAP), Guatemala City.

Reprint requests to the Institute of Nutrition of Central America and Panama, Apartado Postal 1188, Guatemala City (Dr. Ascoli) or to Massachusetts Institute of Technology, Bldg E18-479, Cambridge, Mass 02139 (Dr. Gordon).

the sort in a developing country. It included four randomly selected but different communities within the same local area where the specific study was made, the central region of Guatemala. The population of the four towns was 11,227, and deaths were 1,503 during seven years (1958 to 1964). The number of deaths within the whole of the sampled areas of Guatemala was large, 42,-421, for they were from an average population of 340,211.

In the descriptions which follow, the pattern of deaths in the experimental area is compared with that of the central highland region common to both investigations and also with rural areas of Guatemala as a whole. The study village provided with medical care and preventive and sanitary services was Santa María Cauqué; the village where preschool children received a food supplement was Santa Catarina Barahona; and the control village was Santa Cruz Balanyá.[1]

Crude Death Rates

The three villages began the study on seemingly equal terms. For the two years immediately preceding the start of observations, an interval necessary because of the few deaths, average annual rates were 22.8 deaths per 1,000 population in the medical care village, 25.5 in the feeding village, and 24.7 in the control.

Comparison of these rates with the average annual rate for the years 1950 to 1959, given in Table 1, indicates strongly that while the villages may have started the expeirmental period with essentially equivalent death rates, the long-term behavior was certainly different for the control. Inspection of rates for individual years in each of the villages showed all to have experienced the experimental period with essentially equivalent and small populations and suggested probable differences in long-term behavior of the two test villages. To gain reliability in rates with the small populations involved, a midpoint was taken in the nine-year period, and rates were calculated for the years 1950 to 1954 and 1955 to 1959, as in Table 1.

Santa María Cauqué had an initial 1950-1951 rate of 29.2 deaths per 1,000 population. Annual rates decreased regularly during the first four years, then rose to fall again, with a resulting average for the first period of 26.3 and for the second period of 21.8. Whether based on the rates of the first and last two years which were less reliable because of small numbers or the long periods, deaths in that village evidently experienced a downward trend during the nine years.

The feeding village, Santa Catarina Barahona, began in 1950 with the most favorable death rate of its nine-year course, 19.7 deaths per 1,000 population. Minor fluctuations occurred in succeeding years, but no discernible trend was demonstrated either upward or downward. The rates for the two long-term periods were 24.9 and 24.8, and the last two years ended with a rate inconsequentially in excess of the nine-year average, 25.5 per 1,000 population.

The control village started in 1950 with 29.5 deaths per 1,000 population, essentially the same as for Santa María Cauqué. Death

Table 1.—*Deaths and Deaths per 1,000 Population, Three Rural Villages of Guatemala, May 1950 to April 1964*

Years		Santa María Cauqué	Santa Catarina Barahona	Santa Cruz Balanyá
May 1950-April 1954	Accumulated populations	2,776	3,218	5,072
	All deaths	73	80	154
	Death rate	26.3	24.9	30.3
May 1954-April 1959	Accumulated populations	4,125	3,865	6,623
	All deaths	90	96	212
	Death rate	21.8	24.8	32
May 1950-April 1959	Accumulated populations	6,901	7,083	11,695
	All deaths	163	176	366
	Death rate	23.6	24.8	31.2
May 1959-April 1964	Accumulated populations	5,027	4,254	7,273
	All deaths	78	66	187
	Death rate	15.5	15.5	25.7

rates thereafter varied greatly, were regularly in excess of those noted at the extremes of the nine-year period, and in one year reached 38 per 1,000 population. For the first four years the average was 30.3 deaths per 1,000 and for the second period 32 to give a nine-year average of 31.2.

In summary, the treatment village during the baseline period had shown an appreciable decline in death rates. Rates for the feeding and control villages had remained stable, although for the feeding village at a lower level than for the control. These differences in behavior enter into the interpretation of values observed during the trial period of 1959 to 1964. The nine-year average is taken in each instance as the basis for comparison.

Average annual death rates during the study period were less in all three villages than the average for the baseline 1950-1959 rate and also for rates at the beginning of the study. They differed in extent of decline. The village with added medical facilities had a death rate of 15.5, a decrease of 34% from the baseline average. The expected decrease based on preceding experience was 17%. The feeding village had a crude death rate of 15.5 per 1,000, precisely the same as in the treatment village. The decline was 37%, while the expected result from the trend line was no change. The rate of 25.7 deaths per 1,000 population for the control village given in Table 1 corresponded to a decline of 18% from values of the baseline period, where the expected result was again no change.

The treatment village had a program which reached all ages. The anticipated improvement in crude death rates might reasonably have been greater than in the feeding village where the program was limited to children less than five years old, other than for mothers who had the food supplement incident to its provision to their children.

Deaths in the control population had shown little change in numbers in previous years. During the observational period, rates declined by 18%, another example of the effect of study and observation of a population in the absence of a specifically introduced factor intended to produce a given change.[6,7] One identifiable influence was the occasional transport of a sick person on request to the district hospital, mainly adults but also children.

For the stated reasons, more specific indication of changes induced by the two experimental programs is to be had from age-specific death rates in infancy and early childhood, with the repeated caution that numbers of deaths are so small as to have limited statistical validity. The real index of the worth of the findings is how well they are supported by the larger INCAP-OIR series.

Crude death rates of the three study villages during the experimental period averaged 19.9 per 1,000 population per year. For the larger INCAP-OIR survey the rate was 17.8, which in itself was in close agreement with the nationally reported rates for those particular years. For rural communities of the central region of Guatemala where the nutrition and infection study was conducted, the crude death rate was 19.1 per 1,000 population per year. For Mayan Indian populations of the country, which was the predominant racial group of the study villages, annual rates averaged 20.8/yr; for predominantly Ladino (culturally non-Indian) communities, they were 15; and for villages with both Ladino and Indian residents, 15.8. Geographically, crude death rates varied considerably throughout the country. They were highest in the northwest region, 22.7, and lowest in the eastern section, 13.2.

Infant Mortality

Crude death rates as great as those for populations of the study villages and for Guatemala as a whole predicated unusually high age-specific rates for infants and for preschool children from one through four years of age. In large part, crude rates are a secondary reflection of what happens in early childhood, for deaths are most numerous at those ages. The differences in magnitude between death rates in developing countries for infants and for children aged one through four years and those observed in socially and economically favored regions overshadow other considerations so much that distinctive qualities of the two rates and the relation they have, one to another, receive less attention than is warranted.

These attributes strongly reflect causes.

They can guide the organization of control programs, and they are a significant measure of accomplishment in improved health for young children of a community. In this study they have special importance in determining the relative merits of measures directed against infection and nutrition because the two programs were directed primarily to children after weaning starts and until school age.

Deaths in the first year of life per 1,000 live births during the study period averaged 88 for Santa María Cauqué, the treatment village; 146 for the feeding village; and 191 for the control village Santa Cruz Balanyá. Birth rates were notably high, in general exceeding 40 per 1,000 population. The death rates cited in Table 2 mark a decrease of 35% from baseline averages for the treatment village, 19% for the feeding village, and for the control, infant mortality was numerically slightly greater than expected.

The observed differences require interpretation on the basis of preceding behavior in the baseline period. Santa María Cauqué had evidenced a downward trend in infant mortality during the nine-year period which possibly was influenced by some nursing and medical care associated with previous INCAP programs in that village. The observed result during the experimental period followed the projected trend. Santa Catarina Barahona had had an upward trend at the midpoint; and the observed result of a 19% lesser rate than for the preceding nine years was better than the expected stationary rate predicted by the trend line. Santa Cruz Balanyá had shown a similar upward trend at midpoint, and the slight increase beyond the nine-year average followed the trend.

The rates were generally high compared with average infant mortality as determined in the INCAP-OIR survey for the central region and for the country as a whole. For rural regions the average rate in that study was 100.2 deaths per 1,000 live births. The average for the central rural region in which the present study was conducted and for the same years was 131.5 deaths per 1,000 live births. Variations between villages were also great; and other Mayan Indian communities were observed with rates as high as those of the study villages or higher.

In field studies in rural Punjab, India,[8] similar to those here reported, a crude death rate of 16.9 was associated with an infant mortality of 162; the officially reported rate was 103. Santa Catarina Barahona with a crude rate of 15.5 and infant mortality of 146 and Santa Cruz Balanyá with a greater crude death rate of 25.7 and infant mortality of 191 are comparable.

Table 2.—*Deaths in Infancy and Deaths per 1,000 Live Births, Three Rural Villages of Guatemala, May 1950 to April 1964*

Years		Total First Year	Neonatal	Postneonatal
		Santa María Cauqué		
May 1950-	Deaths	56	26	30
April 1958	Infant mortality	136	63	73
	Deaths/all deaths under 1 yr, %		46	54
May 1959-	Deaths	23	7	16
April 1964	Infant mortality	88	27	61
	Deaths/all deaths under 1 yr, %		30	70
		Santa Catarina Barahona		
May 1950-	Deaths	56	22	34
April 1959	Infant mortality	182	71	110
	Deaths/all deaths under 1 yr, %		39	61
May 1959-	Deaths	24	11	13
April 1964	Infant mortality	146	67	79
	Deaths/all deaths under 1 yr, %		46	54
		Santa Cruz Balanyá		
May 1950-	Deaths	115	59	61
April 1959	Infant mortality	186	88	99
	Deaths/all deaths under 1 yr, %		47	53
May 1959-	Deaths	70	33	37
April 1964	Infant mortality	191	90	101
	Deaths/all deaths under 1 yr, %		47	53

The supplementary feeding program would be expected to have a limited effect on infant death rates. It would not apply to the neonatal period; and with infants universally breast fed, the food supplement was not ordinarily received until after the sixth month when depletion in breast milk usually becomes evident by the failure of growth and development. The significant finding in the feeding village was that after years of continuing fixed rates of high infant mortality a downward although marginal trend occurred.

Infant mortality in industrialized countries shows a characteristic proportion of neonatal deaths to postneonatal fatalities of about 2:1 as for the United States,[3] and infant mortality rates are low. Neonatal deaths have still another characteristic. Those within the first seven days usually outnumber deaths within the remaining three weeks.

As a group they are due to obstetrical causes, prematurity, and developmental anomalies, which together constitute the hard core of infant mortality, difficult and slow to reduce. In developing countries, tetanus neonatorum is frequently important. The 7th-27th day deaths are mainly from late effects of these causes with some few due to infections acquired after birth. Postneonatal deaths are mostly from acquired infection, some few from accidental traumatic injuries, and in developing countries a significant contribution from malnutrition. To a major extent they are preventable. At any rate as health services improve the gains in infant mortality in developing countries are chiefly in the postneonatal period. In the study villages, three fifths of neonatal deaths were in the first week. Table 3 further indicates that neonatal death rates were about double those for all infant mortality in industrial countries.

The most significant feature of total infant mortality in the study villages was the inverse ratio of neonatal to postneonatal deaths. This behavior is characteristic of developing countries: Postneonatal deaths outnumber neonatal. It comes about not from any lesser number of neonatal fatalities; indeed they are generally more numerous as noted for the study villages. The disproportion is from an excess of deaths from infection and nutrition in the latter half of infancy.

The reversed ratio was true for the control village, both before and after observations started. It remained unchanged at 47:53, more postneonatal deaths than neonatal.

In the baseline period, postneonatal deaths in the feeding village were more than ordinarily frequent, in a ratio of 39:61. During the time food supplements were given, the proportion improved slightly (45:54) but not significantly. This was not unexpected, because as already noted supplemental foods were little used in the first six months and to a limited extent in the last six months.

In the treatment village, the main effect of the program was on neonatal deaths; rates decreased by more than a half, from 63 per 1,000 live births in the baseline period to 27 in the study years. A coincident epidemic of acute diarrheal disease,[9] which mainly affected older infants and preschool children, prevented appreciable decrease in postneonatal deaths. Rates changed from 73 to 61 per 1,000 live births, and the neonatal-postneonatal ratio was 30:69.

The validity of the inverse neonatal-postneonatal ratio here observed was well supported by the comprehensive INCAP-OIR survey. Among 5,582 deaths of infants in rural regions of Guatemala during 1958 to 1964, where infant mortality was 100.2 per 1,000 live births, neonatal deaths accounted for 41% and postneonatal for 59% of the total. The proportion of postneonatal deaths was somewhat greater than for the study villages, of which the control village provides the best comparison.

Deaths Within the Age Group One Through Four Years

During the preexperimental period, deaths in the villages among children past the first year of life and less than five years old followed much the same pattern as did crude death rates and deaths among infants except that rates for the treatment and feeding villages were for these ages about equal (Table 4). Both rates were measurably less than for the control village. These are the ages at which children were most directly affected by the experimental programs,

Table 3.—*Deaths During the First Year of Life, by Age, Three Guatemalan Villages, May 1959 to April 1964*

Age at Death	Santa María Cauqué No. Deaths	Santa María Cauqué % of Total	Santa Catarina Barahona No. Deaths	Santa Catarina Barahona % of Total	Santa Cruz Balanyá No. Deaths	Santa Cruz Balanyá % of Total	Total No. Deaths	Total % of Total
0-6 days	3	13	6	25	21	30	30	26
7-27 days	4	17	5	21	12	17	21	18
0-27 days	7	30	11	46	33	47	51	44
28-days 11 mo	16	70	13	54	37	53	66	56
0-11 mo	23	100	24	100	70	100	117	100

Table 4.—*Deaths and Age-Specific Death Rates per 1,000 Population by Year, Ages 1 Through 4, Three Rural Villages of Guatemala, May 1950 to April 1964*

	May 1950 to April 1959 Age in Years					May 1959 to April 1964 Age in Years				
	1	2	3	4	Total	1	2	3	4	Total
					Santa María Cauqué					
Deaths	22	13	8	3	46	15	4	2	4	25
Death rates	88	58	33	14	50	77	23	10	24	34.5
Deaths/all deaths 1-4 yrs, %	48	28	17	7		60	16	8	16	
					Santa Catarina Barahona					
Deaths	16	5	12	7	40	5	4	2	0	11
Death rates	77	28	72	42	55.6	38	35	19		24.3
Deaths/all deaths 1-4 yr, %	40	13	30	17		46	36	18		
					Santa Cruz Balanyá					
Deaths	54	26	13	8	101	19	14	5	4	42
Death rates	166	80	42	28	81	91	68	25	22	50
Deaths/all deaths 1-4 yr, %	53	26	13	8		45	33	12	10	

Table 5.—*Deaths and Death Rates per 1,000 Population in Early Childhood, by Sex and by Age*

	Boys Age in Years			Girls Age in Years		
	1	1-4	Total	1	1-4	Total
			Santa María Cauqué			
Deaths*	17	11	28	6	13	19
Death rates	128	30	55	47	36	39
			Santa Catarina Barahona			
Deaths	12	7	19	12	4	16
Death rates	145	30	61	148	18	53
			Santa Cruz Balanyá			
Deaths*	30	25	55	40	16	56
Death rates	166	63	97	216	39	95
			Total			
Deaths	59	43	102	58	33	91
Death rates	149	43	73	148	33	66

* Age 1 to 4, one death sex unknown.

much more so than infants. They had the greater participation in the feeding program. They made greater use of treatment measures.

All three villages showed lesser death rates for these ages during the study period than the average for the preceding nine years. The extent of decline in the study years was 31% for the medical care village, 56% for the feeding village, and 38% for the control. The two test villages had experienced improving death rates for children of these ages during the baseline period; for the medical care village, a decrease of about 19%; and for the feeding village, 17%; while the trend in the control was numerically slightly upward although not significantly so. During the study period the decline in rates in the feeding village was three times the expected, and the treatment village had a ratio better by a half than the projected rate. However, the improvement was less than for the control village where no decline would have been predicted.

The rate for the three study villages as a group and for these ages (39 per 1,000) was in excess of the average for the central highlands region in the INCAP-OIR study (28.3 per 1,000 per year). The improved rates for

children of these ages in the control village during the study period was in accord with the better crude death rate observed there and presumably for the same reasons. It reached a level (50 per 1,000) which characterized the test villages in 1950.

More significant even than the high death rates among preschool children considered as a group was the distribution of deaths by individual years. That was a consistent feature of both baseline and experimental periods in all three villages. As repeatedly stressed, the limitations imposed by small numbers become acute when divisions within the preschool ages are by individual years. The results would not be presented, especially the computed rates, except that in principle they are supported by the larger INCAP-OIR survey, by the studies in rural Punjab[10] and by the results of a third investigation, as yet incomplete, of deaths during preschool years in representative developing countries of the world.

First to be noted is that deaths during the second year accounted for about one half of all fatalities for ages one through four years. The remaining three years were responsible for the other half (Table 4).

As for death rates before and after the treatment program, a gross decline occurred at ages one through four years comparable with that of infant mortality and yet with little change for one-year-olds. The main effect was in lower rates in the later years except for an anomalous result for children of the fifth year. As mentioned earlier in connection with infant mortality, the results in the treatment village were influenced by the presence of an epidemic of diarrheal disease which persisted during two of the five years.

In the feeding village with a marked decline in death rates for children aged one through four years, the improvement extended through all individual ages, and no deaths occurred during five years among four-year-old children. With generally lowered rates equivalent to the decrease in the treatment village, the control village also showed improvement at all four ages. The main factor in lesser general rates for preschool children was a lessened mortality during the second year of life. The proportion of deaths in the second year to all deaths at ages one through four years was 60% for the treatment village, 46% for the feeding village, and 45% for the control.

These relationships among death rates at different ages were entirely consistent with those of the larger INCAP-OIR survey in the same central highland region. The age-specific death rate for children one year old and less than two years was 54.2 per 1,000 children of that age per year; for age two years it was 28.5; and for the next two years respectively, 20.4 and 7.5 per 1,000 per year.

Sex Differentials

Deaths among males and females of preschool age during the study years, Table 5, were essentially equal with no more than a suggestion of the usual excess mortality among boys. The discrepancies when deaths were divided by villages and by ages are a probable result of small numbers. Rates for the larger INCAP-OIR survey population were in good agreement with the stated totals for all villages. Radically different results are sometimes noted in developing countries. The Punjab rural populations in India had death rates for preschool children aged one through four years of 19.4 per 1,000 for boys and 36.9 for girls.[11] This sex difference also characterized infancy and extended to older ages.

Causes of Death

Causes of death identified in the five years of the village study were heavily weighted by infectious diseases of the intestinal and respiratory tracts, Table 6. Respiratory diseases, including the pneumonias and tuberculosis, are consistently among the ten leading causes of death in most countries of the world. Those from diarrheal diseases are a prominent feature in developing countries, often exceeding deaths from respiratory infections. In this experience the two were about equally frequent and greatly exceeded other main causes. The dominant place of acute infections leads to much variation in proportionate death rates by cause from year to year because of epidemic prevalence.

Injuries which are the leading cause of death at ages one through four years in industrialized countries had low rank because of the dominance of acute infectious dis-

eases. In numbers they were a scattered few and less than expected from experience in a developing country where injuries were specifically studied.[12]

The common communicable diseases of childhood, which includes measles, whooping cough, rubella, chickenpox and mumps were more frequent causes of death than in countries with well-developed health services. In one epidemic[13] the case fatality for measles was 6.8%. Complications were more frequent and of exaggerated severity in the presence of an initially deficient nutritional state. Even chickenpox[14] served to precipitate kwashiorkor in children already malnourished. A depleted nutritional state at the time of attack was an important influence in determining the likelihood of death in these diseases and also in other infections, notably diarrheal disease.[15]

All patients with death ascribed to malnutrition had edema and other clinical signs of kwashiorkor. In the feeding village, no deaths from malnutrition occurred among children who had been receiving food supplements regularly in the immediately preceding months. Three children died whose participation in the program had been sporadic at best, and a fourth had discontinued supplemental feeding after an attack of severe diarrhea four months earlier. Recorded deaths from nutritional disorders were less numerous by a half than in the earlier study in the same general region[3] where two fifths of deaths at one through four years were from this cause. The number of malnutrition deaths, about one per village per year, was too small for meaningful comparison of villages.

No death from tetanus was recognized in this experience. In the Punjab study that disease was the leading cause of death in the neonatal period. A disproportionate number of deaths in the feeding and control villages of the present study, mainly in the first year of life, are listed as cause unknown. Unlike the treatment village where a resident medical service was available, numerous patients in the other villages were not seen by a physician before death. The medical history obtained from the family or midwife was depended upon for identification of cause. When reasonable doubt existed, cause was listed as unknown.

Comment

A comparison of death rates in Guatemala derived from the INCAP-OIR survey, Table 7, with those prevailing in an industrialized country (United States) during the same years clearly identifies the situations in which health problems of early childhood in developing countries are most acute. The data pertain to Guatemala but a familiarity with developing regions in other parts of the world justifies broader generalization.

Death rates in Guatemala in the neonatal first 28 days of life were twice those in the United States. As judged by the similarity of death rates in the first seven days, genetic and developmental abnormalities would appear to be about equal in the two situations. The differences between the two countries can be attributed reasonably to a poorer prospect for infants born prematurely and to a poorer quality of obstetrical care. In some developing countries, deaths from tetanus make an important contribution.

The high infant mortality in Guatemala results from more infectious disease and a steadily worsening nutritional state once breast milk is no longer an adequate source of protein and calories. The ratio of infant mortality rates in Guatemala to those of the United States is 4:1.

A characteristic feature of infant mortality in developing countries, aside from the high general rates, is an inverse proportion of neonatal deaths to those of the postneonatal months, after the first month. The usual ratio in advanced countries is 2:1, neonatal to postneonatal. In most developing countries it approximates 2:3. The cause is an excess of deaths from acquired disease, mainly infectious and nutritional. These conditions are preventable. An interaction between the two has been emphasized, and programs for prevention and control require a common effort. A trend toward reversal of the ratio is a practical means to measure accomplishment.

The second year death rate in Guatemala approximated that of the postneonatal period. In other words, after the neonatal month, death rates continued at much the same high level through the second year of life. In the United States, rates for the second year were a fraction of those in the first

Table 6.—*Deaths by Cause and Age, Three Guatemalan Villages, May 1959 to April 1964*

Cause	Santa María Cauqué		Santa Catarina Barahona		Santa Cruz Balanya	
	1 Yr Pop 261	1-4 Yr Pop 725	1 Yr Pop 164	1-4 Yr Pop 455	1 Yr Pop 366	1-4 Yr Pop 802
Acute diarrheal disease	7	7	5	2	8	17
Respiratory diseases	11	5	8	1	19	7
Common communicable diseases of childhood	0	2	1	2	3	9
Malnutrition	0	5	0	4	2	3
Other known causes	0	1	2	1	11	2
Cause unknown	5	5	8	1	27	4
Total	23	25	24	11	70	42

Table 7.—*Deaths per 1,000 Children per Year, by Age (Infants per 1,000 Live Births), United States and Guatemala, 1958 to 1964**

Age	United States	Guatemala	Ratio, Guatemala to United States
Neonatal, first 28 days	18.6	35.9	2:1
Postneonatal, 29 days to 11 mo inclusive	7.2	55.9	8:1
Infant, under 1 yr	25.7	91.8	4:1
1 yr	1.7	50	29:1
2 yr	1	35.2	35:1
3 yr	0.8	24.9	31:1
4 yr	0.6	16.1	27:1
1-4 yr	1	32.1	32:1

* Source for United States, *Vital Statistics of the United States, 1958 to 1964*, US Department of Health, Education, and Welfare; for Guatemala, INCAP-OIR Survey.

year, 7%. The reasons for the high rates in the second year were also infectious disease now augmented by deaths from kwashiorkor and other nutritional disorders, with the effects of both exaggerated by their synergistic interaction. The Guatemala-United States ratio for second year death rates rose abruptly 29:1.

Guatemalan death rates decreased progressively during the third, fourth, and fifth years, as they did in the United States but not in equivalent amount. The striking feature was that the ratio of deaths in Guatemala to those in the United States continued at the same high level. Indeed ratios were slightly greater in the third and fourth years; and for the whole period, one through four years, the ratio was 32:1. This behavior is due primarily to inadequate nutrition fostered by the long period of weaning (median 25.5 months) with insufficient supplementation of breast milk.

Once weaning is complete, death rates fall if diet becomes promptly more adequate; if not, they decline more slowly. The time of weaning and subsequent improvement in feeding determines the course of death rates each year during the first five years. When weaning occurs much before the end of the first year, the frequency of deaths from marasmus is commonly high.[16]

In rural India,[10] for example, where the median for completed weaning was 19.5 months and food available in fair amount thereafter, the death rate in the fifth year was 3 per 1,000 per year. The ratio to the United States rate became 5:1 instead of 27:1 in Guatemala despite actual rates in infancy and the second year which were greater than in Guatemala.

Summary

A Guatemalan rural village of about 1,000 inhabitants had a newly introduced program of supplemental feeding for children less than five years old. A second village had an integrated service of medical care, preventive medicine, and sanitary services available to all, but directed primarily to preschool children. A third village served as a control.

In the course of five years, infant mortality improved in both the village with medical care and the feeding village, compared with a preceding baseline experience of nine years. Infant mortality in the feeding village improved 19% during the experimental period under conditions where infant mortality had remained the same during the preceding nine years. With universal breast feeding, the feeding program reached most children of this age for only a few months. Although small, the recorded gain marked a change in trend. Infant mortality in the control village remained unchanged. Although the gain was greatest in the treatment village, 36%, this was no more than expected from the decline during the baseline period.

Deaths among children of the treatment village, aged one to four years, showed a 50% greater decline than expected from rates of the preceding nine years. The best result was in the feeding village with a gain threefold that of an expected 17% improvement. The control village showed a somewhat greater percentage improvement than the treatment village but less than the feeding village. No change was expected on the basis of the preceding baseline record. The prevailing high rates declined to a level of 50 per 1,000 population, that of the test villages 1950.

The principal causes of death among infants were diseases characteristic of the newborn, respiratory infections, and a minor representation of acute diarrheal disease. Acute diarrheal disease dominated all others at ages one through four years; respiratory disease had less prominence; and the common communicable diseases of childhood and kwashiorkor gained significance. An associated malnutrition was a contributing factor in a high proportion of deaths from specific infectious diseases among older infants and toddlers.

The deaths during the field study were too few to permit firm conclusions or to allow generalizations on the nature and frequency of deaths in childhood in Guatemala or other less-developed regions. However, a subsequent survey of a large random sample of the population of Guatemala (INCAP-OIR) supported the findings.

Aside from high rates, the characteristic feature of infant mortality in Guatemala and most other developing countries is an inverse ratio of neonatal deaths to postneonatal deaths, those occurring after the first month, ordinarily 2:1 in industrialized regions and 2:3 in preindustrial areas.

Second year deaths account for a half or better of the total for the age group one through four years. Death rates during the second year approximate those of the 11 postneonatal months. After the neonatal period with its causes of death those peculiarly associated with the newborn, mortality continues through the second year at much the same rate because the contributing factors are similar. Mortality ordinarily remains high until weaning ends. Thereafter, death rates decline with relative promptness if the food supply of the community is adequate for children of this age, more slowly if it is not.

The death rates in this study indicate that in Guatemala as in most other developing countries the toddlers of late infancy and the second year warrant as much consideration as younger infants.

Unpublished data of the Institute of Nutrition of Central America and Panama-Office of International Research survey are used by permission of the Institute of Nutrition of Central America and Panama and the US Office of International Research. This research was supported by the Advanced Research Projects Agency (Project AGILE) and was monitored by the Nutrition Section, Office of International Research, National Institutes of Health under ARPA order No. 580 program plan 298. It was also supported in part by grant AM-4827 from the National Institutes of Health.

References

1. Scrimshaw, N.S.; Guzmán, M.A.; and Gordon, J.E.: Nutrition and Infection Field Study in Guatemalan Villages, 1959-1964: I. Study Plan and Experimental Design, *Arch Environ Health* 14:657-662, 1967.

2. Scrimshaw, N.S., et al: Nutrition and Infection Field Study in Guatemalan Villages, 1959-1964: II. Field Reconnaissance, Administrative and Technical; Study Area; Population Characteristics; and Organization for Field Activities, *Arch Environ Health* 14:787-801, 1967.

3. Béhar, M.; Ascoli, W.; and Scrimshaw, N.S.: An Investigation Into the Causes of Death in Children in Four Rural Communities in Guatemala, *Bull WHO* 19:1093-1102, 1958.

4. Gordon, J.E.: Ecologic Interplay of Man, Envi-

ronment and Health, *Amer J Med Sci* 252:341-356, 1966.

5. Scrimshaw, N.S., et al: Nutrition and Infection Field Study in Guatemalan Villages, 1959-1964: III. Field Procedure, Collection of Data and Methods of Measurement, *Arch Environ Health,* 15:6-15, 1967.

6. Roethlisberger, F.J., and Dickson, W.J.: *Management and the Worker,* Cambridge, Mass: Harvard University Press, 1939.

7. Landsberger, H.: *Hawthorne Revisited,* Ithaca, NY: Cornell University Press, 1958.

8. Gordon, J.E.; Singh, S.; and Wyon, J.B.: A Field Study of Deaths and Causes of Deaths in Rural Populations of the Punjab, India, *Amer J Med Sci* 241:359-382, 1961.

9. Gordon, J.E., et al: Studies of Diarrheal Disease in Central America: VI. An Epidemic of Diarrhea in a Guatemalan Highland Village With a Component Due to *Shigella dysenteriae,* Type 1, *Amer J Trop Med Hyg* 14:404-411, 1965.

10. Gordon, J.E.; Singh, S.; and Wyon, J.B.: Demographic Characteristics of Deaths in Eleven Punjab Villages, *Indian J Med Res* 51:304-312, 1963.

11. Gordon, J.E.; Singh, S.; and Wyon, J.B.: Causes of Deaths at Different Ages, by Sex and by Season in a Rural Population of the Punjab, 1957-1959: A Field Study, *Indian J Med Res* 53:906-917, 1965.

12. Gordon, J.E.; Gulati, P.V.; and Wyon, J.B.: Traumatic Accidents in Rural Tropical Regions: An Epidemiological Field Study in Punjab, India, *Amer J Med Sci* 243:382-402, 1962.

13. Scrimshaw, N.S., et al: Studies of Diarrheal Disease in Central America: VIII. Measles, Diarrhea and Nutritional Deficiency in Rural Guatemala, *Amer J Trop Med Hyg* 15:625-631, 1966.

14. Salomon, J.B.; Gordon, J.E.; and Scrimshaw, N.S.: Studies of Diarrheal Disease in Central America: X. Associated Chickenpox, Diarrhea and Kwashiorkor in a Highland Guatemalan Village, *Amer J Trop Med Hyg* 15:997-1002, 1966.

15. Gordon, J.E., et al: Acute Diarrheal Disease in Less Developed Countries: II. Patterns of Epidemiological Behavior in Rural Guatemalan Villages, *Bull WHO* 31:9-20, 1964.

16. Scrimshaw, N.S. and Béhar, M.: Protein Malnutrition in Young Children, *Science* 133:2039-2047, 1961.

SHIFT-WORKERS AND DAILY RHYTHM

An early Scandinavian contribution to present knowledge of the health problems of shift-labourers was the investigation by Bjerner, Holm, & Swensson (1948) in Sweden. This investigation included laboratory studies of variations in the 24-hour rhythm of behaviour and spontaneous activities in rats, the glycogen content of the liver, the body temperature, and diuresis. It was shown that the normal 24-hour patterns in regard to maxima and minima of these functions could rapidly be altered and displaced in time by changing the environment, particularly the periods of darkness and light within the 24-hour cycle. This observation was contrary to previously held views to the effect that the 24-hour patterns were rather stable. In studying human beings these investigators observed that industrial work was actually more difficult to carry out at night than during day time. This observation was based on a comparison of writing errors and miscalculations committed by workers during day-and night-work periods. A marked increase in the frequency of writing errors and miscalculations was found to occur between 0100 and 0400 hours in the early morning. There was also a small "peak" during day time, between 1300 and 1600 hours. No difference was observed between the first and the last night of the week among labourers working on night-shifts, as would have been expected if an adaptation to a different 24-hour rhythm had taken place. Nor was there any difference between the first and the last day of the week in regard to the sleeping pattern of the labourers. The difference between the results of the animal experiments and the observations of industrial labourers was ascribed to the fact that a total change of the environment was effected under experimental conditions, whereas the daily rhythm of shift-labourers was altered in an environment which remained essentially unchanged. These investigators furthermore studied the effect of sleep (and the lack of sleep) in shift-labourers and day-labourers by means of psychotechnical testing and electroencephalographic recording. It was found that the adverse effects of too little sleep were greater at night than during day-time. Sufficient sleep was therefore more important for shift-labourers than for day-labourers.—Aanonsen, A.: Shift Work and Health, Norwegian Monographs on Medical Science, Oslo, Norway: Forlag for Universitetsforlaget, 1964, p 8.