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THE PATTERN OF MORTALITY CHANGE IN LATIN AMERICA

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Abstract—Using 69 new life tables recently made by Arriaga for Latin American countries by stable-population methods, the authors examine the mortality trends for more countries and more periods of history than have previously been available for analysis. For the late nineteenth and early twentieth centuries, the new tables yield a substantially lower life-expectancy than that shown by previously published life tables; for recent decades the difference is smaller, though in the same direction. As a consequence, the new tables show a speed of mortality decline in Latin America greater than the speed hitherto assumed. When the trend is analyzed in terms of economic development, it appears that the decline was extremely slow in the more backward Latin American countries until around 1930, whereas in the more advanced countries of the region, a more rapid decline had set in before that. After 1930, however, in both groups of countries the pace of decline was faster than ever, and it was virtually the same for both groups, suggesting that after that date public health measures were exerting a strong influence independently of local economic development. This result is confirmed by comparison with the past history of now developed countries; the mortality decline in Latin America after 1930 was much faster than it was historically at the same level in the industrial countries. As compared with other underdeveloped countries today, the unprecedented decline of mortality in Latin America is typical. In most underdeveloped countries, whether in Latin America or elsewhere, mortality change seems increasingly independent of economic improvement and more dependent on the importation of preventive medicine and public health from the industrial countries.

With a new set of abridged Latin American life tables made at the University of California and recently published there (Arriaga, 1968), an improved analysis of mortality trends in the Latin American region is possible. The life tables extend back in some countries to the past century; they are more numerous (69 new tables all told) than those previously available, and for some of the countries they are substantially more accurate.

The method used in constructing the life tables in the absence of reliable vital statistics is derived from stable population theory. It employs the age distribution of only the population aged 10–59, an estimate of the natural growth rate, and model life tables. By using only the *proportional* age distribution, the technique eliminates the effect of any under- or over-enumeration that is common to all age groups. Further, by considering only ages 10 to 59, it eliminates the spe-

cial enumeration errors that tend to characterize the childhood ages and the elderly ages. A life table obtained with this method would be the same even if the population under age 10 and over age 59 were assumed to be zero. A full presentation of the method will be found in the volume cited.

Employment of the method has enabled us practically to double the total number of dates covered by life tables in Latin American countries, and especially to increase the number of dates covered in the late nineteenth and early twentieth centuries. All of the Latin American countries are included in the new series except Argentina, Cuba, and Uruguay. Cuba and Uruguay were excluded for lack of suitable information; Argentina was omitted because its previous fertility decline makes it unsuitable for application of the method. Most of the previous life tables available for Latin American countries are for the years 1950 and 1960; relatively few go back further. The oldest of the previously existing life tables, to our knowledge, were those of Brazil for the period 1872–1890 (Mortara, 1941). The oldest in our series is the one pertaining to Costa Rica in 1864. All told, for the years prior to 1930, we have located life tables for 12 dates, while our series provides tables for 30 new dates.

Comparison of the New Life Tables with Previously Existing Ones

There are enough dates covered both by our series and by one or more previously existing life tables (counting male and female tables separately) for 52 comparisons between the tables made by our office and the previous tables made by others. In Table A-1 in the Appendix, where the life expectancy at birth yielded by each of our tables is shown, comparison is made with previously existing life tables for dates when such tables could be found. The results of these comparisons, grouped by historical periods, are shown in Table 1. In most cases the new life tables reveal a lower life expectancy at birth than did the previous tables for the same date. There are 43 cases in which our table shows a lower life expectancy than the previously existing table, and nine in which it shows a higher life expectancy. The average difference for the 43 cases in which our table gives a lower value is 3.87 years, and the average difference for the 9 cases in which ours gives a higher value is only 2.09 years. The net effect of our series, then, is to give a less favorable picture of Latin American mortality than previous tables have given, and this is especially true for earlier dates.

Table 1.—Comparison with Respect to Average Life Expectancy at Birth Between the New and Previous Life Tables for Latin America

Period of time	Number[a]	Expectancy		Per cent difference
		Previous	New	
Before 1900	2	31.1	25.5	22
1900-1929	7	31.6	29.8	6
1930-1949	12	42.9	37.1	16
Since 1950	33	53.2	51.2	4

a-Countries compared in each period: Before 1900, Brazil and Mexico; 1900-29, Brazil, Chile, and Mexico; 1930-49, Chile, Colombia, Mexico, and Venezuela; Since 1950, Bolivia, Brazil, Chile, Costa Rica, Dominican Republic, El Salvador, Guatemala, Haiti, Mexico, Panama, and Peru.

Examination of the periods in Table 1 shows that the difference between the new and the previously existing life tables tends to be greater the further back in time the comparisons are made. The period 1900–1929 appears to be an exception, but in that period the tables compared were for Brazil, Chile, and Mexico, where the data even then were fairly good, whereas in the next period Brazil dropped out while Colombia and Venezuela, both with poor registration, were added. Unfortunately, we do not

have enough comparisons to be able to deal with the same group of countries throughout the four periods. However, there are three countries (Brazil, Chile, and Mexico) for which comparisons can be made at three or more dates. Grouping the tables into "early," "intermediate," and "recent" for each of them, we get the following comparisons:

	Early	Inter-mediate	Re-cent
No. of tables compared...	10	12	10
Average life expectancy:			
Previous	29.8	38.2	52.6
Our tables	27.1	35.4	51.4
Per cent difference.....	9.7	6.5	2.3

The finding, as judged by our series, that previously existing life tables exaggerated life expectancy more in earlier than in later periods has an important consequence. It means that the speed of mortality improvement in Latin America has been underestimated. In the figures just given, the average improvement from "early" to "recent" was 77 per cent in previously existing life tables and 90 per cent in ours. In Table 1 the improvement from "prior to 1900" to "since 1950" was 71 per cent in the other life tables, 101 per cent in ours.

The main reason for the generally lower life expectancy in our life tables lies in the greater reliability of the information on which they are based. In previous life tables the varying degrees of completeness of the censuses and of the vital statistics was the principal source of error. In the case of Brazil, where no vital statistics were used and where the life tables were deduced from intercensal survival ratios, differential census completeness was the cause of error. This hypothesis not only explains why the differences in life expectancy between the new life tables and the previously existing ones becomes greater as we go back in history, but it also accounts for the fact that the widest discrepancies occur at the young and the old ages.

If the previous and the new life tables are compared with respect to the probability of surviving a given number of years, as shown in Table 2 (for details, see Appendix Table A-2), the differences by age appear clearly. For dates prior to 1960, the probability of surviving from age 0 to age 15 is 5 per cent higher in previous life tables than in ours; the probability of surviving from age 45 to 70 is 14 per cent higher; but the probability of lasting from age 15 to age 45 is only 2 per cent higher.

The discrepancy at young ages is due to the usual fact of under-registration of infant deaths, which tends to reduce the probability of dying when the infant mortality is incorporated in the traditional life tables. In the older ages the discrepancy stems both from some failures in registration and, more commonly, from exaggeration of age by persons of advanced years. As a consequence of these two irregularities in vital statistics and census enumeration, the conventional life tables substantially overstate survivorship at both ends of life.

TABLE 2.—Differences in Survival Ratios Between New and Previous Life Tables: Before and After 1960

Item	$_{15}P_0$	$_{15}P_{15}$	$_{15}P_{30}$	$_{25}P_{45}$
For 23 tables before 1960:				
New. . . .	.693	.879	.832	.434
Previous .	.726	.897	.847	.495
Per cent difference. . .	4.7	2.0	1.8	14.1
For 10 tables after 1960:				
New. . . .	.844	.952	.919	.606
Previous .	.859	.961	.929	.659
Per cent difference. . .	1.8	0.9	1.1	8.7

Source: Appendix Table A-2.

Trend of Mortality in Latin America

A major question concerning the trend of mortality in the Latin American region is how fast it has moved in modern history, and when did it move the fastest. In the new series, unfortunately, there are not enough life tables prior to 1900 to establish a trend for the nineteenth century. The nine tables we do have all relate to the last four decades of the century. They reveal, as Table A-1 of the Appendix shows, an astonishingly high level of mortality at that time. Around 1900 Bolivia, Brazil, Chile, Costa Rica, Guatemala, Mexico, and Paraguay show life expectancies at birth varying from 24 to 30 years. Some time before that date—1864 in Costa Rica, 1872 in Brazil, and 1883 in Paraguay—the life expectancies were 26, 27 and 23 respectively. The data suggest at best a very slow decline in mortality during the latter part of the nineteenth century from extremely high levels. Table 3 shows the average trend for the countries included in the series. Clearly, the jump in improvement came after 1910, as can be seen by calculating the rates of improvement for longer periods:

	Added to life expectancy annually	
	Years	Per cent
1860–1910	.15	.37
1910–1930	.24	.81
1930–1960	.74	2.20

In each of these periods, the rate of improvement approximately doubled that of the previous period. Of special interest is the performance in the 1930–40 decade. This was the Great Depression decade, when the economy of Latin America was at an extremely low ebb, yet the rate of mortality improvement was far higher than it had been in any previous decade.

Of course, the countries of Latin America were not all similar either in their economic or their demographic evolution. For instance, there are five countries for which we can compare life tables in 1900 and 1930, as is done in Table 4. Three of these countries—Chile, Costa Rica, and

Table 3.—Decade Changes in Life Expectancy in Latin America

Decade	Number of countries	Average life expectancy at Beginning	Average life expectancy at End	Average annual Years added	Average annual Per cent added
1860-1870	1	25.9	27.6	.17	0.7
1870-1880	2	27.5	28.1	.06	0.2
1880-1890	3	26.3	27.3	.10	0.4
1890-1900	5	25.8	27.3	.15	0.6
1900-1910	6	27.5	29.0	.15	0.5
1910-1920	7	29.2	33.1	.39	1.3
1920-1930	9	30.8	33.5	.27	0.9
1930-1940	13	32.8	38.0	.52	1.6
1940-1950	15	38.0	45.9	.79	2.1
1950-1960	14	46.1	55.1	.90	2.0

Note: The countries are the same for each decade, but for succesive decades the number is increased when possible in order to gain more representation of all Latin America. The pattern of change shown does not differ much from the pattern when the countries are the same for several decades. For instance, after 1900 the average per cent changes of the life expectancies for the same six countries considered on up to 1950-60 are virtually the same: .5 for 1900-10; .9 for 1910-20; .9 for 1920-30; 1.3 for 1930-40; 2.1 for 1940-50; and 1.9 for 1950-60. The two countries having the longest representation in the table, Brazil and Mexico, have half or more of the population of all Latin America.

TABLE 4.—Change in Life Expectancy at Birth for Five Latin American Countries, 1900–1930

Country	Life expectancy at birth		Added to life expectancy, annual average	
	1900	1930	Years	Per cent
Brazil . .	29.4	34.0	.15	0.5
Chile. . .	28.7	35.2	.22	0.8
Costa Rica	31.6	41.9	.34	1.1
Guatemala.	24.0	26.6	.09	0.4
Mexico . .	25.3	33.9	.29	1.1

Mexico—manifest a good start in mortality decline during the thirty-year period, in conformity with the general trend. Another, Brazil, shows only a slow trend, and the improvement in the fifth country, Guatemala, is almost nil. If we look at the level of Guatemala's mortality, we see that it was akin to most of the region before 1900; it had not developed to a point where fast change was likely. As late as 1930, Guatemala had a life expectancy of only about 27 years. In that year Nicaragua and the Dominican Republic had a very similar mortality condition, with a life expectancy of 27 and 26, respectively. Hence, we can deduce that prior to 1930 they had experienced no more improvement than Guatemala had experienced.

HISTORICAL TIME VERSUS PREVIOUS LEVEL IN ASSOCIATION WITH MORTALITY IMPROVEMENT

The data so far presented show two facts worthy of note—first, that there was a sharp rise in improvement after 1910, which became even more noticeable after 1930, and second, that up to 1930 different Latin American countries shared unequally in the improvement. These facts, which are interrelated, have an important bearing on the theory of changes in mortality during modern times; but in order to see their significance, let us try to phrase a question for further analysis.

In general, the view is often taken (and has much to recommend it) that the health of a population is a function of the economic level. Since economic development involves the entire society, it is a process that tends to be ponderous, relatively slow, and somewhat regular over the long pull. Anything that depends on this process could be expected to share the same traits. Furthermore, granted the premise on which the view we are discussing rests, the life expectancy in a population can be taken as an index of its economic stage. It follows, logically, that the rate of improvement in mortality can further be expected to be a function of the existing level of the death rate. Both of these deductions can be tested with the new series of life tables.

What we find is that up to about 1920 or 1930 the deductions appear to be true. The higher the mortality, the slower the rate of improvement. Countries with a very short life expectancy, like Guatemala, had a painfully slow rate of improvement. On the other hand, countries like Costa Rica and Chile, with a longer life expectancy, had a more rapid improvement at that time.

After 1930, however, the deductions no longer hold true. From that date on, the rate of mortality change was almost the same for every country, regardless of the level of the death rate at that time. Furthermore, the rate of improvement in life expectancy was extremely rapid, no matter whether the economy was booming or not.

Our evidence for this switch can be marshalled in many ways. For instance, if the speed of mortality decline prior to 1930 was inversely related to the level of the death rate, we could expect that the countries would become more diverse in their life expectancies during the past century and the first years of the present one, with a climax around 1920–30. This is what is actually found, as the coefficients of variation in Table 5 show. After 1930, the trend toward diversity was reversed.

Another way of organizing the evidence is to see if, between the two periods, there was a change in the relation of the improvement rate to the starting level of mortality. Table 6 shows that there was clearly such a change. Up to 1930 the advancement in life expectancy tended to be greater in those countries where the life expectancy was longest; after 1930, if there was any relationship at all, the reverse was true. (See Figure 1.)

Economic Development and Mortality Decline

It follows from what has just been said that the demographic behavior of Latin American countries, grouped according to their economic status, will differ in the two periods. The countries can be sorted into two groups: those that had an early mortality decline (Group A), and those where only after 1930 a substantial mortality decline was observed (Group B). The available data for eight countries allows us to form Group A with Brazil, Chile, Colombia, Costa Rica, and Panama; Group B with the Dominican Republic, Guatemala, and Nicaragua. The differences in mortality between these two groups are shown in Table 7. The time lag between the two groups is narrowed to the point when a life expectancy of 40 is attained; after which the time lag remains almost constant. The time lag was reduced between the levels of life expectancy of 25 to 35 because the Group A countries had these levels before 1930 when the decline of mortality was not very rapid, and the Group B countries approach the life expectancy levels of 30 and 35 after 1930 when mortality decline for every country was very fast. Once the two groups of countries started to move after 1930, however—for life expectancy levels of 40, 45, and 50—the rate of mortality decline was almost the same in all places; hence the time lag remains constant.

There is no doubt that before the 1930's the decline of mortality was related to some extent to the economic situation. Group A countries were more economically developed at that time than those of Group B. After the 1930's the relation is almost independent of economic development; other factors were

Table 6.—Average Change of Life Expectancies for Two Periods: Latin America 1890–1960

Period and life expectancy	Number of countries	Increase during decade after life table date	
		Years	Per cent
1890-1930			
25	3	2.3	9.2
30	4	3.5	11.7
35	1	4.1	11.7
40	1	6.2	15.7
1930-1960			
30	4	7.7	25.7
35	10	7.2	20.6
40	11	8.7	21.8
45	10	7.9	17.6

Table 5.—Mortality Differences Among Latin American Countries, 1900 to 1960

Year	Number of countries	Mean life expectancy	Standard deviation	Coefficient of variation
1900	7	27.2	2.38	.088
1910	8	29.1	2.58	.089
1920	9	30.8	3.28	.106
1930	14	32.9	4.35	.132
1940	15	38.0	4.17	.110
1950	17	45.7	4.80	.105
1960	14	55.1	4.78	.087

Note: The inclusion of the newly available countries at each date is to obtain a better representation of the region. The coefficients of variation throughout for the same seven countries considered in 1900 are very similar to those shown; they are: .088 for 1900; .095 for 1910; .118 for 1920; .139 for 1930; .150 for 1940; .114 for 1950; and .079 for 1960.

TABLE 7.—Time Lag Between Two Groups of Latin American Countries in Achieving the Same Life Expectancy Levels

Level	Date level achieved		Time lag in years
	Group A	Group B	
25 . . .	1860	1914	54
30 . . .	1908	1935	27
35 . . .	1927	1943	16
40 . . .	1939	1949	10
45 . . .	1946	1955	9
50 . . .	1951	1960	9

Group A: Brazil, Chile, Colombia, Costa Rica, Mexico, and Panama.
Group B: Dominican Republic, Guatemala, and Nicaragua.

affecting the mortality decline. We shall talk about them in the conclusion.

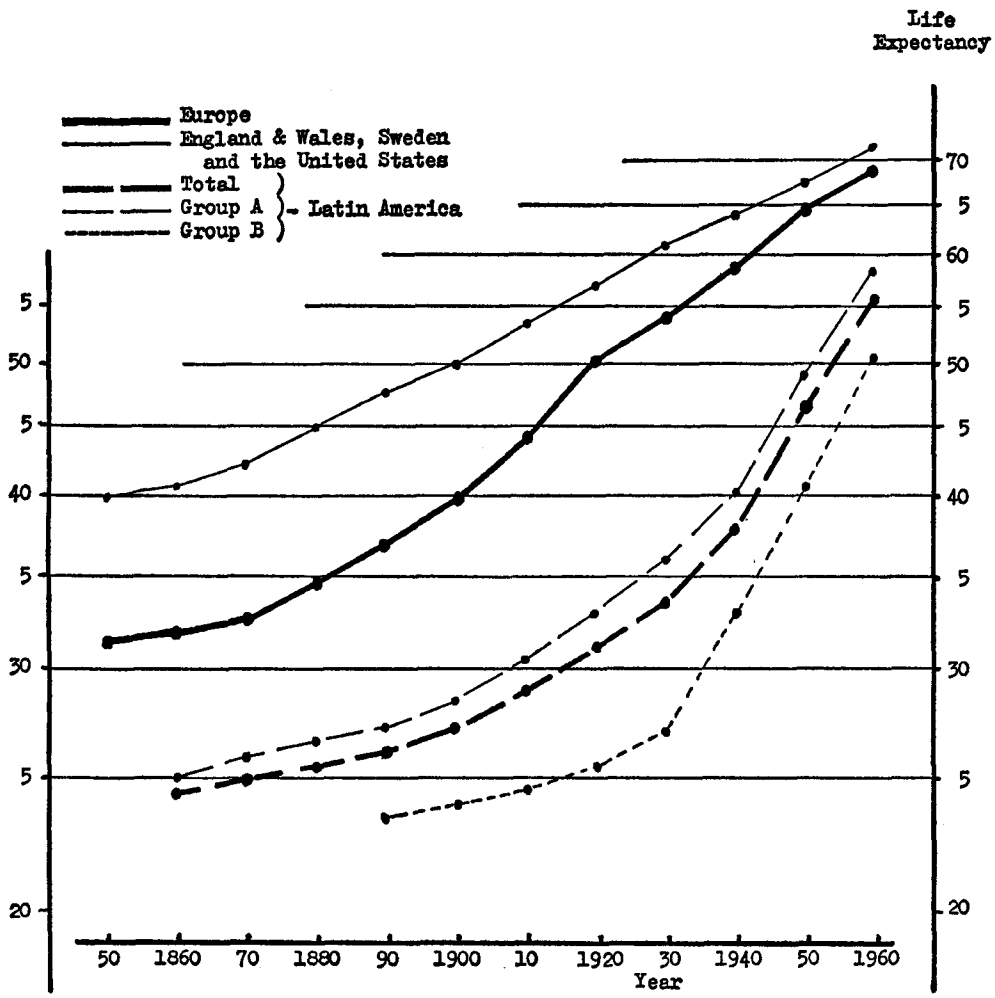
Latin America versus Developed Countries in Speed of Mortality Decline

Let us now compare the past mortality trend in our Latin American countries with that in highly industrialized countries outside the region. Is mortality in Latin America following the same trend that it followed in industrialized countries with relation to time, mortality level, and economic development? For convenience we shall rely on three industrial countries—England and Wales, Sweden, and the United States. (See sources of the life tables in the Appendix.)

By the time our Latin American data became available in the middle of the nineteenth century, the industrial countries had a life expectancy at birth that was already around 40 years. (See Figure 1.) Latin America had at that time, as we have seen, a life expectancy of around 25 years. We cannot find such a low level in the now industrialized countries at any time in the nineteenth century or even earlier. In Sweden the first life table (for 1751–90) gave an average lifetime after birth of 33.7 years (Statistiska Centralbyran, 1955, p. 61). Evidently the conditions of mortality in Latin America remained worse than eighteenth century Western European standards up to the end of the nineteenth century. The differences in mortality trends in Latin America and the three industrialized countries can be analyzed in various ways. We shall analyze the differences, first by establishing the time lag between the two groups in reaching the same life expectancy level; second by calculating the differences between the mortality levels of each group of countries at the same date; and third by showing the differences between them in rate of decline at given periods and after given levels.

In relation to the time lag, the lowest life expectancy that both sets of countries have in common is 40 years. This level was reached in Latin America 93 years after it was registered in the three industrial countries, as Table 8 shows. As we deal with successively higher levels of life expectancy, the time lag is continuously reduced. For a life expectancy of 55, the lag was only 44 years.

When we turn to the differences between the mortality levels in the two groups of countries at the same date, we find, as Table 9 shows, that both the absolute and relative differences widen during the first 50 to 60 years of the period, remain more or less constant during the next 10 to 20 years, and become steadily more narrow after 1930. A particular and curious trend is shown by the absolute differences. In 1860 the difference in life expectancy between our Latin American countries and the industrial countries was 16 years. A century later, in 1960, the difference was also 16 years. In the meantime, the gap had gone through a cycle of change. Prior to 1920 the gap was widening, because the industrial countries were gaining faster. It was during the period 1900–1930 that the widest differences in mortality were observed between the two kinds of countries (see Figure 1). After that the gap declined until, in 1960, it reached its starting level. But, of course, the return



Source: Appendix, Table A-4

FIG. 1.—Historical trends in life expectancy: European and Latin American countries

to the same absolute level did not imply a return to the same relative level. Sixteen years as a per cent of 56 in 1960 is much less than 16 as a per cent of 24. In relative terms the Latin American countries were better off in 1960 compared to the industrial nations than they were in 1860, even though the absolute difference remained.

A further finding is brought out in Table 10 and Figure 1. The industrial countries changed at an almost uniform rate during the 100 years. The shifting

TABLE 8.—Time Lag Between Industrial and Latin American Countries in Achieving the Same Life Expectancy Levels

Level	Date level achieved: Latin American countries	Date level achieved: Three industrial countries	Time lag in years
25 . . .	1870	...	...
30 . . .	1885	...	...
35 . . .	1934	...	...
40 . . .	1943	1850	93
45 . . .	1949	1880	69
50 . . .	1954	1900	54
55 . . .	1959	1915	44

TABLE 9.—Differences in Life Expectancy Levels Between Three Industrial (TIC) and Latin American (LAC) Countries at Same Dates

Year	Average life expectancy		Difference	
	LAC	TIC	Absolute	Per cent of LAC
1860	24.4	40.7	16.3	66.8
1870	25.0	42.3	17.3	69.2
1880	25.5	45.0	19.5	76.5
1890	26.1	47.7	21.6	82.7
1900	27.2	50.0	22.8	83.8
1910	28.9	53.5	24.6	85.1
1920	31.1	57.0	25.9	83.3
1930	33.6	61.0	27.4	81.5
1940	38.0	64.0	26.0	68.4
1950	46.4	67.5	21.1	45.5
1960	55.8	71.5	15.7	28.1

difference between them and the Latin American countries in our list was all due to variations in the rate of mortality change in Latin America. Before 1900 the rate of mortality decline in Latin America was slower than in the three industrialized countries; from 1900 to 1930 it was almost the same as that of the industrialized group; and after 1930 it has been consistently faster.

We can now compare how the developed and underdeveloped countries changed from the same life expectancy levels. The analysis is limited because the only range common to both sets of countries is that lying between 40 and 56 years of life expectancy. Within this range, the rate of improvement from given levels during a decade was as follows:

Starting e_0^0 and countries	Years added	Per cent increase
$e_0^0 = 40$		
Latin American	8.2	20.5
Industrial	0.1	2.5
$e_0^0 = 45$		
Latin American	8.9	19.6
Industrial	0.3	6.7

Obviously, at these levels, the Latin American region was making tremendously faster gains. This was because these levels came much later in history than did those levels in the now developed countries. England and Wales reached a life expectancy of 40 years during the decade 1841–1851, Sweden had a 41-year life expectancy in the period 1816–40, and the life expectancy in the United States was 49 years in 1901. In 1927 Costa Rica was the first Latin American country (among those considered here) to approach the level of a 40-year life expectancy at birth. At the other extreme, Haiti did not reach this level until 1950. This gives an idea of the time lag (70 to 100 years) between the two different kinds of countries at a level of life expectancy of 40 years. In the 1960's, seven Latin American countries (which have 72 per cent of the whole population considered here) passed the level of 55 years of life expectancy at birth. The rest of the countries had an expectation of life over 48. In the three developed countries, a level of 48 years was observed in Sweden in 1890 and in England and Wales and the United States between 1900 and 1910, while a level of 55 for all three was reached between 1910 and 1920. Hence the level of life expectancy in Latin American countries in the 1960's is only 40 to 60 years behind the developed countries. The causes affecting the mortality level during this period are analyzed later.

TABLE 10.—Per Cent Change in Life Expectancy During Each Decade

Decade	Latin American countries	Three industrial countries
1860-1870	2.4	3.9
1870-1880	2.0	6.4
1880-1890	2.4	6.0
1890-1900	4.2	4.8
1900-1910	6.3	7.0
1910-1920	7.6	6.5
1920-1930	8.0	7.0
1930-1940	13.1	4.9
1940-1950	22.1	5.5
1950-1960	20.2	5.9

Latin America versus Other Underdeveloped Countries in Speed of Mortality Decline

The comparison of Latin America with other underdeveloped areas faces the problem of inaccurate information, principally for African countries. Nevertheless, from the available information, there is no doubt that, at present, mortality in Latin America is more similar to that in the underdeveloped countries of Asia than it is to that in countries of Africa. Most of the African countries still have a very high mortality: in the 1960's, 13 out of 20 countries with information still had a life expectancy no higher than 40 (United Nations, Statistical Office, 1962, 1966). In the whole underdeveloped world outside of Latin America, a few countries with reasonably good statistical information or good estimates of mortality may be utilized for comparison with Latin America. Let us take Ceylon, India, Mauritius, and Taiwan (Davis, 1951; United Nations, Statistical Office). (See Appendix Table A-3.) Due to the fact that the Latin American countries differ considerably among themselves in degree of development, we shall compare those having a lower mortality (Brazil, Chile, Costa Rica, Mexico, Panama, and Venezuela) with Ceylon, Mauritius, and Taiwan, and those having a high mortality (the Dominican Republic, Guatemala, and Nicaragua) with India. For three dates for which information is available, the average life expectancy for Ceylon, Mauritius, and Taiwan is almost identical with that for Latin American low-mortality countries:

	Average life expectancy		
	1940	1950	1960
Ceylon, Mauritius, and Taiwan	40.6	49.6	59.2
Latin America Low Mortality	39.0	50.7	60.7

(Interpolations for life expectancies were made when required.)

The similarity between the two groups is obvious not only in the rate of change, but also in the level of life expectancy at birth in each year. Even the case of Ceylon, which is generally recognized as one of the fastest mortality declines in the history of the world, can be compared perfectly with the case of Venezuela. Figure 2 shows very similar levels and patterns of mortality for these two particular countries.

On the other hand, we have the following comparison of India with three Latin American countries of high mortality:

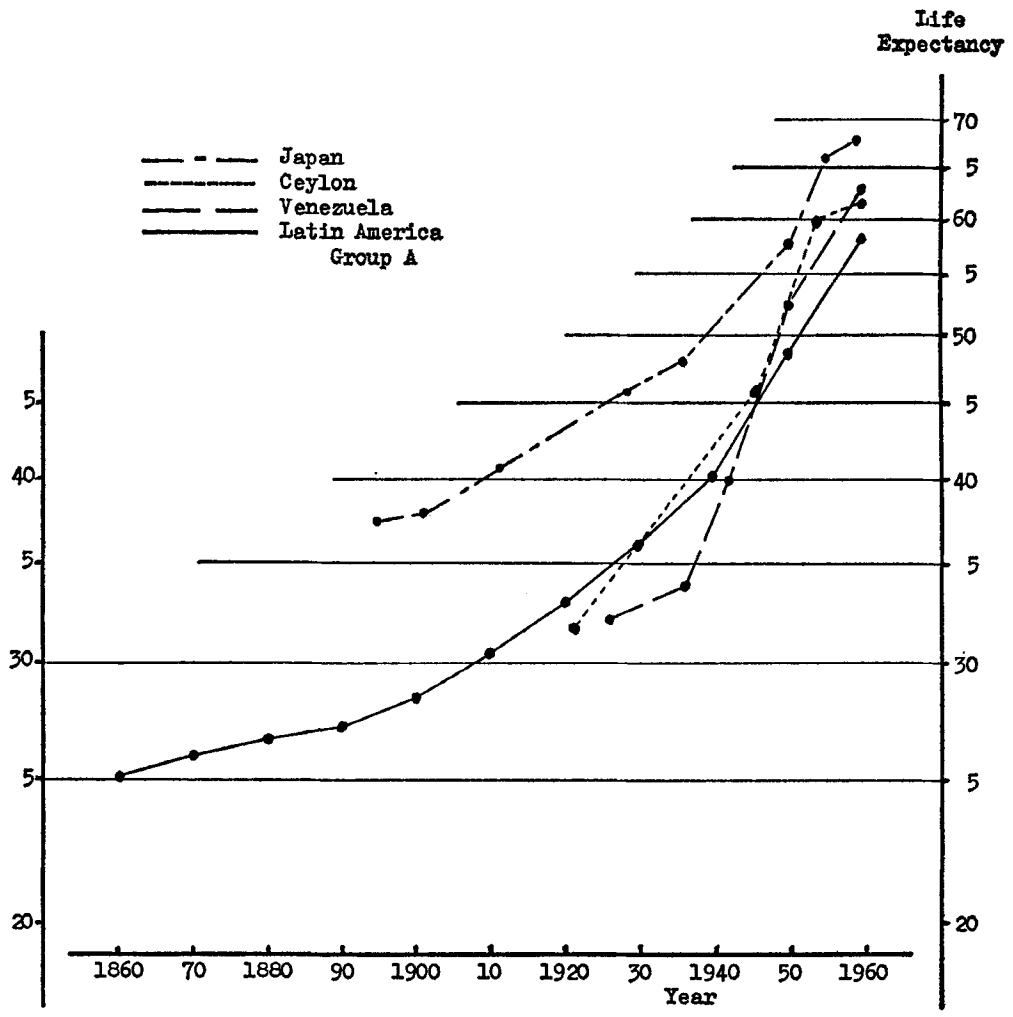
	Average life expectancy				
	1920	1930	1935	1945	1955
India	25.2	28.5	31.5	32.5	41.2
Latin America High Mortality	25.5	27.4	30.0	37.0	45.5

(Interpolations for life expectancies were made when required.)

The rates of change in the life expectancies were as follows:

	Average annual per cent increase			
	1920–30	1930–35	1935–45	1945–55
India	1.15	2.34	0.32	2.67
Latin America High Mortality	.75	1.90	2.33	2.30

During the decade 1935–1945, because of the war and various other problems,



Source: Appendix, Table A-4

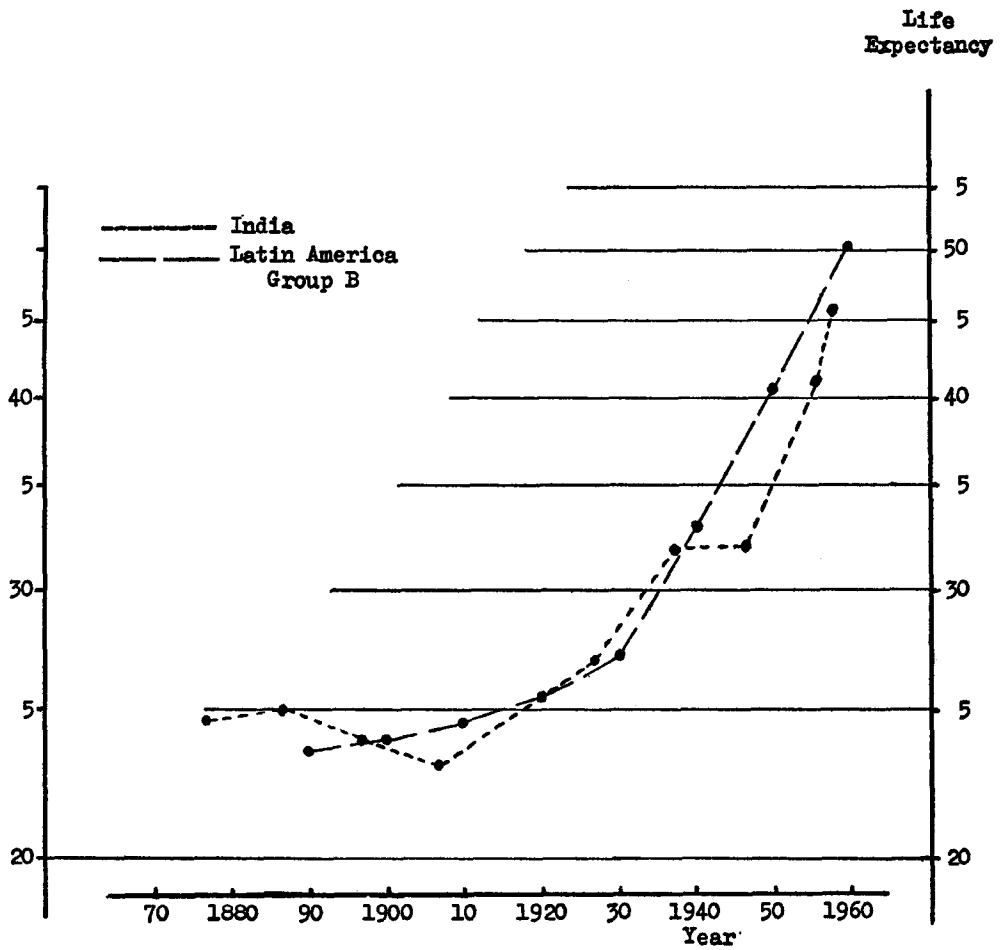
FIG. 2.—Historical trends in life expectancy in selected countries

India had famine conditions that helped to maintain mortality at a high level. After that decade, mortality in India followed the same pace of decline as in Latin America, although the level of life expectancy was lower. A graphic comparison can be seen in Figure 3.

In general, mortality trends in other underdeveloped areas—probably with some African exceptions—follow a pattern almost identical to that in Latin America. After the 1930's, whatever the life expectancy level, the rate of mortality decline was very fast in all underdeveloped populations.

CONCLUSION

Thus the historical and comparative analysis of Latin American mortality—an analysis facilitated by the 69 new life tables for this region—lends support to the view that in recent decades public health measures have exercised a strong influence on death rates, independently



Source: Appendix, Table A-4

FIG. 3.—Historical trends in life expectancy: India and the less developed Latin American countries

of economic development. In the most advanced countries the improvement in mortality has always depended mainly on economic development, because it is this development that supports public health itself. This is why the rate of improvement in those countries has been gradual and amazingly constant throughout their modern history. In the currently underdeveloped countries, on the other hand, the rate of gain in mortality during recent decades has been notably accelerated by the importation of public health techniques, personnel, and funds from the industrialized countries, regardless of local economic development or non-development. (For an earlier presentation of the theory see Davis, 1956a and 1956b, and Stolnitz, 1955.)

The period prior to 1925 was one in which the old dependence of mortality decline on economic development prevailed. The poorer Latin American countries in particular showed a slow rate of advance from given levels. After about 1925, however, the unprecedented rate of

decline in mortality in all Latin American countries covered by our life tables cannot be explained solely in terms of economic development. The differences in rate of change between the more developed and the less-developed Latin American nations disappeared; the rate of change became similar, regardless of the starting level; and the rate itself was faster than that ever exhibited, at similar levels or at any time, by the most advanced countries.

The evidence within Europe tends to confirm the same conclusion. In most advanced European countries the spread of medical discoveries and their effective application was a gradual process. Among these countries, as already mentioned, there was a smooth rate of mortality decline during the century and a half for which we have evidence. When, however, *all* of Europe is examined, a more rapid decline of mortality is observable sometime after 1900 and before 1930 (see Figure 1). This acceleration reflects the advances of medical science in the less advanced parts of the continent —mainly Eastern Europe—during that time. The diffusion of public health from the developed to the less-developed countries came earlier and less forcefully in Europe than it did in the world as a whole. The movement from one continent to another, as Latin America illustrates, came mainly after 1930; but when it did come, the impact was swift in virtually all underdeveloped areas. In Latin America the decline of mortality during the last thirty-five years can be best described as sudden, and the same can apparently be said of Asia and Africa.

As a consequence of their faster drop in death rates, contemporary developing countries have mortality levels that are lower than they were in industrial countries at the same stage of development. If economic development is measured in terms of per capita income, there are four countries in Latin America that had exceeded a life expectancy of 55 years by 1960 and had in that year an average per capita of U.S. $358. These countries were Chile $480, Costa Rica $300, Mexico $318, and Panama $332 (Pan American Union, 1965, table 342–12, p. 33). This income level was considerably surpassed by England and Wales in 1875–84; at that time average income was U.S. $555 at 1960 prices but the life expectancy was only about 45 years. (Income computed from Kuznets, 1956, Appendix Table 1, and United Nations Statistical Office, 1956, 1966, Tables 165 and 173 respectively; life expectancy from Case and others, 1962.) Similarly, the United States had a much higher per capita income with a lower expectation of life than the Latin American countries now exhibit: in the 1900's its life expectancy was lower than 50 but the average income was $1025 at 1960 prices (United States, Bureau of the Census, 1960, p. 139). At the present, regardless of the stage of development of a country, certain public health and medical techniques can be applied—principally those measures whose applications are not expensive. These include community health measures such as eradication of disease vectors, chlorination of drinking water, and good sewage systems, as well as individual health practices such as vaccination, dietary supplements, use of new drugs, and better personal hygiene. These techniques need not necessarily have been developed locally since they can be imported. As a consequence, a backward country can succeed in combating a particular infectious-communicable disease without having to develop or maintain a major medical establishment of its own.

This interpretation, apparently applicable to virtually all underdeveloped countries, has a future significance. As yet, we have not seen the end of the rapid decline in mortality. Given a continuation of preventive medicine and public health programs, the death rate of underdeveloped countries can still

drop substantially. The decline can be continued by reducing the number of deaths due to infectious-communicable diseases. Even in 1960, in Latin American countries, around 40 per cent of the deaths were due to these diseases. Although a part of this percentage is attributable to the youthfulness of the age structure, the proportion is still very high when compared with that of the United States, Sweden, or England and Wales—5.6, 6.6, and 12.7 per cent, respectively (Arriaga, 1967). A rough idea of how much reduction in mortality could still be achieved by working on the infectious-communicable diseases is provided by the case of the United States. This country had 40 per cent of its deaths due to these diseases in 1900 when its life expectancy was 49 years at birth (United States, Bureau of the Census, 1940, Table 82). At the present, when these diseases represent only 6 per cent, its life expectancy has increased 20 years since that date. We do not imply that Latin America will follow exactly the same pattern; what we are stressing is that the deaths due to these diseases will probably be reduced in a short period of time. It is probable that mortality in Latin America will continue to decline very rapidly during the period of time left in this century. It is unfortunate that we cannot say the same for economic development in the region.

Appendix: Sources for Previous Life Tables

Latin America

BOLIVIA

—United Nations Demographic Yearbook 1966.

BRAZIL

—Mortara, Giorgio, "Estudos Sobre a Utilização das Estadisticas do Movimiento da População do Brasil," *Revista Brasilera de Estadistica,* Year II, Jul. Sept. 1941, No. 7, pp. 493–538.

—United Nations Demographic Yearbook 1966 and 1957.

CHILE

—Cabello, O., Vildósola, J. y Latorre, M., "Tablas de vida para Chile, 1920, 1930, 1940," *Revista Chilena de Higiene y Medicina Preventiva,* Vol. VIII, No. 3, septiembre 1946, y Vol. IX, No. 2, junio 1947.

—Tacla, O. and Pujol, J., "Tablas abreviadas de Mortalidad 1952–1953 y 1960–1961," Centro Latinoamericano de Demografía, Serie C, No. 11, Santiago, Chile, 1965.

COLOMBIA

—United Nations Demographic Yearbook 1966.

COSTA RICA

—Ministerio de Economía y Hacienda, Dirección General de Estadística y Censos, *Tablas de vida de Costa Rica 1949–1951,* San José, Costa Rica, 1957.

—United Nations Demographic Yearbook 1966.

DOMINICAN REPUBLIC

—United Nations Demographic Yearbook 1966.

EL SALVADOR

—Dirección General de Estadística, *Boletín Estadística,* No. 13, Jan.-Feb. 1954, pp. 26–31.

—United Nations Demographic Yearbook 1966.

GUATEMALA

—Arias, J., *Estadística,* Dirección General de Estadística, No. 54, March, April 1955, pp. 1–19.

TABLE A-1.—Comparison of Life Expectancy Levels Between New and Previous Life Tables in Latin America

Country and year	Life expectancy at birth: Previous table Male	Previous table Female	New table Male	New table Female	Difference, Years: Male	Female
BOLIVIA						
1900	n.a.	n.a.	25.2	25.7	n.a.	n.a.
1950	49.7	49.7	42.2	44.0	7.5	5.7
BRAZIL						
1872	...	...	27.1	27.6	...	...
1890	32.7[a]		27.8		4.9	
1900	...	...	29.0	29.7	...	...
1920	38.0[b]		31.4	32.5	6.1	
1940	...	...	36.1	37.3	...	...
1950	39.3[c]	45.5[c]	42.1	43.9	-2.8	1.6
1960	...	...	54.0	57.0	...	...
CHILE						
1907	...	...	29.7	30.5	...	...
1920	30.9	32.2	30.1	30.8	0.8	1.4
1930	39.5	41.8	34.6	35.8	4.9	6.0
1940	40.7	43.6	37.4	38.7	3.3	4.9
1952	53.0	54.4	50.8	53.5	2.2	0.9
1960	56.8	59.9	54.2	58.7	2.6	1.2
COLOMBIA						
1918	...	...	32.0		...	...
1938	44.2	46.0	36.0	37.2	8.2	8.8
1951	...	...	47.9	50.4	...	...
COSTA RICA						
1864	...	...	26.3	27.0	...	...
1883	...	...	28.4	29.3	...	...
1892	...	...	30.4	30.9	...	...
1927	...	...	39.2	40.8	...	...
1950	54.7	57.1	54.0	57.0	0.7	0.1
1963	62.0	64.8	62.2	65.0	-0.2	-0.2
DOMINICAN REPUBLIC						
1935	...	...	29.9	29.9	...	...
1950	...	...	43.6	43.8	...	...
1960	57.2	58.6	50.8	53.5	6.4	5.1
ECUADOR						
1950	...	...	46.6	49.0	...	...
1962	...	...	53.2	56.2	...	...
EL SALVADOR						
1930	...	...	28.8	28.5	...	...
1950	49.9	52.4	46.1	48.2	3.8	4.2
1961	56.6	60.4	54.5	57.5	2.1	2.9
GUATEMALA						
1893	...	...	23.6		...	...
1921	...	...	25.6	26.1	...	...
1940	...	...	30.3	30.5	...	...
1950	43.8	43.5	39.9	41.5	3.9	2.0
1964	...	...	49.3	53.3	...	...
HAITI						
1950	32.6		38.7	40.1	-6.8	
HONDURAS						
1930	...	...	33.4	34.5	...	...
1940	...	...	36.9	38.1	...	...
1950	...	...	41.8	43.6	...	...
1961	...	...	52.6	55.6	...	...
MEXICO						
1895	29.5		24.3	24.5	5.1	
1900	27.6		25.0	25.6	2.3	
1910	27.4		27.3	27.9	-0.2	
1921	31.7[d]	33.5[d]	33.7	35.6	-2.0	-2.1
1930	35.5	37.1	33.0	34.7	2.5	2.4
1940	38.0	40.4	37.7	39.8	0.3	0.6
1950	48.1	51.1	46.2	49.0	1.9	2.1
1960	57.6	60.3	56.4	59.6	1.2	0.7
NICARAGUA						
1920	...	...	24.3		...	...
1940	...	...	33.9	35.1	...	...
1950	...	...	39.3	40.8	...	...
1963	...	...	50.5	53.3	...	...

TABLE A-1.—Comparison of Life Expectancy Levels Between New and Previous Life Tables in Latin America (Continued)

Country and year	Life expectancy at birth: Previous table Male	Previous table Female	New table Male	New table Female	Difference, Years Male	Difference, Years Female
PANAMA						
1930 . . .	...	...	35.5	36.2	...	...
1940 . . .	...	...	41.5	43.3	...	...
1950 . . .	60.4	63.1	48.8	51.1	11.6	12.0
1960 . . .	57.6	60.9	59.8	63.2	-2.2	-2.3
PARAGUAY						
1886 . . .	...	...	22.7	24.6	...	...
1899 . . .	...	...	25.4	26.8	...	...
1950 . . .	...	...	44.8	46.8	...	...
1962 . . .	...	...	54.2	57.2	...	...
PERU						
1940 . . .	...	...	34.6	38.3	...	...
1961 . . .	51.9	53.7	46.9	50.8	5.0	2.9
VENEZUELA.						
1926 . . .	...	...	31.6	32.8	...	...
1936 . . .	...	...	33.3	34.5	...	...
1941 . . .	45.8	47.6	39.2	40.7	6.6	6.9
1950 . . .	...	...	51.2	54.0	...	...
1961 . . .	...	...	61.2	64.7	...	...

a - 1872-1890
b - 1890-1920
c - 1940-1950
d - 1922

TABLE A-2.—Comparison of Survivor Ratios from New and Previous Life Tables

Country, year, and life table	Male				Female			
	$_{15}P_0$	$_{15}P_{15}$	$_{15}P_{30}$	$_{25}P_{45}$	$_{15}P_0$	$_{15}P_{15}$	$_{15}P_{30}$	$_{25}P_{45}$
BOLIVIA								
1950, new[a]	.690	.922	.904	.400	.703	.917	.904	.466
1950, previous[a]	.730	.934	.905	.550	.726	.938	.923	.597
BRAZIL								
1870-90, new[b]	.537	.803	.707	.268	...	...	...	...
1870-90, previous[b]	.609	.829	.757	.366	...	...	...	...
1890-1902, new[b]	.582	.821	.742	.312	...	...	...	...
1890-1902, previous[b]	.681	.859	.786	.385	...	...	...	...
1940-50, new[c]	.678	.877	.821	.392	...	...	...	...
1940-50, previous[c]	.685	.872	.827	.383	...	...	...	...
CHILE								
1920, new	.572	.838	.743	.276	.582	.819	.742	.335
1920, previous	.587	.825	.741	.337	.593	.835	.758	.392
1930, new	.628	.858	.786	.335	.641	.846	.788	.398
1930, previous	.676	.881	.832	.430	.692	.875	.840	.522
1940, new	.659	.875	.811	.368	.673	.864	.813	.431
1940, previous	.692	.885	.839	.432	.704	.882	.854	.528
1950, new	.794	.926	.895	.524	.812	.928	.904	.567
1950, previous	.823	.943	.896	.514	.838	.949	.915	.615
1960, new	.838	.952	.898	.511	.848	.965	.931	.637
1960, previous	.837	.953	.898	.541	.854	.966	.930	.669
COLOMBIA								
1938, new[b]	.653	.853	.797	.378	...	...	...	...
1938, previous[b]	.733	.922	.879	.545	...	...	...	...
COSTA RICA								
1950, new	.821	.940	.913	.554	.840	.943	.921	.628
1950, previous	.823	.954	.920	.553	.840	.959	.918	.597
1963, new	.878	.974	.949	.663	.894	.982	.957	.701
1963, previous	.872	.972	.948	.646	.889	.981	.955	.699
DOMINICAN REPUBLIC								
1960, new	.795	.926	.895	.524	.812	.927	.904	.597
1960, previous	.849	.969	.949	.724	.868	.971	.947	.776
EL SALVADOR								
1950, new	.750	.909	.870	.476	.766	.906	.876	.543
1950, previous	.778	.911	.870	.572	.791	.930	.881	.597
1961, new	.824	.944	.916	.558	.843	.947	.925	.632
1961, previous	.840	.939	.909	.627	.857	.961	.930	.661
HAITI								
1950, new[b]	.682	.870	.820	.421	...	...	...	...
1950, previous[b]	.602	.791	.744	.397	...	...	...	...
MEXICO								
1950, new	.745	.915	.850	.496	.752	.931	.881	.560
1950, previous	.769	.916	.856	.505	.786	.932	.892	.567
1960, new	.848	.945	.895	.588	.856	.958	.922	.648
1960, previous	.860	.946	.901	.594	.866	.956	.924	.654
VENEZUELA								
1941, new	.679	.879	.823	.393	.693	.871	.827	.457
1941, previous	.768	.902	.825	.461	.776	.896	.831	.530

Note: Survivor ratios, $_nP_x = {}_{x+n}l_x/{}_xl_x$

a - $_{20}P_0$; $_{10}P_{20}$; $_{10}P_{30}$; $_{30}P_{40}$

b - Both sexes

c - Males only

HAITI

—United Nations Demographic Yearbook 1966.

MEXICO

—Zulma L. Recchini, "Tabla Abreviada de Mortalidad República de México, 1959–1961," Centro Latinoamericano de Demografía, Serie C, E/CN. CELADE/C. 1, Santiago, Chile, 1963.

—Raúl Benitez Zenteno, "Tabla de Vida en la República Mexicana (1950)," *Revista Mexicana de Sociología*, Año XXI, Ene.-Abr. 1959, Vol. XXI, No. 1.

—Becherelle, B. and Reyes, Jiménez, "Tablas de Vida para México 1893 a 1956," *Revista del Instituto de Salubridad y Enfermedades Tropicales*, Vol. XVIII, No. 2, Jun. 1958, pp. 81–136.

PANAMA

—United Nations Demographic Yearbook 1966.

PERU

—United Nations Demographic Yearbook 1966.

VENEZUELA

—Michalup, E., "The Construction of the First Venezuelan Life Tables 1941–42," *Estadística*, Vol. IX, March 1951, pp. 61–78.

Industrial Countries

ENGLAND and WALES

—Case, Coghill C., Harvey, J. and Pearson, J., *The Chester Beatty Research Institute, Serial Abridged Life Tables, 1841–1960*, The Chester Beatty Research Institute, Institute of Cancer Research, Royal Cancer Hospital, London 1962.

JAPAN

—United Nations Demographic Yearbook 1966.

—Matsuura Koichi, "Reformation of Japanese Pre-Census Life Tables," *Kyushu Journal of Medical Science*, Vol. 9, Nos. 2–3, June 1958, pp. 70–85.

SWEDEN

—Statistiska Centralbyran, *Statistisk Arsbok* (several years) and *His-*

TABLE A-3.—Mortality in Selected Underdeveloped Countries

Item	Ceylon	India	Mauritius	Taiwan
Life expectancy at birth for selected dates:				
Year	...	1931-40	...	...
Expectancy	...	31.8	...	...
Year	1945-47	1941-50	1942-46	1936-41
Expectancy	45.7	32.5	33.0	43.4
Year	1954	1951-60	1951-53	1956-58
Expectancy	59.8	41.0	51.4	62.2
Year	1962	1957-58	1961-63	1959-60
Expectancy	61.6	46.0	60.2	63.5
Years added to expectancy during 20-year period of fastest mortality decline:				
Period	1942-62	1938-58	1943-63	1940-60
Years added	19	14	28	18
Years needed to increase expectancy from 50 to 60	10	...	8	10

TABLE A-4.—Life Expectancy Levels

Year	Latin America Total	Latin America Group A	Latin America Group B	Europe	England and Wales, Sweden, U.S.	Ceylon	Venezuela	India	Japan
			average						
1850. .	...	...	...	31.4	40.0	...	...	...	...
1860. .	24.4	25.1	...	31.8	40.7	...	...	...	...
1870. .	25.0	25.9	...	32.7	42.3	...	...	...	...
1871-81	...	...	...	...	...	...	...	24.6	...
1880. .	25.5	26.6	...	34.8	45.0	...	...	...	...
1881-91	...	...	...	...	...	...	...	25.0	...
1890. .	26.1	27.2	23.4	37.1	47.7	...	...	...	...
1891-01	...	...	...	...	...	...	...	23.8	...
1895. .	...	...	...	...	...	...	...	...	37.5
1900. .	27.2	28.5	23.9	39.8	50.0	...	...	...	...
1901.5.	...	...	...	...	...	...	...	...	37.9
1901-11	...	...	...	...	...	...	...	22.9	...
1910. .	28.9	30.5	24.6	44.0	53.5	...	...	...	...
1911.5.	...	...	...	...	...	...	...	...	40.7
1920. .	31.1	33.0	25.5	50.3	57.0	...	...	...	...
1920-22	...	...	...	...	...	31.7	...	...	...
1921-31	...	...	...	...	...	...	...	26.8	...
1926. .	...	...	...	...	...	...	32.2	...	...
1928.5.	...	...	...	...	...	...	...	...	45.8
1930. .	33.6	36.1	27.1	54.0	61.0	...	...	...	...
1931-41	...	...	...	...	...	...	...	31.8	...
1935.7.	...	...	...	...	...	...	...	...	48.1
1936. .	...	...	...	...	...	...	33.9	...	...
1940. .	38.0	40.2	33.0	58.7	64.0	...	39.9	...	...
1941-50	...	...	...	...	...	...	...	32.1	...
1945-47	...	...	...	...	...	45.8	...	...	...
1950. .	46.4	48.9	40.7	64.5	67.5	...	52.6	...	57.9
1951-60	...	...	...	...	...	...	...	41.2	...
1954. .	...	...	...	...	...	59.9	...	...	...
1955. .	...	...	...	...	...	...	...	...	66.1
1957-58	...	...	...	...	...	...	...	45.9	...
1959-60	...	...	...	...	...	...	...	...	67.8
1960. .	55.8	58.2	50.4	68.8	71.5	61.7	...	...	...
1961. .	...	...	...	...	...	...	62.9	...	...

Note: In the case of averages, each life expectancy was weighted by the population of the country. In the case of India, the life expectancy for 1911-20 was not considered because of the very low level due to the famine during that decade.

For Latin America, Group A consists of Brazil, Chile, Colombia, Costa Rica, Mexico, and Panama; Group B consists of the Dominican Republic, Guatemala, and Nicaragua.

Source: See list at the beginning of the Appendix. For all Europe, the life expectancy average was calculated from the information given by Robert R. Kuczynsky in The Measurement of Population Growth, London, Sidgwick and Jackson, Ltd., 1935, and The Balance of Birth and Death, Vols. 1 and 2, New York, The Macmillan Company, 1928.

torisk Statistik for Sverige (1720–1950), Stockholm 1955.

UNITED STATES

—Department of Commerce, Bureau of the Census, *United States Life Tables 1890, 1901, 1910, and 1901–1910*, Washington, 1921; *United States Life Tables 1930*, Washington, 1936; *United States Life Tables and Actuarial Tables 1939–41*, Washington, 1946.

—Department of Health, Education and Welfare, Public Health Service, *Life Table for 1949–51*, pp. 22–25, Tables 8 and 9; *Vital Statistics of the United States 1962, Vol. II, Mortality*, Part A, pp. 2–7.

Other Underdeveloped Countries

CEYLON

—United Nations Demographic Yearbook 1962, 1966.

INDIA

—Davis, Kingsley, *The Population of India and Pakistan*, Princeton University Press, Princeton, New Jersey, 1951, p. 36.
—United Nations Demographic Yearbook 1962, 1966.

MAURITIUS

—United Nations Demographic Yearbook 1962, 1966.

TAIWAN

—United Nations Demographic Yearbook 1962, 1966.

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REFERENCES

Arriaga, E. 1967. Rural-urban mortality in developing countries: an index for detecting rural underregistration. Demography 4:98–107.

———. 1968. New Life Tables for Latin American Populations in the Nineteenth and Twentieth Centuries. Population Monograph Series No. 3. Berkeley: Institute of International Studies, University of California.

Case, Coghill C., J. Harley, and J. Pearson, 1962. The Chester Beatty Research Institute Serial Abridged Life Tables, 1841–1960. London: The Chester Beatty Research Institute, Institute of Cancer Research, Royal Cancer Hospital.

Davis, Kingsley. 1951. The Population of India and Pakistan. Princeton, New Jersey: Princeton University Press.

———. 1956a. Amazing decline of mortality in underdeveloped areas. The American Economic Review 46:305–318.

———. 1956b. The unpredicted pattern of population change. The Annals, American Academy of Political and Social Science, May: 53–57.

Kuznets, Simon. 1956. Quantitative aspects of the economic growth of nations. Economic Development and Cultural Change 5:5-94.

Mortara, Giorgio. 1941. Estudos sobre a utilizacao das estadisticas do movimiento da populacao do Brazil. Revista Brasilera de Estadistica, Year II, No. 7: 493–538.

Pan American Union. 1965. America en Cifras 1965, Situacion Exonomica: 4. Balanzas de Pagos, Producto e Ingreso Nacionales, y Finanzas. Inter American Statistical Institute.

Statistiska Centralbyran. 1955. Historisk Statistik For Sverige, I, Population 1720–1950. Stockholm.

Stolnitz, George J. 1955. A century of international mortality trends: I. Population Studies 9:24–55.

United Nations. 1962, 1966. Demographic Yearbook. New York: United Nations.

———. 1956, 1966. Statistical Yearbook. New York: United Nations.

United States Bureau of the Census. 1940. Statistical Abstract 1940.

———. 1960. Historical Statistics of the United States, Colonial Times to 1957. Washington: Government Printing Office.