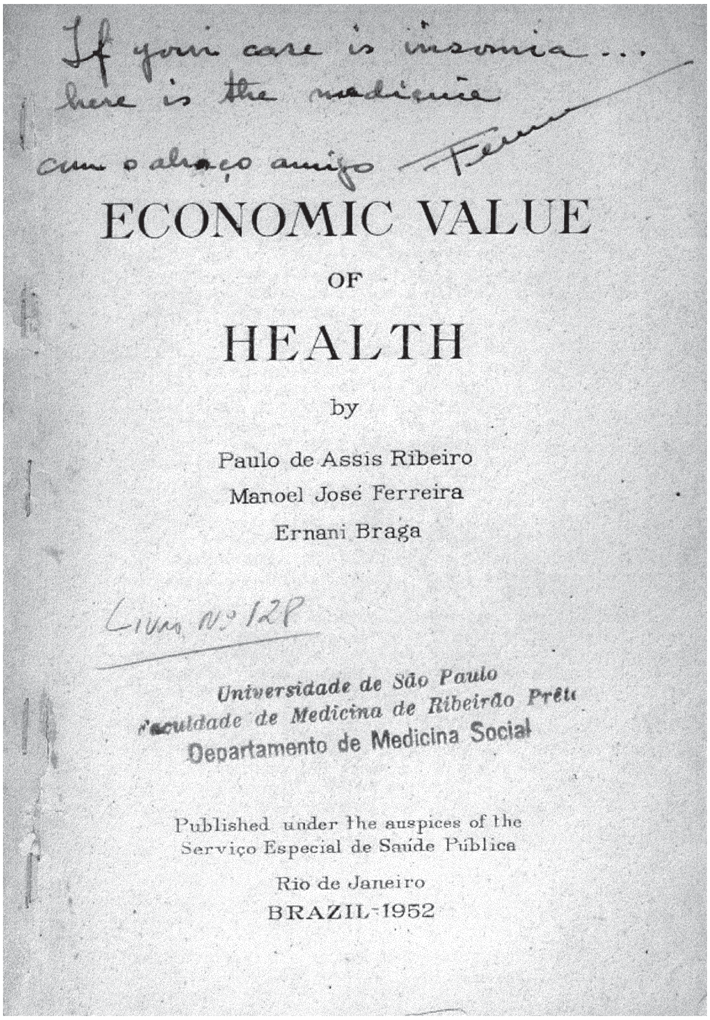
Economic value of health

Valor econômico da saúde



If your care is insomnia ...
here is the medicine
com o abraço amigo

ECONOMIC VALUE
OF
HEALTH
by
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Manoel José Ferreira
Ernani Braga

Livro Nº 128

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The Serviço Especial de Saúde Pública, created on July 17, 1942 by virtue of the contract between the Governments of the United States of Brazil and of the United States of America, signed respectively by the Ministry of Health and Education to which it is subordinated, and the Institute of Inter-American Affairs, is maintained on a co-operative basis by the governments of booths countries.

ETPAR - 1952

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We cannot neglect to make special reference and express our deep gratitude for the effort of Vera de Assis Ribeiro and Dorothéa Viot de Albuquerque. They have gone up to the boundaries of their strength during all phases of the work.

To Mathilde Kastrup, in charge of the English translation we are, not only deeply thankful but also, on the obligation to present our excuses for the many errors and defects due to the hurry of revising, typing and printing.

The graphs, so many times corrected and redrawn by Heriberto Alves de Albuquerque as well as the preparation of the cover and designs of symbols and formula by Sebastião M. Silva, contribute to give a better presentation to "Economic Value of Health".

The pressure of time was a heavy burden on Clélio Ximenes Carneiro and Roberto Martins Costa in charge of the printing.

We are also not less thankful to a number of others not mentioned by name.

Rio de Janeiro, April 28, 1952

PAULO DE ASSIS RIBEIRO
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Contents

CHAPTER I
GENERAL ASPECTS

1) Principles of Measuring the Economic Value of Health

A) Economic Factors Function of Health

The purpose of this study is to explain the value of health from the viewpoint of the expenses and losses caused by disease and other physical deficiencies which, in all age groups, reduce or hinder the full normal productiveness of the healthy man in a specific period; also losses in productivity-resulting from premat\ure deaths and causing a reduction in the number of individuals in each age group in ages below the normal age of Lexis for the region under consideration - throughout the period between the age when death occurred and the respective normal Lexis ages.

An analysis will be made elsewhere of the cost of disease and the cost of death. This study will frost define the fundamental concepts followed.

In analyzing the cost of disease, an examination will be made of the expenses and losses incurred by diseases and physical lesions:

- Directly, in private economy - individually and of in each family group - and in the general economy - of the state;
- Indirectly, by reducing individual productivity rates and the various age groups of the population in the region under consideration;
- Indirectly, by an increase of the population groups of low productivity; and finally,
- By a growth in the relation between total consumption and total production of the population of the region under consideration, owing to the duration of disease and the effects of physical lesions.

In analyzing the cost of death, special consideration will be given to the losses consisting in increase of goods and services which should normally be consumed:

- Owing to social and economic desiquilibrium in the communities where they occur;
- Owing to increased production cost of the population group reaching adult age;
- Owing to the reduction of the average value of the rate relating of duration of the economically productive life; and consequently,
- Owing to increase of the relation between total consumption and total production of the population of the region.

Attention should also be given to reduction in the normal total consumption, resulting from the reduction of the number of consumers eliminated from the population by premature death.

Values relating to death will be discussed for the period included between the age at which death occurred and the normal Lexis age for the region.

B) Basic Concepts

It will therefore be necessary to define some basic concepts used in fixing measurement units for the value of health. These are to determine the total value of all expenses and losses referred to and also to establish rates relating to each region. Such rates should represent the value of health in relation to the balance of total reproduction for the population considered and in relation to each age group of that population, both as instantaneous values and for determining the variation of these in the course of time, inclusively by the influence of growth rates to be considered.

Throughout this work, it is admitted that the well being of a given population is in direct proportion to the average productivity of its members. Productivity, in turn, depends on the rate of heath of the region and grows as the rate improves. The rate is determined by the conditions of morbidity in general and by the characteristic death curve.

In a general way, all the factors that have a bearing on calculating the value of health, according to the principles followed in this study, are of completely different values for each region considered. Moreover, in one and the same region these values undergo noticeable change as time goes on, and this will taken into consideration in the analysis of each of the following chapters.

2) Principles of Individual Productivity and Consumption According to Age

Jean Dayre (1), Technical Consultant of the French National Productivity Committee, has stated, in a parody of the title of Alexis Carrel's book, "Man, the Unknown", that in the modern world the idea of *productivity is another unknown*.

In 1911, Albert Aftalion (2), in an article published in the Revue d'Economie Politique, entitled "The Three Notions of Productivity and Rent", pointed out the confusion existing in economic literature on productivity: global productivity (in natura); the special productivity of each agent (in nature); and the special productivity of each agent (in value). These agents are the three groups of classical factors of economy: land, work, and capital.

Although contemporary specialists still use these distinctions in economic studies, there is a tendency, pointed out by Jean Dayre, to group the three classical factors of productivity into one element, *human work*. This specialist also proposes that, for the needs of the measure, productivity be defined as the relation between production and work.

In this study, except for the approximations necessary to reduce the complexity of practical evaluations of the values of productivity, adopted by economic technique, consideration will not be given to certain factors bearing on the precision of those values but of little significance to the objectives in view.

In addition to the global average values for a nation, region, or city, we should also know the average values for each age group in the respective populations, with a classification for each group of the average values of productivity and of production, as well as of average consumption in goods and services, for each individual in these age groups.

It would also be advisable to classify, for each of the cases, the average values applicable to individuals of both sexes, but the lack of statistical data does not permit carrying the study this far.

In this respect, there is also one other necessary approximation, referring to the unit of production: individual, family, or family group.

In the present day social organization, with the gradual disappearance of the patriarchal family, it is difficult to adopt the average family as a unit of production and of consumption in a population. It would be easier to study the family groups which, in modern society, constitute the social and economic unit and which are formed not only of closely related members but of *symbiotic association*.

However, approximations of the same order will be arrived at more easily by determining the average values for each individual of the various age groups.

Graphic representation of average values of production and individual consumption, during the statistical period of one year, for individuals of the various ages, may be taken to present forms, for each region considered, similar to those presented in Figures 1 and 2.

Absolute values of the ordinates of these curves, however, will vary greatly according to productivity rates. In one the same region, these will vary in the course of time with the economic progress, but the forms indicated in the figures will be maintained with slight changes.

In Figures 1 and 2, the values of the ordinates represent an empirical estimate, with a primary approximation, for drawing the curves relating to individual average production and consumption, at each age, for Brazil. There are represented, respectively, by π_x and γ_x.

E. Engel (3), who dedicated his latter life to systematizing statistical investigations on consumption, proposed the adoption at the end of the 19th century of the unit of individual consumption, justifying this a follows: "It was necessary for me to introduce this new expression. Since the constitution of families varies greatly, and its members increase, grow, move, etc., it is clear that family consumption can not remain always the same. Attention should be given to the age of consumers, because this condition has considerable influence, from birth to the 25th year for men and to the 20th year for women.

"Detailed investigations on the cost of man in the most numerous class warrant evaluation of expenses for a newborn infant of this class, prior to birth and during birth, of 100 marks. It seems advisable to use this amount as an initial reference figure, increasing it, according to the results of investigations, at the arithmetic annual rate of

INDIVIDUAL PRODUCTION PER YEAR

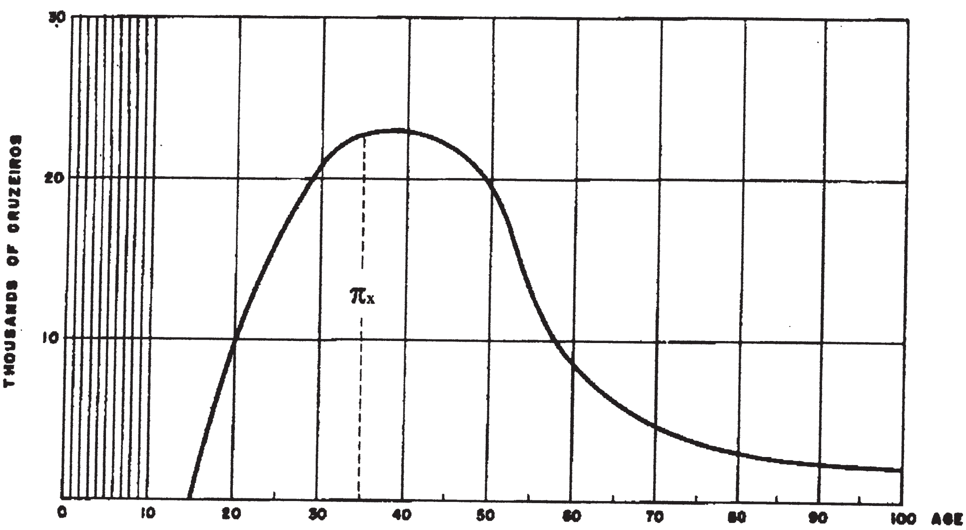

FIGURE - 1 -

INDIVIDUAL CONSUMPTION PER YEAR

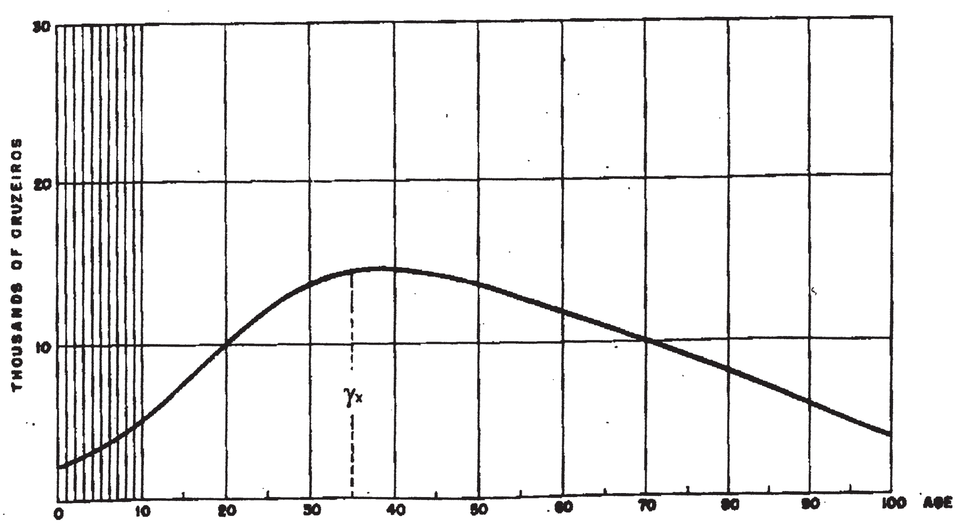

FIGURE - 2 -

10% until the respective ages of 25 to 20 years".

After presenting a table for ages 0 to 25, he continues:

"I do not claim that the figures on this scale are irrefutable. On the contrary, they may be questioned for the reasons I pointed out in my study on the cost of man. However, they suffice perfectly for the purpose.

"The degree of consumers is therefore determined by the average amount of annual consumption expense. Upon reaching the age of 5, this represents 1.5; at 10 years, 2.0; at 25 years, 3.5 units. A family composed of father, mother, and six children aged 11, 9, 7, 5, 3 and 1 represents 16.1 units (father, 3.5; mother, 3.0; child of 11 years, 2.1; 9 years, 1.9; 7 years, 1.7; 5 years, 1.5; 3 years, 1.1; and 1 year, 1.1.

The introduction of this unit makes the composition of family independent from the valuation of the balances of consumption. The field of choice for families to be studied is greatly increased, since its composition is inconsequential and its is sufficient to know the number, sex, and age of its members".

It can be seen that Engel introduced a unit of individual consumption based on prenatal and natal expense and established that the variation of individual consumption, with the years, could be represented by arithmetic progression.

Giorgio Mortara (4) suggests substituting arithmetic progression for geometric progression and also presents the possibility of a more general form of representation. He pointed out, however, that the lack of numerical values to determine the functions for expressing variation of consumption, according to age, discourages the adoption of these general functions.

On the other hand, Vilfredo Pareto (5) drew up a method for substituting the discontinuous functions of Engel's formulas by continuous functions, using infinitesimal calculation and substituting the totalities by integrals.

When using the coefficients established by E. Engel as well as those proposed by Giorgio Mortara and V. Pareto to determine the cost of production of adult man, it should be noted that the values obtained increase to the limits of the ages under consideration. In applying these to the present study, it is necessary to take into account the fact that after a certain age, coefficients of consumption in relation to age again decrease.

3) Principles of the Productivity and Consumption of Population According to Composition by Age Groups

The composition of populations by age groups may present three classical types: progressive, stationary, and regressive.

For the three types, however, all individuals from 15 to 50 years represent approximately 50% of the total population, and the percentages of the number of individuals from 0 to 15 and from 50 to w are characteristic of the three types.

According to Sundbärg (6) the characteristically progressive type of population would have 40% individuals from 0 to 15 years, and 10% 50 to w years; the stationary type, 26.5% to 15 years and 23% 50 to w years; the repressive type, 20% 0 to 15 years and 30% 50 to w years. Sundbärg establishes the percentages for the three large age groups in a standard type of population: 0 to 15 years group - 33.3% 15 to 50 years - 50%, 50 to w group - 16.7%.

Accordingly, the population of Brazil would be immediately included in the clearly progressive type, and the distribution curve of the population by ages is represented in Figure 3, with approximate average values for the population in 1950.

R. R. Kuczynski (7) shows that is necessary to know the death and birth rates and the immigration data in order to reach a definite conclusion on whether the population is of the stationary, regressive, or progressive type.

For evolutive studies of the composition by ages for the population of a determined region, it is obviously necessary to use precise methods to measure the tendency of the natural movement of the population.

POPULATION BY AGE GROUPS

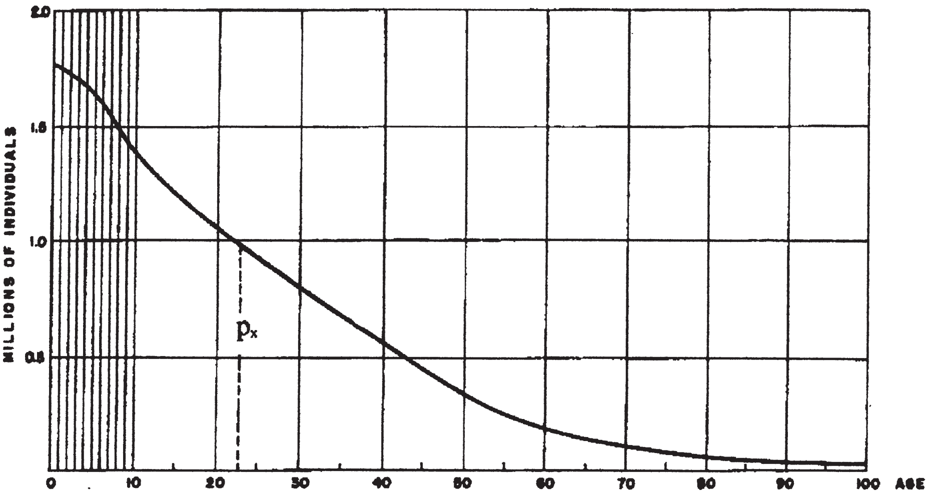

FIGURE -3-

From this aspect, however, the development of studies on the general theory of population have reached a point where it is possible to obtain approximation degrees suitable for economic studies.

In addition to his general studies on the subject, Alfred J. Lotka (8) made a special study of the fundamental types of population: stationary, malthusian and logistic, in relation to effective populations. These contributed decisively to the practical application of demography in economic studies, especially with reference to the differential rates of growth for the productive age groups in a population of each of these types.

It is therefore possible to know the composition of the population of a region by age groups and also to make an approximate forecast to this composition in periods of time necessary for economic studies.

The economic aspect of the composition by ages of a population is of utmost importance, since the percentage of individuals in the economically productive age groups is of itself an indication of the production effort which individual of this group must make to maintain the population where the as yet non-producing age groups and those of advanced age, of very limited productivity, constitute consuming groups weighing heavily in the absorption of the production by the economically producing group.

At times, in one and the same country, there is a great variation in the compositions by age of the populations of its various regions. There are especially great discrepancies in the economically productive ages. For the purposes of this study, this requires a knowledge of regional data in order to evaluate the value of health.

It is not sufficient, therefore, to know the average values in a country, in a determined period, representing results of components with various characteristics representative of each one of its regions.

It is true that all work of reducing avoidable mortality leads, at the end of a certain period, to a percentage increase of the population over a certain age. This is the case with the population of the United States where, according to a recent study by Oscar R. Ewing (9), administrator of the Federal Security Agency, there were 18% over 45 years in 1900, increasing to 28% in 1945, with a forecast of 34% for 1975.

After overcoming the causes of death from the most frequent diseases in childhood and adolescence, we arrive at the problem of the increase of chronic disease such as heart disease, cancer, cerebral lesions, nephrites, etc. The control of these is not only more costly but also less efficient with the resources available.

In the economic study of the value of heath, this represents a substantial modification in the forms of the characteristic curves presented in this study, without, however, altering the degree of validity of the method presented.

On the other hand, in a country with varying regions of economic development, population groups of low production contribute to a decrease in average rates of national productivity. It is therefore of general national interest to go to work in these regions, intensifying the means of production, providing the population with instruction according to the environment, and lastly providing economic recuperation by all means in order to raise the average rates of productivity.

Figure 4 shows the forms of the curves of total production and of total consumption, as well as the zones where there are balances and deficits of production, according to age. These curves are obtained by the product of the ordinate of the curves shown on Figures 1 and 2 and the ordinates of the curve shown on Figure 3. The values of these ordinates are respectively p_{XPX} and g_{XPX}. For those products, will be used the symbols: R_x and C_x.

The production balance of a population indicated by the curves in Figures 1, 2 and 3 may be expressed, using the indicated symbols

$$(1)\ S_p = \sum_{0}^{\omega} \pi_X p_X - \sum_{0}^{\omega} \gamma_X p_X$$

or

$$S_p = \sum_{0}^{\omega} p_X - \sum_{0}^{\omega} C_X$$

where Sr indicates the production balance, and w the most advanced age in the population under study.

An analysis of Figure 4 shows how the increase of Sr balance may be obtained.

Theoretically, in order to increase the Sr value, we should try to *increase* the values of pc in all ages, those of rc in the phases where pc is greater than gc, and *reduce* the values of gc in all ages, and those of rc in the phases where gc is greater than pc. However, these changes should not be for the purpose obtaining purely economic data. The aim should be:

- to increase the values of gc, representing a better standard of living for

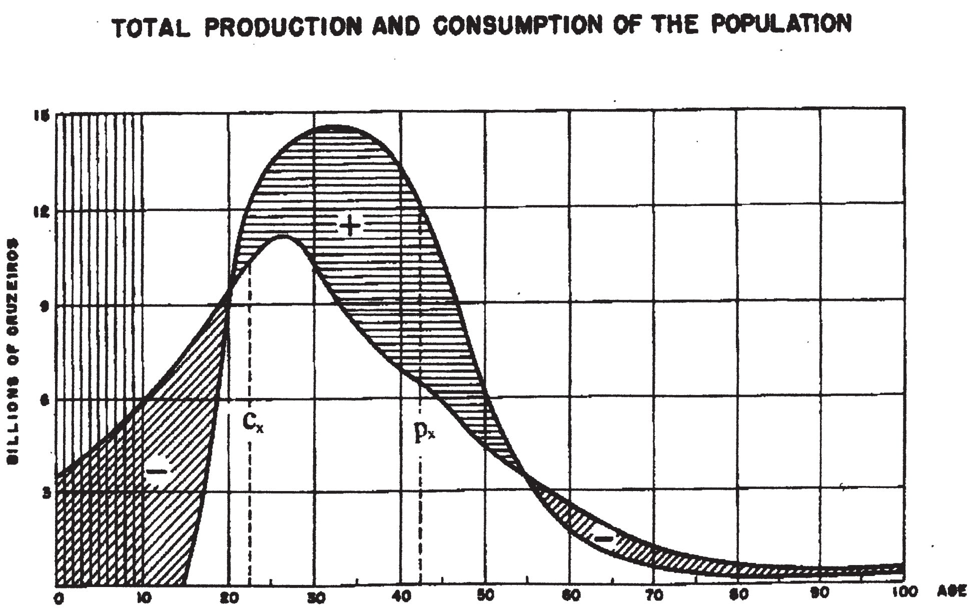

FIGURE - 4 -

the population;

- to increase the values of rc, at advanced ages, representing a greater average life span for the population, an ideal of civilization throughout time.
- two reduce pc in advance ages, a social ideal also being gradually attained with modern labor legislation, by means of retirement pensions.

These ideals, apparently at variance with the purposes of increasing total production balances, must be arrive at simultaneously with a strong increase of pc and rc in the economically productive ages, by means of greater efficiency in the organization of labor. This is being accomplished in countries of better economic situation, especially by means of a well organized system of public health, by planning technique, by the development of mechanization in general, and by well supervised industrialization.

An attempt should be made to obtain for the general population a greater *relative number* of persons in the economically productive ages, and multiply for the production capacity of these by means of the available techniques.

4) Fundamental Principles of Life Span; Representative Rates and its Evolution

A) Various Principles of the Life Span

The lack of a uniform terminology for questions relating to the life span requires that we first define the terms to be used in this analysis in order that data and conclusions may be better interpreted. Various terms are used in the study of the human life span and, according to the point of view taken, ideas are expressed in such varying manners that data and numerical rates differ greatly. This makes comparative studies difficult, whether for the same population in a determined period or what is still more difficult - in cases of comparison of the conditions in various regions, over various periods.

The main principles are:
a) empiric idea of the life span;
b) maximum or potential span;
c) man’s average effective span;
d) median life;
e) average life;
f) normal life.

a) Traditionally, the empiric idea of the life span shows that the human life, in the various regions of the earth, may be considered to have a duration between 70 and 80 years. Considered globally, this empiric notion has not varied throughout the centuries and even in the Bible (10) - with the exception of life spans of ante and post-diluvial patriarchs - the life spans registered show that the common period of the life span did not vary greatly above or below those figures.

In this analysis, however, this empiric idea of the human life span is of little interest, although the numerical rates are the most uniform in time and space.

b) The second principle to be considered in the life span is the maximum or potential span. Numerical values relating to this span do not permit a strict limit on human life. Most of the data registered in the general and specialized literature on longevity are legendary and do not possess sufficient documentation to be accepted scientifically. Specialists in demography and insurance risks refuse to accept as fact the existence of cases of life span much over 115 years. However, references have been made of individuals much older than 120 years, such as Thomas Parr (11), said to have been 152 years and 9 months; Joseph Surrington (11), who died in 1797, at the reported age of 160 year; Henry Jenkins (12) said to have been 169 years; Countess of Desmond (12) 140 years; José Martins Coutinho (13), who was still living on December 4, 1872, in Cabo Frio, State of Rio de Janeiro, Brazil, having been born in Saquarema in 1694, and was therefore 178 years old, according to “The British Brazilian Times” of that date. Figures higher than these are found only in Biblical texts, especially where reference is made to the life span of patriarchs prior to the flood. Literature of Hebrews, Samaritans, and of the Setenta, although differing in the life spans of theirs patriarchs, all refer to spans much higher than 100 years. The Latin Vulgate (10) follows the chronology of the Hebrew text, and in the latter the life spans of ante-diluvian patriarchs varied from 777 (Lamech - Father of Noah) to 969 years (Methuselah - who died the year of the flood), without taking into consideration the life span of Henoch (365 years) since, according to the Bible, this period does not refer to Henoch's life span as he was taken from the midst of men in the year 987 of the world but did not die on that date.

In the censuses of various countries, there are frequent references to a large number of centenarians. Specialists in demography do not accept these statistical data as being entirely true, especially since they are not based on civil registration, which is being used only a little over a century, and not in all countries. In the 1940 census in Brazil, there were several thousand declarations of age over 100 years. In a recent study, Professor Giorgio Mortara attempted to correct the census data, showing numerous causes of error in such declarations.

Declarations of centenarians in the 1940 census numbered 7.889, of whom 2.854 were men and 5.035 women. In addition to many inaccuracies pointed out in these declarations by Professor Giorgio Mortara (14) in his work on "Centenarians in the Brazilian Census of 1940", which leaves no doubt as to the inexacteness of the declarations, it is curious to note that there were 213 cases of childbirth when the woman had already passed her 50th birthday, since the age at which she could have had her youngest child would be:

50 to 59 years	- in 33 cases
60 to 69 years	- in 97 cases
70 to 79 years	- in 49 cases
80 to 89 years	- in 19 cases
90 to 99 years	- in 9 cases
100 to 109 years	- in 3 cases
110 years and over	- in 3 cases

In view of the inaccuracy of the declarations and following a conscientious demographic analysis, Professor Giorgio Mortara reduces the figure of 7.889 to a probable value of 70 to 140 cases of centenarians in Brazil at the time of the 1940 census. Even so, this gives Brazil a rate per 1.000.000 of 1.69 to 3.38, much higher than has been found for Germany, Japan, Switzerland, Finland, Italy, and Holland.

Kuczynski (quoted by Giuseppe Levi (11) in a study on the limits of growth and aging in metazoans), after carefully examining data referring to a person who was said to be 118 years old, concluded that his age was not greater than 106 years. S. Hirsch [apud 11], based on statistical studies and especially those of Pütter, concluded that the existence of men over 110 years is highly improbable, since studies relating to percentages of centenarians in cases of death found in Germany showed that for each individual of 105 years there would be a corresponding 1.1 million deaths, for each individual of 115 years there would be a corresponding 6.550 million deaths, and therefore the probability of a person dying at the age of 115 years would occur only once every 160 years.

Therefore, the statistical principle of maximum or potential human life span is taken as being the period of one century for the normal limit in vital statistical studies.

c) The third principle to be considered is that of man's effective average span, varying according to the region, especially in relation to health indices, and therefore varying also for each era under consideration. The numerical rate of this span is obtained by taking a simple average of the real life spans found for individuals of a determined group born in the same period. For Europe this value varies normally from 35 to 45 years, with the exception of some places where the figure is higher than 50. In the United States, this average reaches values equal to or higher than 70 years. In Brazil, the rate is normally between 35 and 45 years.

These figures are of slight significance for the purposes of this study, but are very representative of the global characteristics of health conditions in a determined region.

d) another characteristic index of a new principle of the life span is that covered by the median life (sometimes incorrectly called probable life), which corresponds to the age at which the initial figure of 100.000 survivors, considered as having been born in the same period, is reduced to 50.000, or half. This rate is very former of the health conditions in a determined region.

In order to have an idea of the approximate numerical value of this index, we quote a few examples taken from Giorgio Mortara (15):

Brazil	(1920)	- 43 years
United States ...	(1940)	- 68 years
Italy	(1930)	- 43 years
Chile	(1930)	- 42 years

e) Another principle of the life span is that indicated by average life, representing the probable number of years a man still has to live at each age. This rate is determined in the calculations of the death rate tables, and the life span appears therein as factor of statistical probability. It is of the greatest interest in economic studies of death rates and is the basis for all actuarial calculations of insurance companies and social security. From its definition, we see that this rate varies at each age of the person under consideration. In comparative studies, it is customary to take the rate referring to the ages of 0 to 1 year, although the tables are organized for all ages. The following examples (16) of average life at age 0 give a good idea of these rates:

Brazil	(1920)	- 38
United States ...	(1940)	- 63
Italy	(1930)	- 56
Chile	(1930)	- 38
Australia	(1947)	- 68
New Zealand	(1938)	- 67

f) Finally, we have the principle introduced by Wilhelm Lexis of the normal age corresponding to the age at which the number of deaths of adults, in 100.000 births of the same period, attains the maximum. For a better understanding of this rate, it is indispensable to examine the general curve of deaths, in the manner suggested by Lexis. For this rate to be significant, the age it indicates must be correlated with the frequency of deaths verified at that age (Figure 5).

Figure 5 was drawn in the basis of the survival table, according to mortality in the period 1939-1941, organized by Giorgio Mortara (15), with the Gompertz-Makehan adjustment, starting with age 20, for the Federal District, Brazil.

As examples of these, we have:

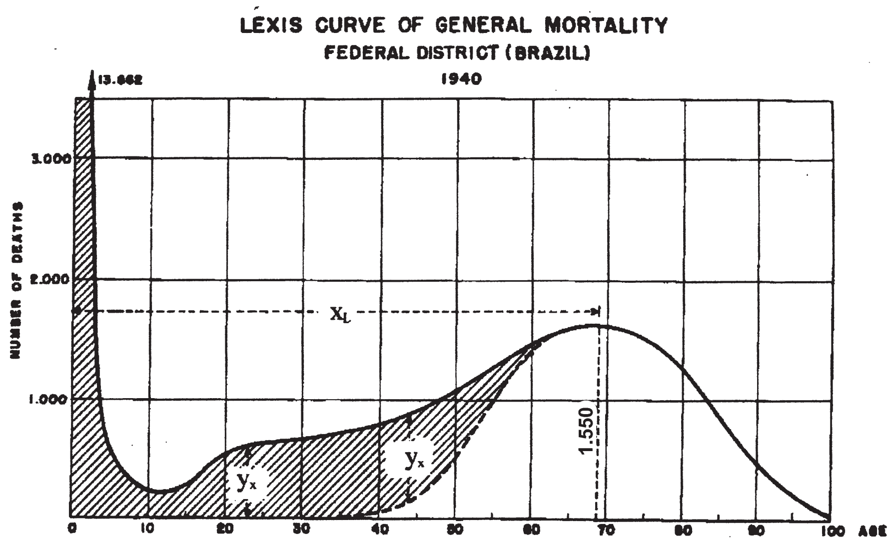

FIGURE - 5 -

Federal District
Brazil .... (1940) - 69
United States ... (1937) - 80

In a general way, all these rates with the exception of that relating to the principle of maximum or potential human life span, are studied separately for both sexes, since variations for all are very noticeable for the group of men and the group of women in one region, in a given period. However, the average values for both groups serve to establish influences relating to death rates in the present economic studies.

B) Evolution of the Rates of Human Life Span

The most common graphic forms for representing data referring to death rates for a population are the probability curves of survival, of average life, and of general deaths.

Figures 6, 7 and 8 give several examples of these three types of graphic representation of death rates.

Figure 6 shows the four following types of survival curves:

a) Survival curve according to the hypothetical life table of L.I. Dublin (1933);
b) Survival curve according to the table calculated by H.L. Dunn for the United States of North America (1946);
c) Survival curve for the city of São Paulo (Brazil) according to the table calculated by Giorgio Mortara (1940);
d) Survival curve for the city of Recife (Pernambuco-Brazil), according to the table calculated by Giorgio Mortara (1940).

Figure 7 shows the five following types of average life curves, at various ages:

a) Representative curve, drawn according to the hypothetical life table of Dublin (1933);
b) Representative curve, according to the table calculated by H.L. Dunn for the United States of North America (1946);
c) Representative curve, according to the data of W. R. Macdonell for the Roman colonies of Africa, 2.000 years ago.

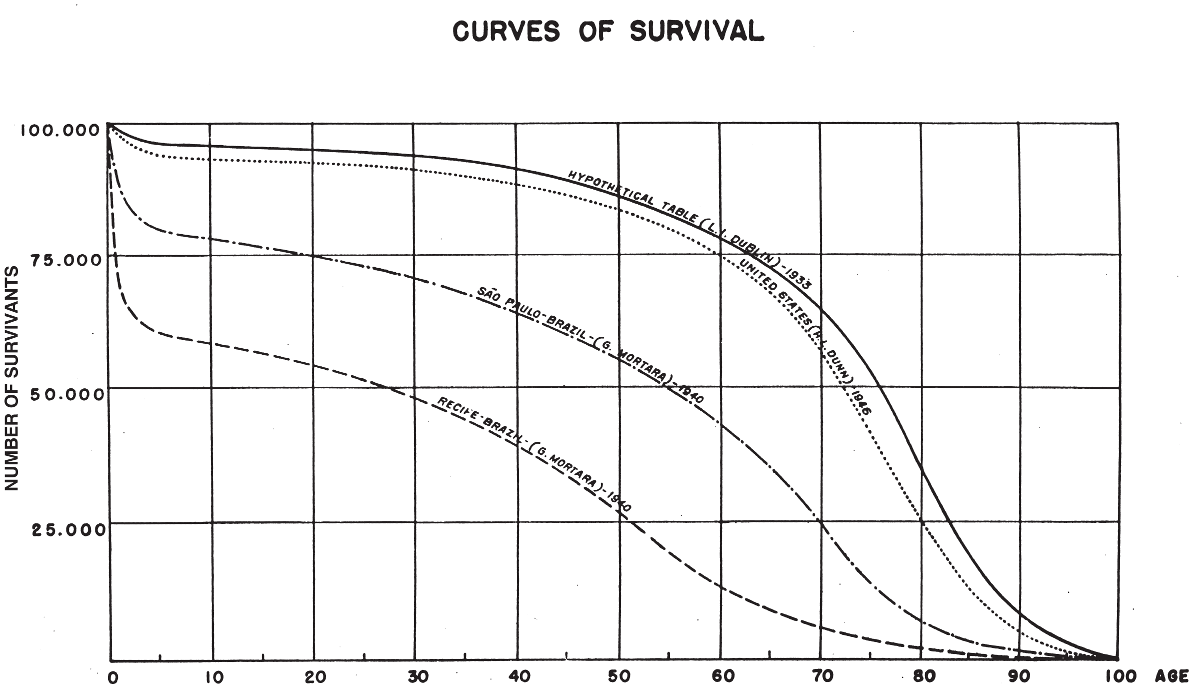

FIGURE - 6 -

EXPECTATION OF LIFE

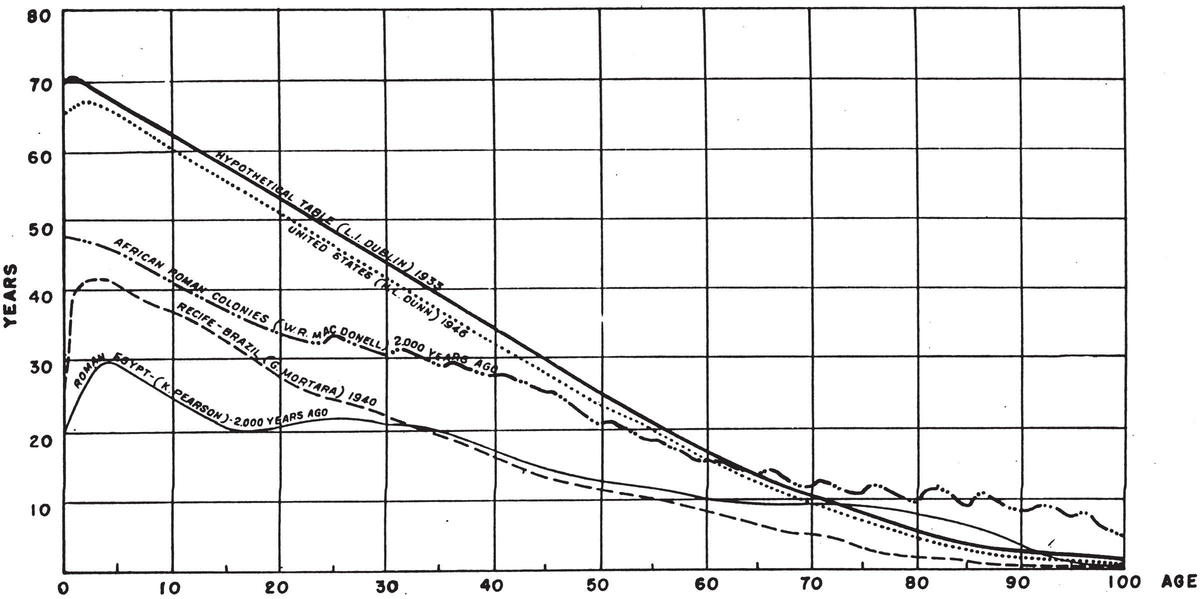

FIGURE-7-

LEXIS CURVE OF GENERAL MORTALITY

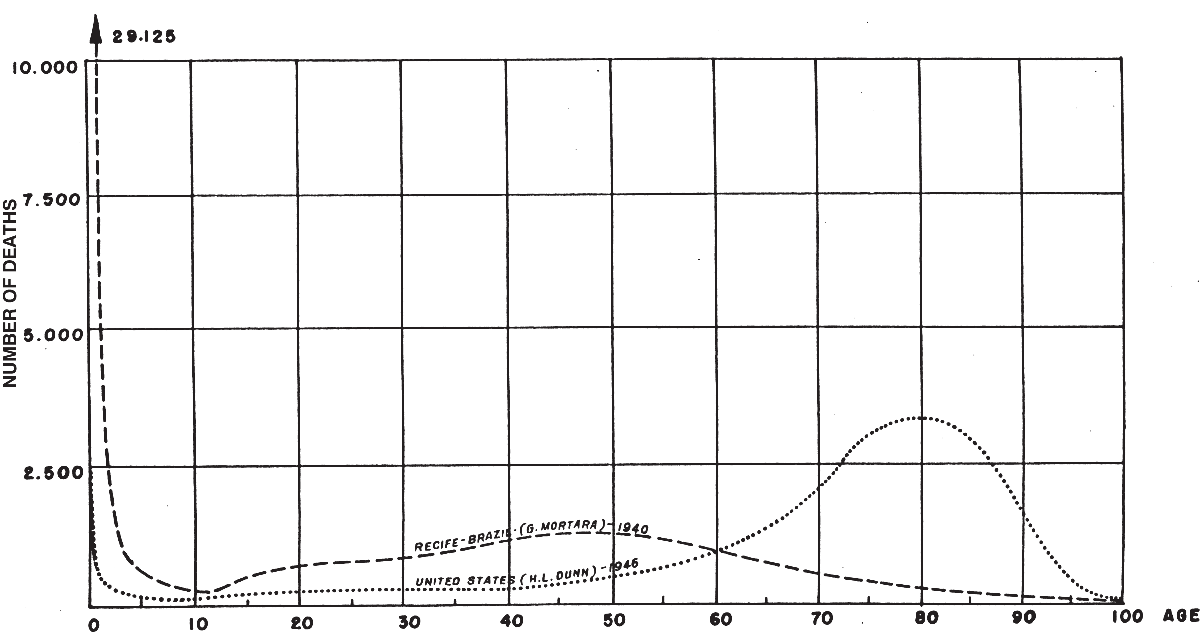

FIGURE-8-

d) Representative curve, according to the data of K. Pearson for Roman Egypt, 2.000 years ago;
e) Representative curve for Recife (Pernambuco-Brazil), according to the table of Giorgio Mortara (1940).

Figure 8 shows the curves of general deaths of Wilhelm Lexis for the United States of North America (1940).

In analyzing these, it is possible to make a general examination of how the life span rates have evolved over the last 2.000 years.

In the evaluative study, it is not possible to consider the life spans registered in Biblical literature, since these have not as yet been interpreted to the satisfaction of all who believe in the truth of the historical book. In any event, we would find references useful only in studying maximum or potential life span.

Scientific studies of value in determining the conditions of life and death about 2.000 years ago are those of Pearson and Macdonell, continued by Macdonell (17,18). The oldest known probability tables (19) are, those of Prefect Pretorian Ulpiano and of Jurisconsult Aemelius Macer, originated in the third century of the Christian era, but these are of purely historical interest. Lists of life spans of eminent personages of ancient times give no evidence of evolution in the increase of the average life or of the normal life or of any other rate. For example, one list among many is the following:

Alexander the Great .... - 33
Aristotles .... - 62
Cicero .... - 64
Demosthenes .... - 62
Herodotus .... - 59
Hippocrates .... - 85
Horace .... - 57
Ovid .... - 60
Plato .... - 80
Pythagoras .... - 82
Thales .... - 94
Virgil .... - 51
The average life span is 67 years

Investigations of Pearson and Macdonell in 1902, analyzing data relative to the populations of North Africa about 2.000 years ago, when Egypt was under the dominion of Rome, enable them to draw a probability curve of live at each age, permitting a comparison of the conditions of life at that period with those in various regions of the world in modern times. Continuing the investigations initiated with Karl Pearson, W. R. Macdonell, based on material extracted from “Corpus Inscriptionum Latinarum” of the Academy of Berlin, selected three groups of data which permitted the establishment of curves analogous to those organized for the Egyptian population of that era, for the inhabitants of Rome, for the inhabitants of Spain and Lusitania under the dominion of Rome, and for the African colonies. These curve were organized separately for each sex and permit comparisons analogous to these referred to.

An observation of Figures 6 and 7 shows how in some regions of the world sanitary and economic conditions have permitted life span rates to approach, and sometimes surpass the theoretical rates of the hypothetical table of Dublin, which has therefore been reviewed on account of that fact.

On the other hand, we note that in certain regions general rates of life span do not show considerable progress when compared with the presumable sanitary conditions in the world 2.000 years ago, expressed by the curves drawn on the basis of the studies of Pearson and McDonnell.

Most basic studies, however, were possible only commencing with the Nineteenth Century, and even so with data referring to few countries, since statistics that could supply sufficient documentation for studies on a scientific basis were rare and still are for a great number of countries. In order to have an idea of the evolution of the rates of life span during recent times, a few examples of average life at age 0 are given on the following page.

After listing these data, it should be pointed out that the situation from 1929 to 1932 for Chile was indicated by the rate of

37.88 for men and 39.76 for women, and the situation for some cities in Brazil from 1939 to 1941 was, for São Paulo, 46.71 for men and 51.77 for women; Federal District, 39.75 for men and 45.24 for women; Salvador 32.49 for men and 37.88 for women; Recife, 28.4 for men and 32.47 for women.

5) The Value of Man and the Economically Productive Life Span - Need for Demo-Econometric Investigations

Following the abolition of slavery the idea of attributing a financial value to man was almost abandoned for a time. Under the former system, at least, a small part of the population was given a value in money and the free man was of less financial value than the slave.

TABLE

		Average Life 0 year	
Countries	Periods	Men	Women
Australia	1881-1890	47.20	50.84
	1946-1948	66.07	70.63
Denmark	1835-1844	42.60	44.70
	1941-1945	65.60	67.70
France	1817-1831	38.30	40.80
	1946-1948	62.50	68.00
Germany	1871-1880	35.58	38.45
	1932-1934	59.86	62.81
Finland	1901-1910	45.33	48.10
	1941-1945	54.62	61.14
Holland	1816-1825	29.32	35.12
	1947-1949	69.40	71.50
New Zealand	1891-1895	55.29	58.09
	1934-1938	65.46	68.45
Italy	1876-1887	35.80	35.50
	1935-1937	54.00	57.49
Sweden	1755-1776	33.20	35.70
	1941-1945	67.06	69.71
Brazil	1870-1890	33.86	33.86
	1890-1920	39.25	39.25
Russia	1874-1883	26.31	29.05
	1926-1927	41.93	46.79
United States	1850-	38.30	40.50
(Massachusetts)	1939-1941	61.60	65.89

Gradually, however, the financial value of man was again considered, taking into account the goods produced by the population.

The creation of the primitive insurance systems required the organization on tables for the value of human life. These are being continuously perfected in all countries, but the values are proportional to the premiums. Their evaluations of the value of human life are gradually becoming more an a priori personal estimate rather than the evaluation of the average values of man in each region.

The first attempts at a rational evaluation of the economic value of man were those of William Petty (1623-1687), who considered the value of a population as being the equivalent of the capital which, at a specific interest rate, would earn the total goods produced by the population. The average value of man would be the value of that capital divided by the number of individuals in the population under consideration.

In addition to other errors in evaluation, consideration was not given to the values of consumption by the population in goods and services.

L. I. Dublin and A. J. Lotka (20) present a study, which can be summarized in the following steps.

In the Eighteenth century Adam Smith, taking into consideration the relation between the productive capacity of nations and the consumption necessary for their populations, attempted to establish and economic value for man.

Adam Smith, however, did not give an intrinsic value to man himself, but gave more weight to the productive capacities such as knowledge acquired, abilities for work, since these contribute to an increase of credits for determining production balances, whereas man himself contributes to increase the credits but contributes even more strongly in increasing debits because of goods and services he consumes.

In the Nineteenth century, stricter interpretations were made and these resulted in the studies of William Farr, T. Wittstein, R. Lüdtge, E. Engel, and V. Pareto.

William Farr tried to determine the values of each individual, taking into account the capacity for production at a specific age, determining the value at other ages by setting interest rates and considering mortality tables. T. Wittstein attempted to determine the value of man at various ages of life by considering the value 0 at the date of birth and establishing that, for a certain population group, total production throughout his entire existence would be the equivalent of the expenses for his maintenance. R. Lüdtge, studying specifically the value of man for the purpose of organizing insurance tables, shows the relative nature of these values, since they do not have a fictitious average value but in each case have a real, physical significance of what the individual represents financially to his family or insurance beneficiary.

E. Engel (3,21), a disciple of Quetelet and of Le Play, was the first to consider the question from a more ample viewpoint and he was the observer and initiator of various heretofore neglected elements among the factors determining man's value.

In addition to the data for determining individual consumption according to age, described above, Engel promised to complete his investigations. His work, however, remained unfinished, but he did have great influence on later investigations.

In his studies, he did not take into account the death rate or capital interest, although he was conscious of these deficiencies, but he introduced the principle of the economically productive period of life.

Vilfredo Paredo (15), starting with Engel's studies, not only introduced the factor of infant mortality in the cost of the adult man, but also established continuous formulas to express the values at each age, using the mortality tables of Bódio. He also proposed that, in determining the cost of adult man, consideration be given to the age limit of 20 years instead of 25 years, as used by Engel. He went so far as to question his value of 20 years as being excessive since individuals already produced special value for their subsistence starting at 16 years.

In the Twentieth century there have been many studies referring to the value of man or of human life, the most important of these being the studies of Louis I. Dublin, Alfred J. Lotka, and Giorgio Mortara.

During this century, the problem became even more significant. The knowledge of the value of human life has become increasingly important for a perfect understanding of economic problems.

A historical analysis shows that all those who took up the problem were limited in their studies by the deficiency of statistical data, which alone shows the need for developing demo-econometric investigations.

In this study, we are trying to introduce into the analysis of the economic value of man the factors of greatest influence in its variation, summarized under the heading of the economic value of health and taking into account disease rate in its many aspects in determining that value, a matter not yet duly estimated.

The study of the economically productive life span will be a result of investigations in each region for the coefficients relating to individual production and consumption, and also of the demographic analysis based on the death tables for the same regions.

Giorgio Mortara (22,23) made special studies to determine the economically productive life, published in a series of articles entitled "Demo-econometric Investigations", for the purpose of developing knowledge of these two branches of social science, facilitating exploration of the zone of common interest.

The main result of this study may be to develop the interest of investigators to join efforts in obtaining new methods to facilitate not only the determination of the as yet deficient numerical coefficients but also to establish indices corresponding to the economic value of health, fundamental for a knowledge of economic questions.

CHAPTER II
THE COST OF MORBIDITY

1) The Causes of Morbidity and its Economic Importance

In the analysis covered by this chapter, it is first necessary to establish a concept for *morbidity*, since the determination of the characteristic elements of the general morbidity of a population vary greatly according to the concept adopted.

Important characteristics for evaluating cost at each age are:

-the coefficient of morbidity

$$Z_x = \frac{n_x}{p_x}$$

-the frequency of the disease or the possibility of becoming ill

$$f_x = \frac{c_x}{p_x}$$

-the duration of the disease

$$\delta_x = \frac{n_x}{c_x}$$

were p_x, c_x and n_x represent, respectively; individuals, at age x, exposed to the risk of disease during the period of time under consideration; the number of individuals at age x, who in group rc were affected by the disease during the period under consideration; and the total number of sickness-days for individuals of group p_x during the period under consideration.

It is clear that for each concept adopted for morbidity there are very different corresponding numerical values for the characteristic indices.

In calculating the cost of sickness, we should, in a general way, include among the diseases everything that represents harmful modification in the state of health and in the normal vigor of individuals at various ages. Therefore, consideration should be given to diseases in general, whether those of chronic evolution or of acute evolution, both in the forms which hinder the normal activity of the individual during a certain period an in the forms in which they merely reduce the productivity of the individual at work. Consideration should also be given to physical lesions and traumatism in general; whether they cause temporary or permanent disability or whether they are merely harmful to the worker by reducing his output. We should also include all losses resulting from every and any physical or mental deficiency, or loss of productive capacity, caused by diseases, in the broadest sense of the term.

In examining the economic influence of disease, it is also necessary to establish the concept of what may be considered as technically avoidable morbidity and what may be termed as *residual morbidity* of more difficult control, in the population group considered.

This aspect of the problem was been better studied with reference to death, but it is evident that premature deaths are the final phase of a disease and everything indicates that it is by reduction or elimination of these diseases that the more rapid reduction or elimination of premature deaths is obtained.

Statistics, however, leave much to be desired in the majority of countries with respect to morbidity.

During this century some countries have become concerned with the influence of morbidity on the economic indices and have undertaken special investigations and census-surveys to determine fundamental coefficients, not only in order to institute sickness insurance but also to determine the orientation of public health systems for the improvement of production indices of the population.

Edgar Sydenstricker (24) made a very valuable attempt to outline the “Age curve of good health”, which was later developed by Isidor S. Falk, Margaret C. Klem, and Nathan Sinai (25) following an analysis of 8.500 families of the white race from various regions of the United States.

In this study, disease was defined as “any disorder which wholly or partly disables an individual for one or more days or any experience for which medical service of any kind is received. Any condition, symptom or disorder for which drugs costing 50 cents or more are purchased is considered an illness" (26).

It can be clearly seen that this concept is predominantly influenced by corporal factors, whereas the present phase of medicine is daily becoming more firmly based on a psychosomatic viewpoint.

The interrelation of a great number of pathological conditions of purely organic appearance, with alterations in the psychological field, closely associates the clinical aspect of disease with the mental behavior of the patient.

This is the reason why medical care and social assistance, in their broadest sense, are working on parallel levels and as parts of the same system.

We therefore have an idea of the difficulty of appreciating present statistics of the neuropsychological factor, not only in the origin of the sickness but also in the productivity of the individual who has not yet stopped work, but whose activities have been affected.

Although considerations of this aspect of the problem are essential, we will go on to examine morbidity with the concrete elements available, in a effort to present its economic significance in a rough manner.

Global and age rates, showing the economic importance of sickness, have been estimated in various countries, especially by insurance companies.

The United States was even established average percentages of lost production, by virtue of sickness and accidents, as well as owing to tardiness, in the disorganization of routines, in training time required for substitutions, and by lowered production resulting from other conditions of sickness. These percentages were estimated in 1929 - taking into account the cost of living at time - as being 4 billions dollars, corresponding during that year to approximately the ordinary expenditure of the Federal Government of the United States!

These evaluations did not include direct expenses with medical care, such as those paid for by the patients, by the government and public institutions, by philanthropic institutions and by the employers, also representing about 4 billions dollars.

In order to give an idea of the known coefficients, tables 1, 2 and 3 show: Table 1 - a survey of the Metropolitan Life Insurance Co. made in 1915/17; Table 2 - an estimate for 1930 of the cases of diseases and conditions requiring medical diagnosis and treatment; Table 3 - expenses with medical care for 1929, in the United States (26).

It is clear that figures in the three tables above vary considerably according to region. Variations correspond not only to the value of the rates for the various diseases but also the occurrence of types of disease which are non-existent in one region and predominant in others.

Table 1 - Prevalence of Disabling Illness by Age and Sex, Metropolitan Life Insurance Co. Surveys, 1915-17[(1)]

	Percentage of persons sick and unable to work		
Age	Both sexes	Male	Female
0 - 14	1.1	1.1	1.1
15 - 24	1.3	1.2	1.4
25 - 34	1.6	1.4	1.8
35 - 44	2.1	2.0	2.2
45 - 54	3.0	3.3	2.8
55 - 64	4.8	5.4	4.2
65 +	9.5	10.6	8.7

(1) From Sydenstricker, Edgar, Health and Environment (1933), p. 33. Bases on some recent morbidity data compiled by Margaret Looms Stecker from the reports of the Community Sickness Surveys by Lee K. Frankel and Louis I. Dublin.

In addition, direct expenses with medical care, in the various forms indicated in Table 3, show very different rates according to countries, since these expenses are related to the economic conditions of the region and to the political plans of public health as adopted for each country.

As stated, the concept for each region and each period of time of what should be considered as technically avoidable mor-

Table 2 - Estimate of Cases of Disease and Conditions Requiring Medical Diagnosis and Treatment (1)

Disease	Expectancy rates per 1.000 persons all ages	Estimated cases, United States 1930
TOTAL	936.30	114.954.000
Respiratory system	459.00	56.354.000
Digestive system	117.00	14.365.000
Acute diseases	92.50	11.357.000
Injuries from external causes	54.00	6.630.000
Puerperal state	23.56	2.893.000
Syphilis and gonorrhoea	23.00	2.824.000
General diseases	21.00	2.578.000
Diseases of the skin	19.90	2.443.000
Nervous and mental conditions	16.29	2.000.000
Non venereal diseases of the female genital organs	16.00	1.964.000
Diseases of the ear	15.00	1.842.000
Neuralgia, nevritis	13.10	1.608.000
Neurasthenics nervous exhaustions	13.10	1.608.000
Diseases of muscles, bones	13.00	1.596.000
Diseases of the kidneys	12.10	1.486.000
Diseases of the heart	11.70	1.436.000
Diseases of the eye	8.50	1.044.000
Other diseases of circulatory system	6.80	835.000
Non veneral diseases of male genital organs	0.75	92.000

(1) Expectancy rates from Lee, Roger and Jones, Lewis W., The Fundamentals of Good Medical Care, Committee on the Cost of Medical Care, Publication nº 22 (1933), 97-100.

Table 3 - Total Expenditures for Medical Care(1) (in Millions of Dollars)

Service	Total	Patients	Sources of Funds Governments	Philanthropy	Industry
Private physicians	1.090	1.040.0	...	...	50
Private dentists	445	445.0	...	...	...
Secretaries and practical secretaries	193	193.0	...	...	...
Private graduate nurses	142	142.0	...	...	...
Private practical nurses	60	60.0	...	...	...
Hospital operating expenditures	656	278.0	300.0	54.0	24
Hospital new constructions	200	...	100.0	100.0	...
Public health	121	...	93.5	27.5	...
Private laboratory(2)	3	3.0	...	...	...
Orthopaedics and other supplies(2)	2	2.0	...	...	...
Glasses(2)	50	50.0	...	...	...
Drugs(2)	665	665.0	...	...	...
Organized medical services	29	7.9	16.0	0.2	5
TOTAL	3.656	2.885.9	509.5	181.7	79

(1) Source: Medical Care for the American People; the Final Report of the Committee on the Costs of Medical Care (1932), p. 14. The data, with a few minor exceptions, apply to the year 1929.
(2) Includes only those expenditures not included in other items.

bidity is a fundamental matter in the study of the economic value of morbidity.

Climate conditions, basic economic conditions, the cultural development of the people, the degree of perfection of sanitary control, the stages of the main endemic diseases, the financial, technical, and human resources available for the control of possible epidemics, and lastly, genetic conditions of the people result in a varied conception for each region of what should be considered as avoidable morbidity.

This can be seen in an incomplete but expressive manner by analyzing the "age curve of good health" and the already known curves representing specific morbidity tables, taking into consideration modern resources of preventive medicine.

The modern world has the following means of reducing or eliminating avoidable morbidity: sanitation and sanitary engineering in general; health education and modern processes of health information; immunizations; epidemiological controls; chemotherapy; the antibiotics; residual insecticides; and lastly, the resources of mental hygiene and sociology.

Precisely in those regions where the people have poor health rates, the control of disease is most rapid and efficient, and consequently financial results are most gratifying.

Although, as has been pointed out, statistical investigations and surveys have not determined exactly the influence of morbidity on individual productivity and consequently on the total production of a population. It is well known that morbidity can reduce production over 50%.

For example, this is the case in some regions where incidence is high for malaria, trypanosomiasis, certain schistosomiasis, hookworm, etc. These diseases are of long duration and gradually reduce the producing capacity of morbidity, used in organizing the tables for insurance firms, considers only the number of sick days which deprive the worker of activity. As we have seen, in cases similar to those cited, the loss of production is not felt in the reduction of days worked but in the high reduction of productivity of workers infested, but at work.

In addition to the above examples, various other diseases contribute in a high degree to reduced productivity, but are not frequent causes of deaths registered or main causes of absenteeism. Some of these are syphilis, certain types of diseases of the respiratory system, brucellosis and deficiency diseases. Under present conditions, public health services are in a better position to control these.

Another very interesting element in the economic study of morbidity, which can be used until specific coefficients become available, is the relation between the estimated number of cases of death and the number of deaths already determined for various types of diseases, at different ages, in some countries. Tables 4 and 5 are examples (26).

These estimates, although constituting values of little precision, are very important in studies tending to establish numerical value of the cost of health and should be used freely. Often - as occurred in Engel's studies, when he detailed presumable values of the expenses of consumption at successive ages (4) - progress in a determined field of applied statistics results from hypotheses and the fixing of empirical data for approximate solutions.

Table 4 - Deaths and Estimated Number of Cases of Certain Common Diseases of Childhood, USA, 1934(1)

Disease	Estimated cases	Deaths
Whooping cough	1.500.000	7.518
Measles	1.800.000	6.986
Diphtheria	46.000	4.159
Scarlet fever	300.000	2.524
Mumps	1.440.000	...
Chickenpox	1.000.000	...

(1) For case-rate estimates, see Sydenstricker, Edgar, and Wheeler, Ralph E.. Whooping Cough in Surveyed Communities. *American Journal of Public Health*, **26**:582 (June 1936). Also Collins, Selwyn D., Age Incidence of the Common Communicable Diseases of Children. *Public Health Reports*, **44**:763-826 (April 5, 1929). Public Health in New York State, State of New York, Department of Health (1932), 404.

Table 5 - Deaths and Estimated Number of Cases of Tuberculosis, Malaria, and Typhoid Fever in the United States, 1934(1)

Disease	Deaths	Estimated cases(1)
Tuberculosis	71.609	644.000
Malaria	4.520	2.700.000
Typhoid and paratyphoid fever	4.237	42.000

(1) Basis for estimates supplied by L.L. Williams, Jr., M.D. of the United States Public Health Services

Data relating to rates for lesions resulting from accidents and traumatisms of all kinds are very poor. This also contributes in a pronounced manner to lowering production, whether in determining conditions of partial or total disability, or in determing disturbances of lesser importance capable of reducing productivity in the normal field of work of the individual affected, requiring correction by the consumption of considerable financial resources for readaptation to new activities.

Therefore, in a general way, four forms of economic influence of sickness may be considered:

- Number of days lost to production by absence of the worker;
- Percentage reduction in productivity of individuals at work, which may also be computed as work days;
- Percentage reduction in production because of individuals temporarily or permanently disabled, which may also be computed as work days;
- Direct expenses with medical-social assistance necessary for the prevention, reduction, or elimination of effects of disease.

In evaluating the cost of sickness, all four forms will be computed during the annual period referring to the evaluation.

Examples of tables of general morbidity and by disease, usually set values for ages 15 to 80 years, since these are especially used in calculating rates for premiums on sickness insurance taken out mainly to cover periods of inactivity caused by sickness. In this study, it is also necessary to verify morbidity for ages 0 to 15 years and over 80 years.

In a study by Carlo Pinghini (27) we find the main morbidity tables of Italy, France, England, Germany, and Switzerland, as well as one, by diseases, organized for commercial employees in Italy. However, as has been pointed out, these tables show coefficients much lower than those which must be taken into account in calculating the cost of sickness.

Other tables organized on the basis of surveys by the Metropolitan Life Insurance Co., by the United States Public Health Service, and by the Committee on Costs of Medical Care also show the economic effects of disease (20).

It is interesting to note that, according to data of the "German Sickness Insurance", the duration of illnesses resulting in inability to work tends to grow in proportion to the development of the work of insurance companies which undertake early diagnoses and prompt treatment. This increase was also verified in the "British Health Insurance System" (28).

This apparent paradox is probably due to two basic causes:

1st) Inclusion, among the disabling diseases, of types which formerly did not normally hinder work owing to lack of sickness insurance;

2nd) Because the worker who is protected by sickness insurance seeks treatment until he is completely well and does not return to work while still convalescing as was normally the case prior to the benefits of insurance.

2) Influence of Morbidity on the Maintenance of Public Health Systems

Although the general principles of public health technique are the same for the most varied types of disease prevalence, of economic level and cultural development, working methods must vary greatly according to needs.

Starting with underdeveloped regions, priority is given to the phase of sanitation, including the provision of safe drinking water and proper excreta disposal.

Most of the efforts to control sickness without first instituting the above basic sanitation measures are ineffective. Sedgwick and MacNutt (29) gave the name of "Mills-Reinke Phenomenon" to the parallel decline of typhoid fever and intestinal infections resulting from water treatment, with accompanying lowering of general and infant mortality excluded those causes of disease. In regions of the rural type, no public health measure is so effective and give such quick results in reducing morbidity as the proper establishment of water and sewer systems. Sanitation services contributing to the reduction of morbidity in underdeveloped regions must be maintained on constantly higher levels at the rate that these regions are developed economically and attain better health rates. Therefore, in large cities the most advanced services of sanitary engineering guarantee the absence of epidemics or of endemic diseases and should be considered as permanent factors of lowered morbidity.

Another circumstance which should be given priority is the group of diseases produced by microparasites, whether transmitted by vectors or not.

The discovery of the antibiotics and of residual insecticides makes the control of disease a matter of simplicity and feasibility formerly unattainable by even the best equipped systems of public health. Previously unsolvable problems, from the financial or technical point of view, were transformed fundamentally into matters of organization and the availability of normal resources of administration. Reduction already obtained in this sector of sickness and what can hopefully be expected in the near future will permit arriving at the type of residual morbidity and consequently other and more complex systems of public health.

We therefore have two stages where the aspects of morbidity and of the public health systems for combating morbidity are interrelated: *sanitation* and the *control of communicable diseases*. Many regions of the civilized world do not as yet enjoy the benefits of the first and much less of the second, resulting in the enormous amount of sickness which could be avoided by the already known and proven methods.

The existence of such possibilities has originated in the concept pronounced by the World Health Organization (30) that "Health is a state of physical, mental, and social well-being and does not consist merely in the absence of disease or infirmity". Humanity is always looking to the future, in search of new horizons, as obstacles are being overcome. The great epidemics of the past did not permit thinking in positive terms of health. The insecurity of life and the ignorance of the causes of mass destruction concentrated all efforts on scientific investigation in the search for determining causes. Now that the barrier of plagues has been hurdled, man's efforts turn to the wiping out of diseases produced by other microparasites, still constituting the most important causes of disease and of death. With a knowledge of the sources and modes of infection and the methods for cutting these, attention is being directed to wider horizons, health is being given a positive meaning, and a new era is in the offing, appropriately called the era of "hominiculture" or "anthropotechnique" (31). This third phase corresponds to a much more diversified system of public health, since it does not have to do with nature and the correction of the environment nor with parasites and their inability to resist the new therapeutic methods, but with man himself and the complexity of this physical and mental formation and his adjustment to modern society. It is advisable to note that these three great stages which clearly mark the type of evolution of any human group considered from the viewpoint of health do not have well-defined frontiers and frequently exist side in the same region, country, or even city. The numerical data and the graphs used throughout this study make it possible sketch the profile of morbidity in various examples and consequently of eliminating straying from the tendency toward residual morbidity, in many cases practically achieved and in others still far distant. There is not doubt that for each type or stage of morbidity there is an appropriate public health system.

Having examined the tendencies of the life curves, according to the various stages of mortality and of morbidity, it may be - theoretically at the present moment - asserted that the abolition of the present predominant diseases would give place to the purely degenerative or deteriorating diseases.

This fourth phase will require true knowledge of *life* and of *aging*, which would determine improvement of the potential life span.

3) Method of Determining the Cost of Morbidity

A) General Considerations

The above evaluations of the economic influence of disease by means of global indices may be summarized in three groups of estimates:

- Expenses with medical care in all forms, such as that undertaken by government public health services, that financed by semi-official and philanthropic agencies, and also that sought directly by patients.
- Loss of production owing to absenteeism caused by diseases and accidents and also by tardiness by disorganization of routines, and by lowered output of all types, indirectly caused by absenteeism.
- Reduction caused by sub-normal states of health in individual productivity and consequently in the total production of population groups.

This last item has been given the least consideration in statistics, resulting in the impression that it is of minimum influence on the losses caused by morbidity whereas, at least in determined regions, it may be stated that the part it plays is of the greatest economic significance in determining the value of health.

Hence the necessity for developing demo-econometric studies, by means of general surveys and specific sampling in order to more precisely determine the losses, by period and region, which should be attributed to avoidable sickness, in the total production of the population.

In this study, we suggest adopting the following method to determine the cost of morbidity.

B) General Morbidity

It first becomes necessary to determine the characteristic Z_x, representing the total number of sickness-days, verified in the individuals of the population group under consideration in the period of one year.

In order to determine this, consideration must be given to the three first forms of economic influence of morbidity summarized in item 1 of this Chapter, wherein morbidity is described as any disturbance, whether reducing productivity or causing specific consumption.

Until it becomes possible to determine numerically the limits of cases of avoidable morbidity and those that may be considered residual morbidity we may first use the symbol Z_x in calculating from the age 0 to the age w, the highest occurring in the population under consideration.

The curve indicated in Figure 9 shows the general form of the curve obtained by determining Z_x, in accordance with the above principle.

C) Annual Individual Specific Consumption on Account of Morbidity

Following the determination of the general morbidity curve, we should determine the curve representing average annual individual consumption by a patient at age x, owing to sickness in its broadest meaning. This curve, whose ordinates will be indicated by the general sign g_x, varies in form according to the economic conditions of the

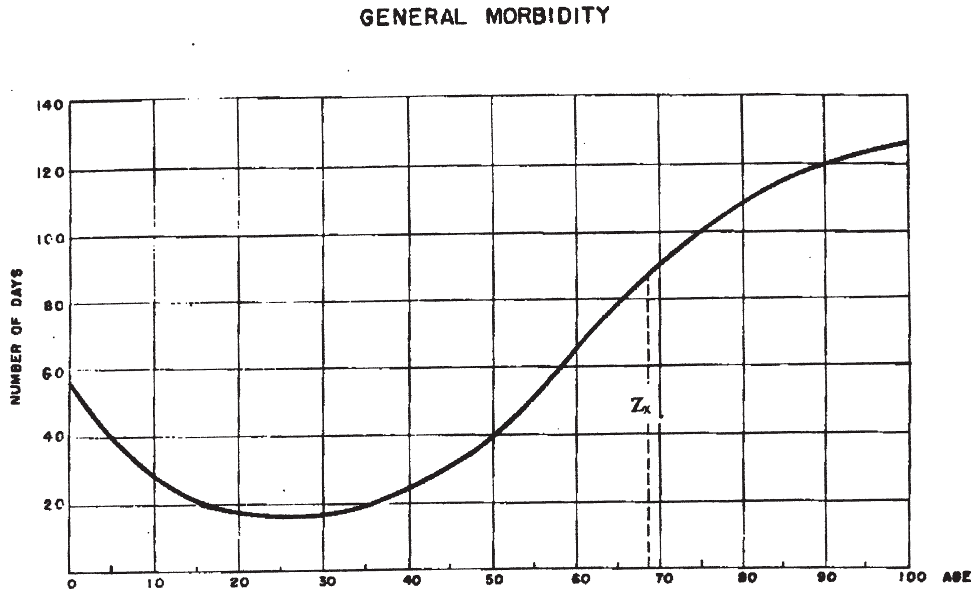

FIGURE -9-

region under consideration and especially with the policy of public health adopted in each region.

In regions where the economy is not highly developed, this curve should have a form similar to that of Figure 10. Statistical determination of the numerical values of this curve offers no greater difficulties than determination of the values of Z_x.

D) Annual Total Production Lost on Account of Morbidity

Having arrived at the curve of values for Z_x, the values of total annual production lost at each age x, owing to sickness, will be found by drawing the curves of ordinates s_x for the various ages, according to the formula:

$$(2)\,\sigma_x = \frac{Z_x \cdot p_x}{300} \cdot \pi_x$$

If we divide the values of $Z_x.p_x$ by 300 we will have for each age a figure equivalent to the number of individuals who, during one year, will not produce a value equal to π_x, the annual individual production assumed in this study for 300 days of effective work.

Figure 11 shows the form of this curve for ordinates σ_x, based on the values taken for drawing the curve of ordinates π_x (Figure 1) and those for the curve of ordinates Z_x (Figure 9).

E) Annual Total Consumption Increased on Account of Morbidity

Having arrived at the curve of values for g_x, the values of total specific annual consumption added, at each age, by virtue of sickness, will be obtained by drawing the curve of ordinates j_x, for the various ages, according to the formula:

$$(3)\,\varphi_x = \frac{Z_x \cdot p_x}{300} \cdot \gamma'_x$$

If we divide the values of $Z_x.p_x$ by 300 we will have for each age a figure equivalent to the number of individuals who, during one year, will consume a value equal to φ_x.

Figure 12 shows the form of this curve for ordinates γ'_x, based on the values takes for drawing the curve of ordinates γ'_x (Figure 10) and those for the curve of ordinates Z_x (Figure 9).

ANNUAL SPECIFIC INDIVIDUAL CONSUMPTION ON ACCOUNT OF MORBIDITY

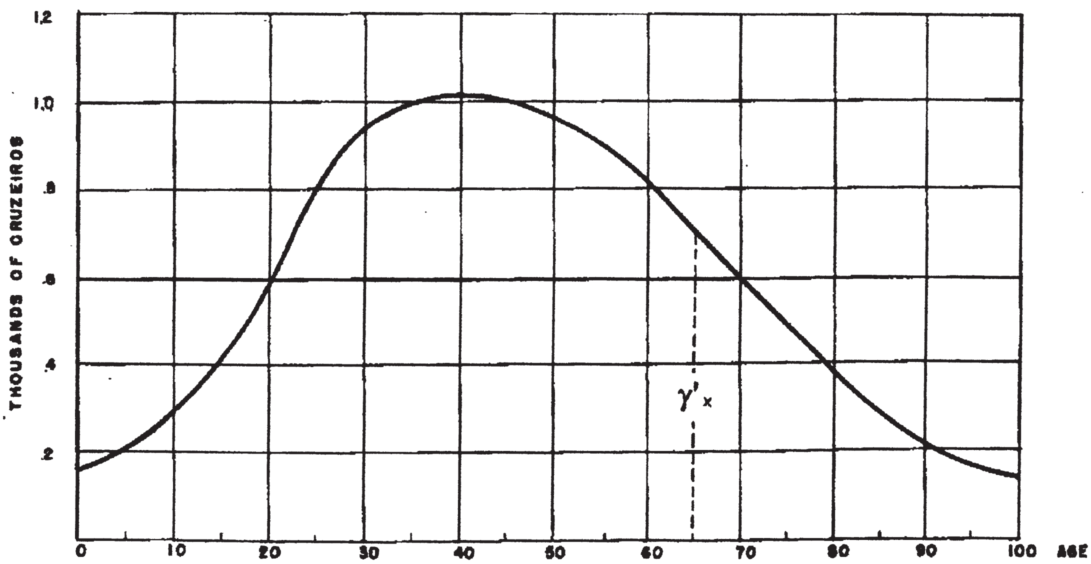

FIGURE-10-

TOTAL ANNUAL LOST PRODUCTION ON ACCOUNT OF MORBIDITY

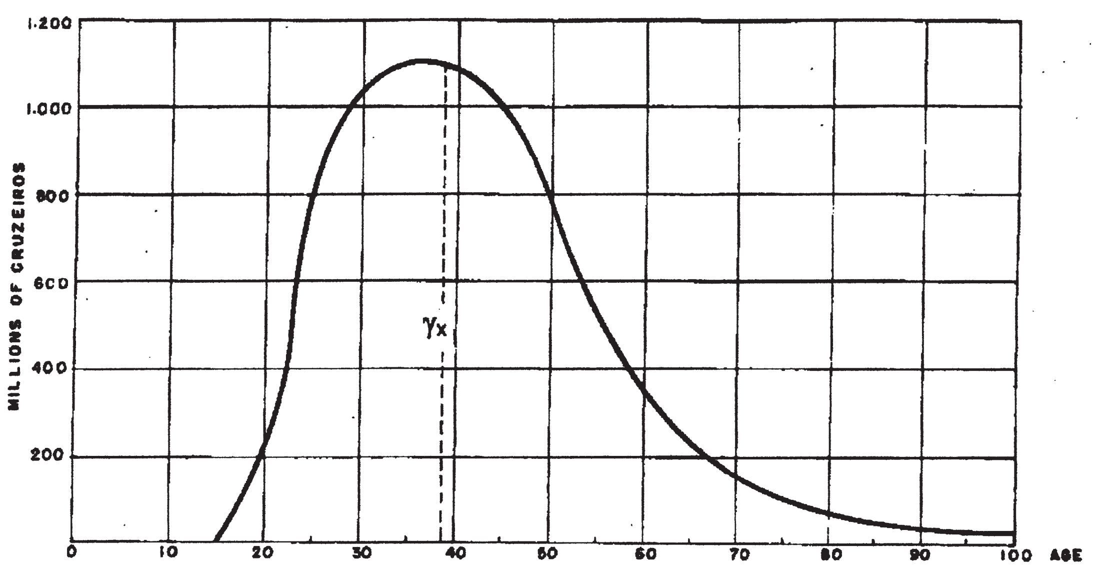

FIGURE-11-

CHAPTER III
COST OF MORTALITY

1) Natural Death and Premature Death in the Moral Field and in the Financial Field

Observations throughout the centuries have shown that pluri-cellular organisms have a limited life. The death of these organisms is normally preceded by phenomena given the global denomination of aging. This aging consists essentially in a decrease of physiological activity and in a modification of the morphological elements making up the body. It reduces the individual's capacity for reproducing the species and makes him less resistant to exterior harmful agents.

Science has not yet definitely established whether aging is part of the pathological processes. This point is of limited interest in this study since an attempt is being made to establish the concepts of natural death and of premature death, independent of the primary causes of death. It therefore suffices to know the data of causes of death and the ages at which death occurs.

Hence it is proposed to give a statistical meaning to premature death. Applying this at each period in a determined region, varying rates will be maintained that are specific for those conditions.

Drawing the distribution curve of the number of deaths in a region, by age, for 100.000 persons supposedly born at the same time, on the basis of survival tables, the age corresponding to the maximum ordinate over age 10 is considered as the normal span of life, according to a denomination introduced by Wilhelm Lexis. By drawing to the left of the maximum ordinate a branch symmetrical to the right descending branch (see Figure 5), a curve is constructed in the form of a bell, of the type of accidental error curve.

This latter curve, according to Lexis, outlines the area of deaths where life was terminated mainly by natural exhaustion of the vital capacity. The remaining area shadowed with lines consists of deaths due to abnormal causes, especially those resulting from insufficiency of sanitary conditions. There therefore represent premature deaths, the majority of which can be avoided by improvement of the health rates. Figures 13, 14 and 15 show regions varying greatly from the viewpoint of health rates and show the corresponding ordinates at the respective ages when premature deaths occur.

A simple analysis of these graphs, constructed for each region, show how, from the financial point of view, priorities should be established for the main activities of public health services in each region.

Theses graphs, however, can and should be drawn as detailed as possible, breaking down each ordinate into the parts applicable to each cause of death. For example, Figures 16 and 17 emphasize the main causes of death in each of those regions. An analysis of these graphs shows the fields in which the control of premature mortality, and consequently of its causes, should be most intense.

In addition to the differences found for the various regions and for the various periods of time, as well as the variations in rates by sex, other aspects require an analysis of mortality for good interpretation of economic characteristics by using the customary indices.

Such investigations have been made of the variations in mortality for urban and rural populations, for populations with a greater or less degree of industrialization, for the professional groups of each specialty of work, in other words, all variations relating to the conditions of human life in modern society. However, the analysis of most interest in the economic studies of mortality are those relating to the characteristics of each of the causes of death, in order to determine the forms of the partial components of the general mortality curve. Each cause is especially characterized by the period of age at which it occurs and by the frequency of the deaths at each of these ages. For each region and for each period of time the limits of those periods and the maximum rate are characteristic of each cause.

LEXIS CURVE OF GENERAL MORTALITY
U.S.A.
1937

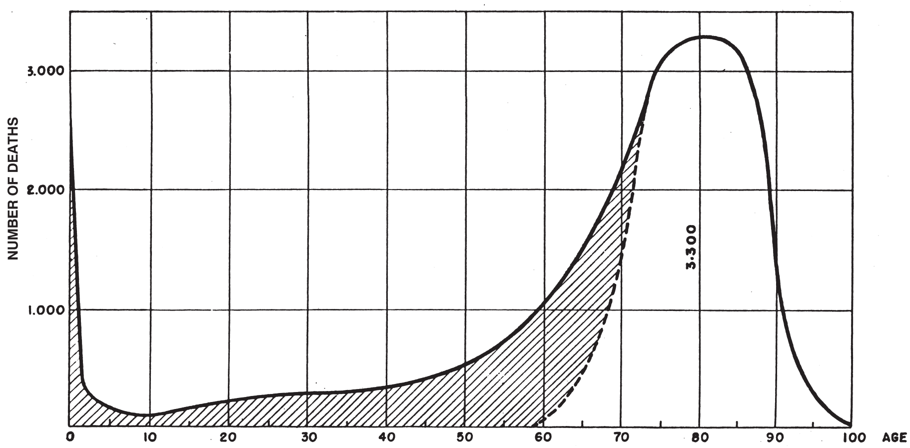

FIGURE -13-

LEXIS CURVE OF GENERAL MORTALITY
SÃO PAULO (BRAZIL)
1940

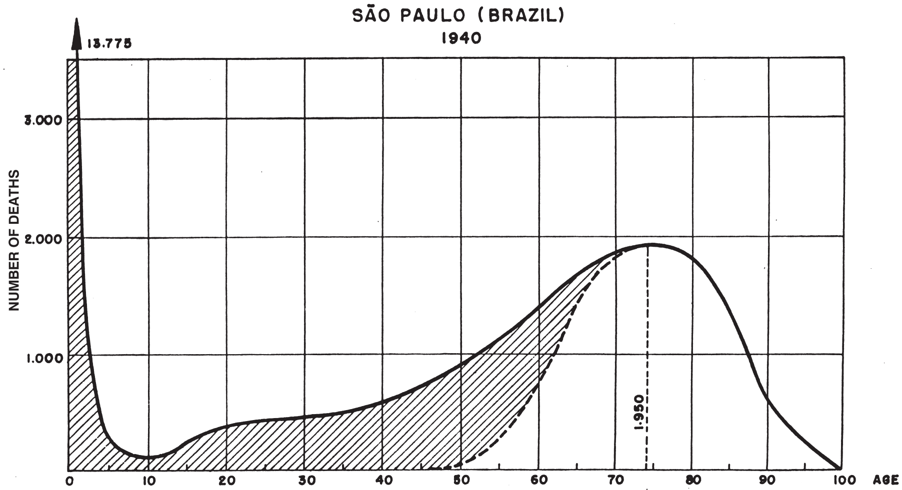

FIGURE -14-

LEXIS CURVE OF GENERAL MORTALITY
SALVADOR (BRAZIL)
1944

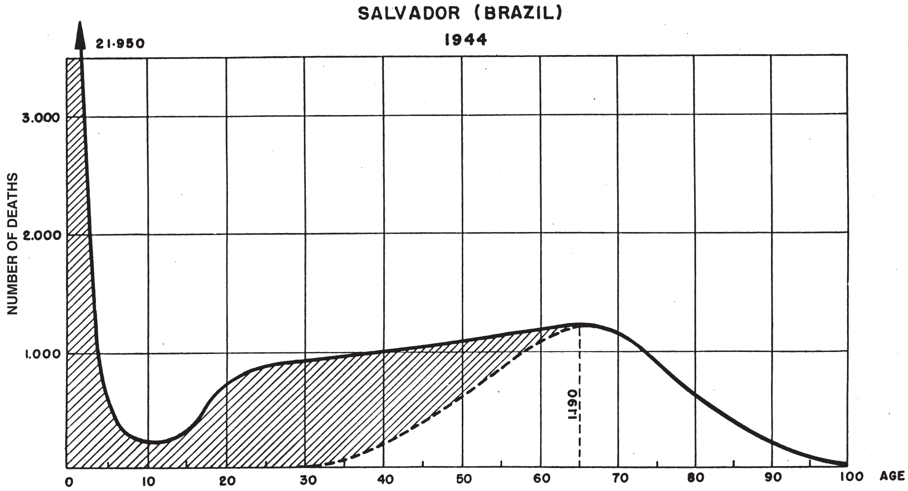

FIGURE -15-

LEXIS CURVE SHOWING THE VALUE OF CAUSES OF MORTALITY

NEW-YORK _ U. S. A.

1937

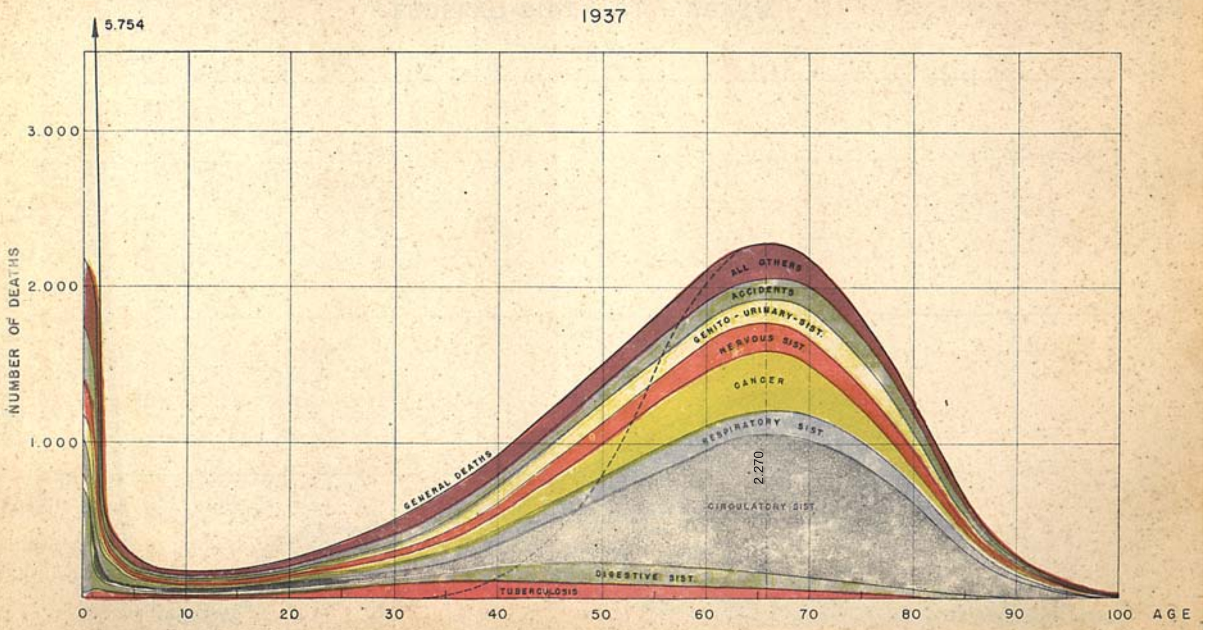

FIGURE -16-

LEXIS CURVE SHOWING THE VALUE OF CAUSES OF MORTALITY

FEDERAL DISTRICT - BRAZIL

1940

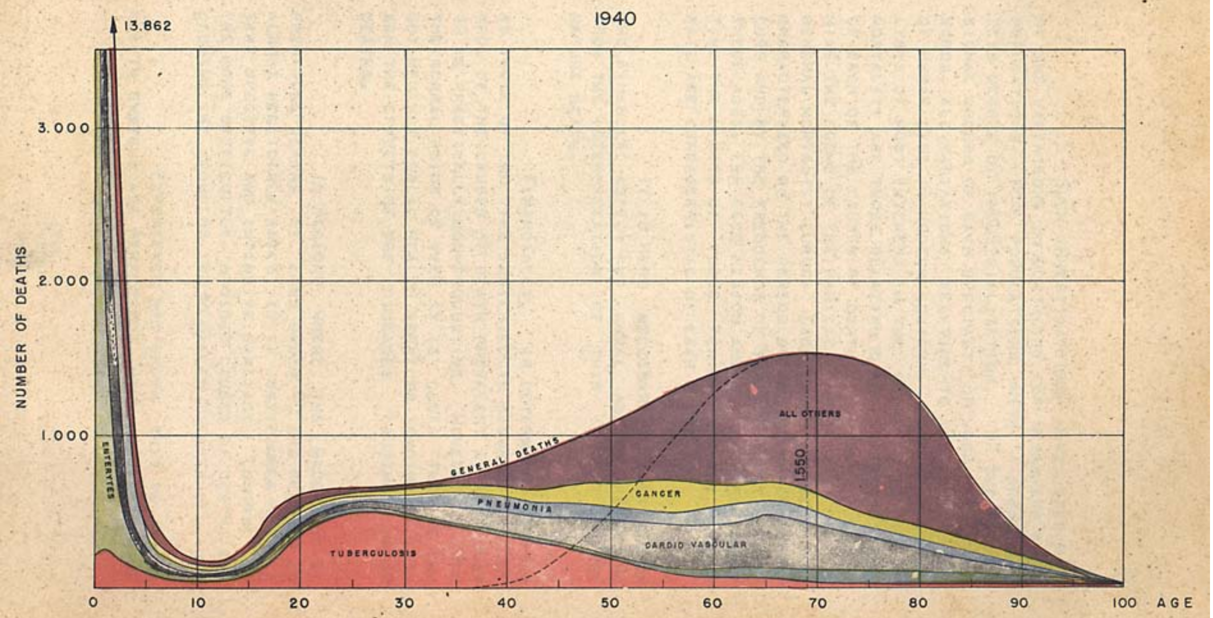

FIGURE -17-

It is here necessary to distinguish the financial aspect and moral aspect resulting from the interpretation of this concept of premature death.

Financially, in determined regions as those of the type indicated in Figure 15, control of the causes of death prevalent at ages over 40 is practically non-productive. However, from the normal point of view it is clear that we can not neglect public health services tending to lessen the effects of the diseases causing those deaths.

In regions where the majority of premature deaths at ages under 40 are reduced to almost negligible rates, it is justificable to undertake specific and intensive sanitary control of the more difficulty avoided causes of death, including the group of the so called diseases of age.

Experience has shown that as their health systems are perfected, many countries have accomplished gradual modification of the curve of general deaths, reducing the area corresponding to premature deaths to almost negligible percentages of the area of deaths considered to be natural.

It is easy to see the economic scope of the reduction in deaths due to causes located in the intervals of ages where ordinates are found partially or totally outside the zone represented by the bell-shaped curve, in the general mortality curve.

In the period from 0 to 10 years, the causes of death are different from those occurring in the period of adolescence and maturity. From 0 to 10 years, the main causes of death are:

a) premature birth
b) congenital debility
c) congenital abnormalities
d) obstetrical traumatism
e) diarrheas and enterites
f) deficiency diseases
g) bronchitis and bronchopneumonia
h) influenza and pneumonias
i) tuberculosis
j) syphilis
k) diphtheria
l) whooping cough

The elimination of death due to these causes is one of the most serious problems of public health in the field of medical-social assistance and in the field of health education.

The group of causes related to the nutritional diseases in general, diarrhea's and entreaties, as well as those in which the factors appear as a highly significant contributing causes, is of the greatest importance in determining the infant mortality rates in countries of a low economic level and deficient means available to public health. These causes, however, have lost their significance during the last few years in countries with a better standard of living and adequate public health equipment.

The causes included in the group of communicable diseases, such as bronchitis, pneumonia, tuberculosis, etc., have been effectively controlled by modern resources available with the chemotherapeutic and antibiotic drugs and have become less significant, especially in countries where their development is hindered by not very severe climate conditions.

Finally, the group of causes most difficult to control includes the usually unavoidable deaths of infants from congenital and hereditary defects.

In a study of "Mortality of Childhood and Adolescence and Survival at the Beginning of the Adult Age" (32), Prof. Giorgio Mortara gives data for four countries, two with low infant mortality and two with high mortality, referring to the two-year period 1935-36, compared in the table below with the same data for the Federal District (Brazil) for the period from 1939 to 1941, which confirms the above statement:

Causes of Death	Death in the first year of life per100 life births				
	Holland	USA	Rumania	Chile	Federal District (Brazil)
Congenital defects, congenital debilities etc.	2.22	2.95	6.03	7.35	2.53
Other causes	1.72	2.69	11.46	17.81	11.25
Total	3.94	5.64	17.49	25.16	13.78

Recent statistics (1946) show much more favorable indices for the United States. For the total population we have the rate of 3.38; 2.33 for the first causes and 1.05 for others. The rate of the white population is 3.18 and for the population of other races, 4.95. For 1950 the average rate for the entire population was 2.92.

Demo-econometric studies are constantly proving that infant mortality occurs especially among children fit to live and is caused mainly by ignorance and poverty, especially in countries with deficient sanitary organization and a low economic and social level.

The application of the theory of natural selection, no matter how respectable, to justify cases of high infant mortality rates, is erroneous and without economic foundation.

In addition to the above causes of mortality, we should consider for the period 0 to 10 years those occurring frequently in infancy, such as:

a) Diphtheria
b) Measles
c) Whooping cough
d) Scarlet fever

The resources of public health have provided very efficient preventive and therapeutic measures for all these causes. Their incidence may be considerably lowered in countries with suitable sanitary organization.

Dublin, in the hypothetical table of mortality which he prepared and published in his study "Health and Wealth" in 1928 and brought up to date in the 1946 edition of the study "The money value of a man" by Dublin and Lotka, based on the study of conditions already attained in New Zealand, established for mortality from 0 to 1 year the rate of 2.500 x 100.000, a value approaching the average verified in the United States for the white population.

The economic aspects of mortality in the period from 0 to 10 years is normally figured by the addition in the cost of production of the adult man and by the reduction of the total production of the population by virtue of its numerical reduction in the economically productive period of life. It is therefore necessary to give some rates relating to mortality at these ages in various countries and in various periods of time.

	Death per 100 survivors at age 0							
	Sweden		USA (WP)		Italy		Federal District (Brazil)	
Ages (completd years)	816 840	931 935	900 902	939 941	881 882	930 932	920 921	939 941
0	16.0	5.0	12.0	4.2	20.0	11.0	15.2	13.9
1 to 4	8.0	1.3	5.6	0.9	16.2	5.6	9.2	9.7
5 to 9	2.8	0.6	1.7	0.4	3.6	1.1	1.7	1.5

In the period from 10 to 40 years, in the stages of adolescence and maturity, there is a predominance of deaths due to communicable diseases and of deaths due to accidents and violence. The latter grow proportionately, especially in the large cities. Principal causes in the group of diseases prevalent in this age group are tuberculosis and typhoid fever.

This study can not examine in detail the specific influences on the economic indices of each of these principal causes.

It has already been pointed out how certain causes of disease show apparently low death rates, since death registration is not yet sufficiently accurate. It is therefore impossible to reach conclusions with correct numerical values on the influence of these diseases in the study of the cost of specific mortality.

In a direct evaluation of the cost of specific mortality, the following method has been adopted (33): determination of the normal evolution of the rate of specific mortality is studied in the hypothesis of the absence of measures indicated by public health technique.

Based on experiments in other countries, the probable evolution in the decline of the mortality rate is established on the hypothesis that adequate sanitary control is established.

Determination of the normal growth of the population of the region where the economic value of death which it is possible to reduce or eliminate is realised.

With these figures, it is calculated the number of deaths in both cases for the various ages during a pre-established period.

Attributing for each age a potential value in money for the deceased, the balance of the number of deaths in both hypothesis will determine the economic value of the reduction of avoidable mortality.

A posteriori, it has been also attempted the verification of the economic results of public health services by means of similar but less precise studies.

As an example of the latter, we transcribe part of the table published by J. Hanlon (34).

After age 40, the predominant causes of death are the diseases of age, the majority or most significant being the degenerative and neoplastic diseases such as arteriosclerosis and cancer.

In this phase, there is a considerable reduction in the economic importance of the results obtained by improvements in public health.

However, health conditions such as those shown in Figure 15 demonstrate that between the ages of 40 and 50 many deaths are not caused by the so-called diseases of old age. These deaths, however, will be automatically eliminated by the general measures adopted in the public health systems for the control of diseases prevalent during adolescence and maturity.

Table - Estimated Saving in Lives and Their Value in Millions of Dollars During 1946 over 1900 as a Result of Public Health Measures Taken Against Certain Diseases, USA

Approximate Mid-Value of Lives in Age Group	$1,500	$4,500	$11,000	$18,000	$22,000	$21,000	$20,000	$18,000	$13,000	Totals
Age Groups	under 5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	0-45
Typhoid & Paratyphoid										
Lives saved	1,971	1,489	4,161	6,789	6.263	4,599	5,081	3,022	3,022	36,397
Estimated value	$3.0	$6.7	$45.8	$122.2	$137.8	$96.6	$101.6	$54.4	$39.3	$607,4
Diphtheria										
Lives saved	34,562	14,471	3,840	890	612	223	334	111	111	55,154
Estimated value	$51.8	$65.1	$42.2	$16.0	$13.5	$4.7	$6.7	$2.0	$1.4	$203.4
Diarrhea & Enteritis										
Lives saved	165,200	1,548	774	387	967	774	967	967	1,161	172,745
Estimated value	$247.8	$7.0	$8.5	$7.0	$21.3	$16.3	$19.3	$17.4	$15.1	$359.7
Measles, Scarlet Fever, Pertussis										
Lives saved	37,364	5,057	1,545	749	421	328	375	187	187	46,213
Estimated value	$56.0	$22.8	$17.0	$13.5	$9.3	$6.9	$7.5	$3.4	$2.4	$138.8
Tuberculosis										
Lives saved	17,444	3,355	4,473	14,313	29,744	29,297	29.744	19,680	20,351	168,401
Estimated value	$26.2	$15.1	$49.2	$257.6	$654.4	$615.2	$594.9	$354.2	$246.6	$2,831.4
TOTAL										
Lives saved	256,541	25,920	14,793	23,128	38,007	35,221	36,501	23,967	24,832	478,910
Estimated value	$384.8	$116.7	$162.7	$416.3	$836.3	$739.7	$730.0	$431.4	$322.8	$4,140.7

2) Method of Determining the Cost of Death

A) General Considerations

In the method suggested by this study, an attempt is made to determine:

- average individual annual consumption, for each age and due to premature death;
- total production lost for each group of age, in the period between the age at which death occurred and the normal Lexis age, for the region under consideration;
- specific total annual consumption augmented at each age because of premature death;

and finally

- reduced total consumption, by virtue of premature deaths, for each age group, in the period between the age at which death occurred and the normal Lexis age for the region under consideration.

B) Number of Premature Deaths

It should first be recalled that the number of premature death is obtained by the Lexis curve, using values γ_x (Figure 5), the ordinates of the curve of general deaths or the difference between their values and those of the ordinates of the curve marking the cases taken as deaths due to natural case.

The Lexis curve should be drawn on the basis of survival tables calculated for the period of the study in the region under consideration.

In the method suggested, it is admitted that the values of π_x and γ_x for the period of the study are maintained approximately constant for the period ξ_L corresponding to the normal Lexis age in the region under consideration. When more accuracy is desired, we can establish the law of variation of π_x and γ_x with time, in accordance with the economic development forecast for the region under consideration.

In the suggested method, it has also been admitted that the normal Lexis age in the region under consideration is maintained constant during that period of time. As has been shown, this is not really the case. However, this simplification is justified by estimates made with rates and coefficients obtained in a not very strict approximation.

In studies of greater precision, calculations can be made with the value of x_L varying according to the time and does not present analytical difficulties, but depends only on the ability to construct sure hypotheses on the progressive evolution to be obtained from the health rates.

To construct a more significant health rate, the normal Lexis age x_L could be combined with its determining frequency of deaths.

We could therefore adopt as the health rate for a region the product $Nx_L.x_L$, where Nx_L is the number of deaths found on the Lexis curve for the normal age x_L.

A more complete interpretation of the nosological conditions of a region could be obtained by combining the above rate with the “Discratic Index” (35). The latter is obtained by the relation for a certain year between the infant mortality rate, per thousand live births, and the average ages of deaths in the population under consideration.

This rate is rarely less than 1. Sanitary and health conditions of a region are considered very good when the rate is less than or equal to 1.5; good when between 1.5 and 2.5; almost good, between 2.5 and 3.5; almost bad, between 3.5 and 4.5; bad, between 4.5 and 5.5; and very bad from 5.5 up.

C) Annual Specific Individual Consumption on Account of Premature Death

The curve representing annual specific individual consumption due to premature death occurring at age x, where ordinates are represented by γ''_x, can not be determined with absolute accuracy owing to the absolute lack of statistical data directly related with this coefficient.

However, rough estimates have already been considered, taking into account this figure which is quite significant to the cost of premature death.

In this study it has been attempted to drawn, in a empirical fashion, according to the observation in specific population groups, a curve to serve only to improve the suggested method but for which the numerical values of the ordinates do not represent indices of reasonable approximation. The need for determining these coefficients for each period of time and each region, in order to obtain the cost of death, would not impart much value to the precision perchance attained for the data presented in this study.

Figure 18 shows the form of the curve for the ordinate of γ''_x, in accordance with the interpretation given in this work to the variation of this coefficient with the age at which premature deaths occur.

D) Total Potential Production Lost Annually on Account of Premature Deaths

The curve representing total potential production lost annually at each age c, owing to premature deaths, where ordinates are represented by tc, is obtained by calculating the values of the formula:

$$(4)\quad \tau_{x_i} = \frac{Y_{x_i}.N}{100.000} \cdot \sum_{x_i}^{x_L} \pi_x$$

where N represents the total number of deaths in the population of the region under consideration, in the period of the year for which the general curve of Lexis deaths was determined.

The first factor

$$\frac{Y_{x_i}.N}{100.000}$$

indicates the number of premature deaths at age x_i in the region during the year in question. The second factor

$$\sum_{x_i}^{x_L} \pi_x$$

gives total production of each prematurely dead individual at age x during the period x_L - x_i, between the age of death and the normal Lexis age x_L in the region under consideration.

ANNUAL SPECIFIC INDIVIDUAL CONSUMPTION ON ACCOUNT OF PREMATURE DEATH

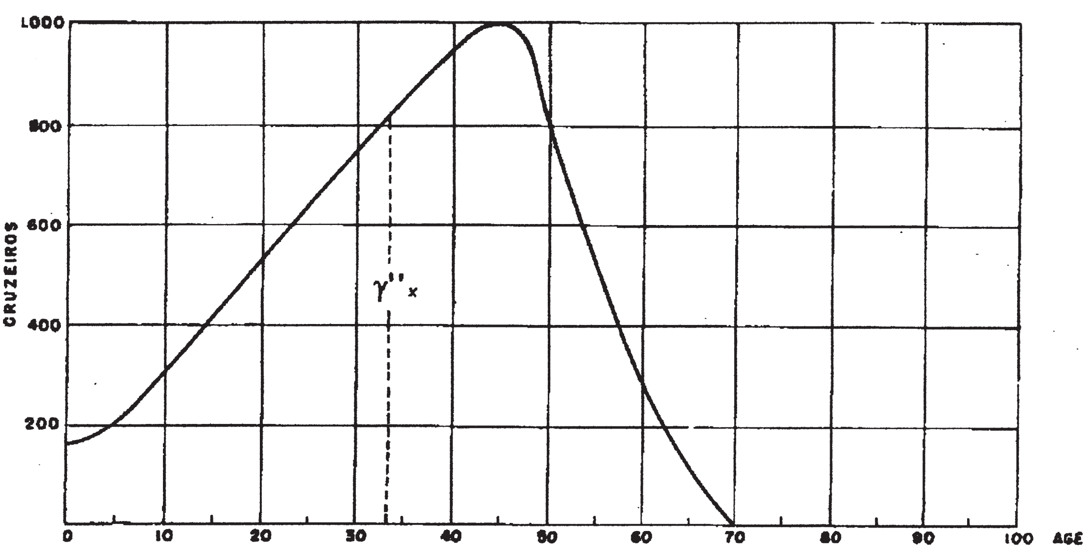

FIGURE -18-

Figure 19 shows the form of this curve of ordinate t_x, drawn on the basis of values taken for curve of Figure 5 and those of the curve of ordinate p_x in Figure 1, and the value of N as approximately 700.000.

E) Specific Total Annual Consumption Increased on Account of Premature Death

The curve representing specific total annual consumption augmented at each age, by virtue of premature deaths, where ordinates are represented by e_x, is obtained by calculating the values given in formula:

$$(5)\quad \varepsilon_{xi} = \frac{Y_{x_i}.N}{100.000}.\gamma'' x_i$$

the elements used have been described above.

Figure 20 shows the forms of this curve of ordinates e_x, drawn on the basis of values given to the curve of Figure 5 and those of the curve of ordinates in Figure 18, and the value of N as approximately 700.000.

F) Total Potential Consumption Reduced Annually on Account of Premature Deaths

The curve representing total potential consumption reduced annually at each age x, by virtue of premature deaths where ordinates are represented by l_x, is obtained by calculating the values given in the formula:

$$(6)\quad \lambda_{xi} = \frac{Y_{x_i}.N}{100.000}.\sum_{x_i}^{x_L} \gamma_x$$

the elements thereof have been described above.

Figure 21 shows the form of this curve of ordinates l_x, draw on the basis of values given to the curve of Figure 5 and those of the curve of ordinates in Figure 2, and the value of N as approximately 700.000.

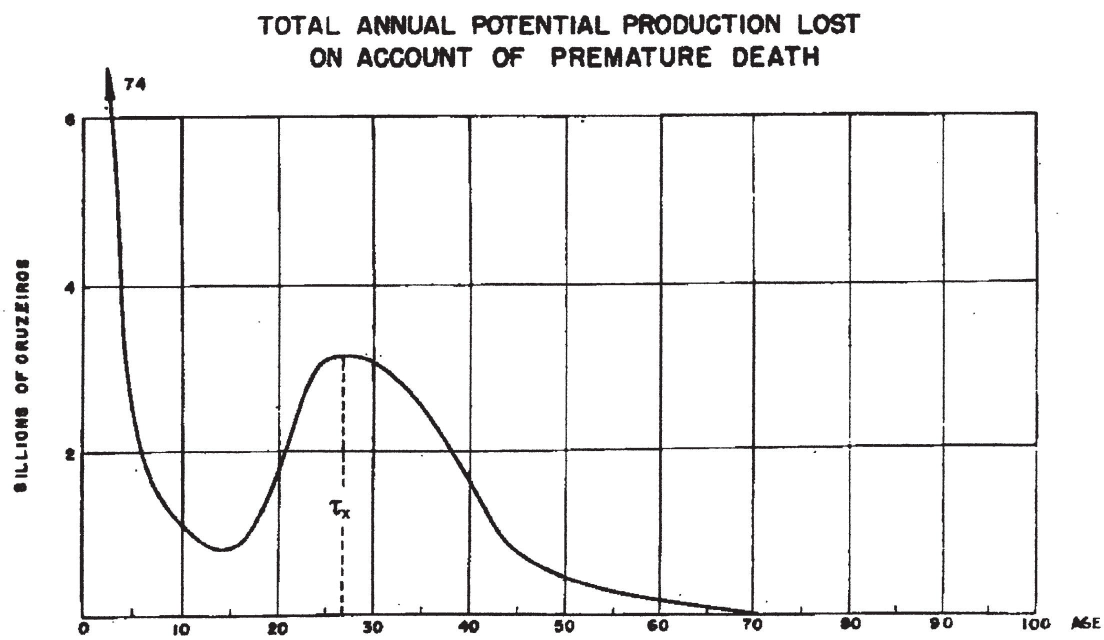

FIGURE -19-.

TOTAL ANNUAL SPECIFIC CONSUMPTION INCREASED ON ACCOUNT OF PREMATURE DEATH

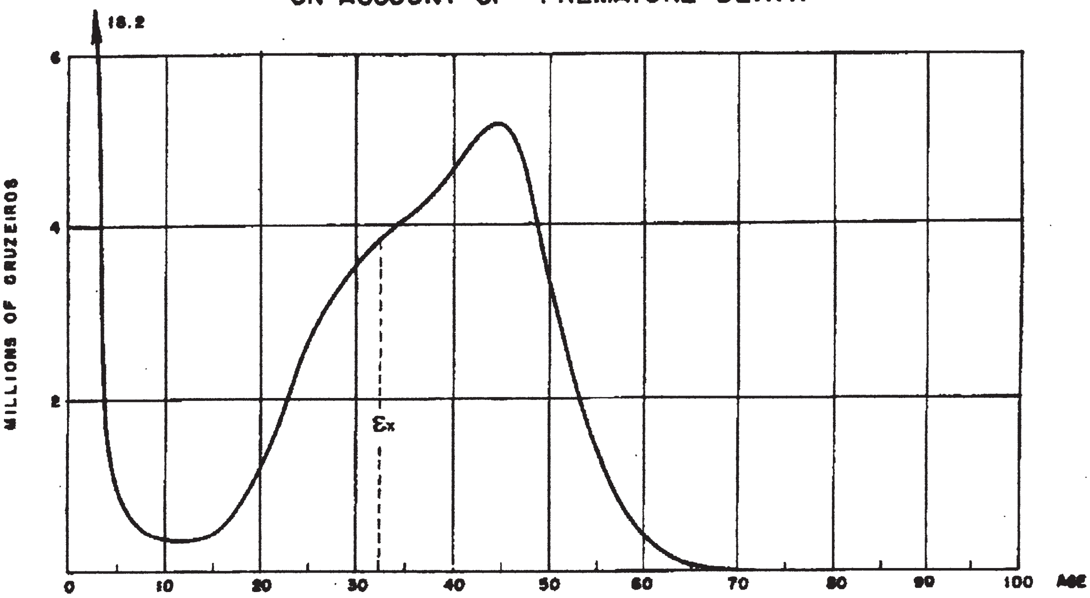

FIGURE -20-

TOTAL ANNUAL POTENTIAL CONSUMPTION REDUCED ON ACCOUNT OF PREMATURE DEATH

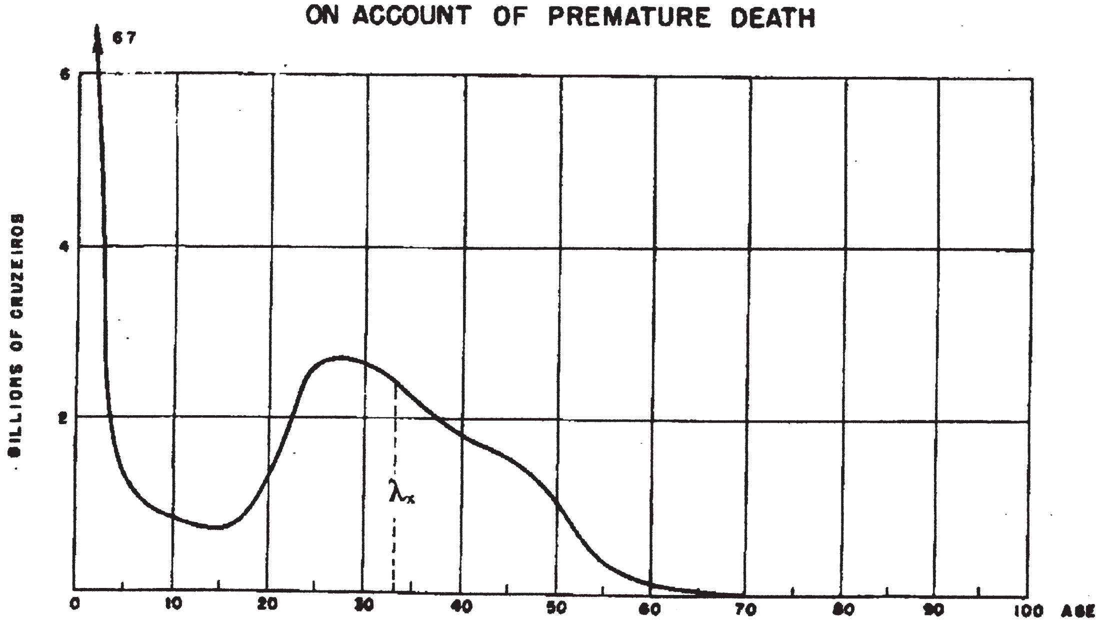

FIGURE -21-

CHAPTER IV
CONCLUSIONS

1) The Value of Health and Some Representative Rates

A) General Considerations

From this study we may deduce general formula for the economic value of health either by grouping separately the figures due to morbidity and mortality, or grouping then in such a manner as to obtain separately the influence of those two fundamental factors on the total reduction of production and on the total increase of consumption.

We can also examine the value corresponding to the year when the study was made as well the potential value, taking into account lost future production and economized future consumption by virtue of the premature deaths occurring during the year being studied.

Also, as has been described, these calculations of potential values may be carried on with greater precision by fixing for $\pi\chi$, $\gamma\chi$, χ_L, a law of growth as time goes on. For this purpose it is sufficient to substitute those values in the formula presented by the following:

$$(7)\quad {}^1\pi_x=\pi_x\times F_1(x) \qquad {}^1\gamma_x=\gamma_x\times F_2(x) \qquad {}^1x_L=x_L\times F_3(x)$$

where $F_1(x)$, $F_2(x)$ and $F_3(x)$, are formulas which provide the coefficients relating to time for calculation of the variation of the value of π_x, γ_x and x_L, in the future periods.

As a primary approximation, we may use $F_1(x)$, $F_2(x)$ and $F_3(x)$, expressions of the form:

$$(8)\quad F(x) = [1+r\,(x-x_i)]$$

The values of rates r, is fixed in each period for each region; and x, varying from x_i, - lower limit of the summations of the respective formulas, corresponding to using the values of p_x, g_x and x_L, for the year being studied, - to x_n, upper limit in the summations of the respective formula.

B) Balance of Potential Values of Production and Consumption of a Population

From the above explanations, it is clear that the following formula can express the balance of the potential value of production and consumption of a population composed of ages shown by the curve of p_x - Figure 3. where S_p, represents the balance of the potential values of production and consumption; x_i, represents each group of age under consideration; x_m, represents the average life for each age under consideration, taken on a hypothetical table fixed in each region for this purpose; and r_1 and r_2, the rates of growth of p_x and g_x in the course of time.

$$(9)\quad S_p=\sum_{i=0}^{i=\omega}\{p_{xi}\cdot\sum_{x_i}^{x_m}\pi_x[1+r_1(x-x_i)]-\sum_{i=0}^{i=\omega}\{p_{xi}\cdot\sum_{x_i}^{x_m}\gamma_x[1+r_2(x-x_i)]$$

The remainder represent values already described.

C) Total Influence of Morbidity on the Economic Value of Heath

The formula for calculation of the total influence of morbidity on the economic value of health, in accordance with this study, may be expressed in the following manner:

$$(10)\quad V_m=\sum_{i=0}^{i=\varpi}[(\frac{Z_{x_i}}{300}\cdot p_{xi}\cdot\pi_{xi})+(\frac{Z_{xi}}{300}\cdot p_{xi}\cdot\gamma'_{x_i})]=\sum_{i=0}^{i=\omega}[(\frac{Z_{x_i}}{300}\cdot p_{x_i})(\pi_{xi}+\gamma'_{xi})]=\sum_{i=0}^{i=\omega}(\sigma_{x_i}+\varphi_{xi})$$

where V_m represents the value of the total influence of morbidity on the economic value of health. The remainder have the values described above.

D) Total Influence of Mortality on the Economic Value of Health

The formula for calculation of the total influence of mortality on the economic value of health, in accordance with this study, may be expressed by the following formula:

$$(11)\quad V_{d\alpha} = \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \cdot \pi_{x_i} + \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \gamma''_{x_i} - \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \gamma_{x_i} = \sum_{i=0}^{i=\omega} \left(\frac{Y_{x_i}.N}{100.000}\right)(\pi_{x_i} + \gamma''_{x_i} - \gamma_{x_i}) = \sum_{i=0}^{i=\omega} (\tau_{x_i} + \varepsilon_{x_i} - \lambda_{x_i})$$

$$(12)\quad V_{dp} = \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \cdot \sum_{x_i}^{{}^1x_L} {}^1\pi_x + \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \gamma''_{x_i} - \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \cdot \sum_{x_i}^{{}^1x_L} {}^1\gamma_x = \sum_{i=0}^{i=\omega} \left(\frac{Y_{x_i}.N}{100.000}\right)\left(\sum_{x_i}^{{}^1x_i} \pi_x + \gamma''_{x_i} - \sum_{x_i}^{{}^1x_L} {}^1\gamma_x\right) = \sum_{i=0}^{i=\omega} (\mathrm{T}_{x_i} + \varepsilon_{x_i} - \Lambda_{x_i})$$

where Vda represents the value for the year under study, for the total influence of mortality; Vdr represents the potential value of the total influence of mortality; Tci the potential value of production lost through premature deaths occurring at age ci; and Dci the potential value of consumption reduced owing to premature deaths at age ci.

The remainder have the values descrived above.

E) Total Production Lost by Virtue of Morbidity and Mortality

Taking into consideration the formula already established, we may express by the following formula the values of total production lost by virtue of morbidity and mortality.

$$(13)\quad P_\alpha = \sum_{i=0}^{i=\omega} \frac{Z_{x_i}}{300} \cdot p_{x_i} \cdot \pi_{x_i} + \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \pi_x = \sum_{i=0}^{i=\omega} (\sigma_{x_i} + \tau_{x_i})$$

$$(14)\quad P_p = \sum_{i=0}^{i=\omega} \frac{Z_{x_i}}{300} \cdot p_{x_i} \cdot \pi_{x_i} + \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \sum_{x_i}^{{}^1x_L} {}^1\pi_x = \sum_{i=0}^{i=\omega} (\sigma_{x_i} + \mathrm{T}_{x_i})$$

where P_a, represents the value, during the year under study, of total production lost by virtue of mobility and mortality; P_p, represents the potential value of production lost for the same reasons; and the remainder have the same values as described previously.

F) Total Consumption Augmented Because of Morbidity and Mortality

Taking into consideration the formula already established, we may express by the following formula the values of total consumption augmented because of morbidity and mortality.

$$(15) \quad C_{\alpha} = \sum_{i=0}^{i=\omega} \frac{Z_{x_i}}{300} \cdot p_{x_i} \cdot \gamma'_{x_i} + \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \cdot \gamma''_{x_i} - \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \gamma_{x_i} = \sum_{i=0}^{i=\omega} (\varphi_{x_i} + \varepsilon_{x_i} - \lambda_{x_i})$$

$$(16) \quad C_{p} = \sum_{i=0}^{i=\omega} \frac{Z_{x_i}}{300} \cdot p_{x_i} \gamma'_{x_i} + \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \cdot \gamma''_{x_i} - \sum_{i=0}^{i=\omega} \frac{Y_{x_i}.N}{100.000} \cdot \sum_{x_i}^{{}_1x_L} {}^{1}\gamma_{x} = \sum_{i=0}^{i=\omega} (\varphi_{x_i} + \varepsilon_{x_i} - \Lambda_{x_i})$$

where C_a, represents the value for the year under study of total consumption augmented because of morbidity and mortality; C_p, represents the potential value of consumption augmented for the same reasons; and the remainder have the same values as those described previously.

G) Representative Rates

In addition to the rough values of formula 10, 11 and 12, or to the sum of these three values, rates may be determined for the economic value of health. In this study, the following are suggested:

$$(17) \quad \rho_{\alpha} = \frac{Vm + Vd_{\alpha}}{Sp}$$

and

$$\rho_{d_p} = \frac{Vd_p}{Sp}$$

which may be obtained by dividing the values given in formula 10 and 11, and those of the formula 12, respectively, by the values given in formula 1 and 9.

2) Organization of Health Systems Based on the Value of Health

Recognition of the Rights of Man to enjoy a state of health such as that defined by the WHO suffers no restriction and has already attained written approval in International Agreements and in the Constitutions of many countries.

This study has emphasized the binomial Production-Well Being and has permitted taking up the problem of health from a material and concrete point of view. In the planning, hierarchical arrangement, and structure of health services, the governing powers should face this problem, not from the angle of mere application of budgetary allocations, but as the investment of capital in a safe and profitable field.

The extreme diversity of the political and economic structure of the various countries creates the corresponding need for adapting to each case the conclusions which may be drawn from the special angle proposed by this study. The main principles, however, will always be valid, whatever the result of concrete application. The disorganization and poor results generally the case with national public health organizations are mainly due to a lack of recognition of the economic value of health.

In analyzing the present organization of the various national public health systems we gain the first impression that in the diversity of those systems little can be found to permit of generalizations.

However, in the first place, there is the prime objective common to all systems: the well being of the population. This objective gives all systems a multitude of points of contact since, in planning, the objective determines the processes and techniques applicable in the proposed organization.

The scope of that objective permits the innumerable special agencies engaged in its realization. Its magnitude causes men to demand always more than those agencies can usefully produce.

"The desire to attain a legitimate purpose is of itself unlimited, but the desire for a means to this purpose will always be proportional thereto. Hence, a doctor will never be too desirous of curing his patient, although he may not give the greatest possible amount of drugs, but only the amount necessary for cure".

The purpose is desirable of itself, and however more the thing is desired of itself, more so is it taken as the purpose.

The forming of a population of healthy men is the greatest ideal of a nation, both from the moral and social meaning and because of the economic value it represents.

Jules Amar (36), in his book on the "Physiological Organization of Work", points out the value of man in the economy of a country and quotes the words with which Charles Duplin initiated one of his admirable courses in the Conservatory of Arts and Crafts in Paris:

"We have concerned ourselves greatly with the perfection on machines, of instruments and of the material tools used by the worker in the mechanical arts. We have concerned ourselves very little in perfecting the worker himself. However, even though he were considered as merely an instrument, a tool, a motor, he should be given first place among all the instruments, among all the mechanical agents, because he has the unappreciable value of being an instrument which observes itself and corrects itself, a motor which stops of its own accord, which moves by its own intelligence and which perfects itself greatly by thinking and not less by work".

After admitting and recognizing the economic value of health, national governments could then give due priority to the problems involved, outline the fields of responsability, avoiding duplication of effort among the various sectors of its political structure, and above all, combining the various fields of public power which, by definition, aim at favoring the well-being of man.

C E.A. Winslow (37), in his noteworthy study on "The Cost of Disease and the Price of Health", quotes Farnsworth, whose concepts present the above perfectly: "The complete success of any public health program is subordinated to the parallel and coordinated study of the social, educational, and economic problems in the region under consideration. Better health is a necessary corollary of better education and higher economic and social level. The efforts of all interested agencies in the region should be joined in a common program".

This necessity to coordinate the various activities in attaining a common purpose involves the national character of the problem of health. This does not mean that the task should be executed by agencies of the central power. This subject, well known by students of sanitary administration, does not belong within the natural limits of this study, but requires reference at the moment. The almost infinite variety of the types of organization of public health work is a consequence of the respective disordered growth, of interference's a political nature, of technical deficiencies, and many other factors causing disturbance of the solid basis of man's recuperation for productivity and consequent realization of his own well-being, that of his family and of the state.

The primary objective is common to all public health systems, and they all have common basic elements and principles of structure.

The basis elements have already been pointed out in this study, when examination was made of the various influences of morbidity and of mortality on questions connected with production and consumption.

The principles determining a good public health system are those universally adopted in the technique of planning. Although these principles are recent they have provided such good results to the organization of the modern world, that they are being adopted in all fields of activity of all civilized nations.

The meaning of planning is so ample that it is difficult to define this technique which "is the group of principles orienting and disciplining the activities of human work; of rules for most advantage use of the capital and of the human labor expended; and of the rules for application of these general principles and regulations, and for control of results obtained" (38).

The structures of public health systems, planned according to this principle, must have points in common in the purposes of their agencies and their constitution.

In the first place, the basic elements of all systems are: personnel (public health workers, doctors, sanitary engineers, nurses, etc.) and public health units (health centers, dispensaries, hospital, etc.). They present little difference from the various present systems of public health.

The forms and processes of work, both of preventive medicine and of curative medicine, also do not present great differences, when adapted to the conditions of each region.

The apparent diversity of public health systems of the various nations results precisely from the identical form of interpreting these basic elements applied to the great variety of health conditions, of social conditions, of cultural levels and of economic levels occurring in the regions of the world, determining forms of articulation and of coordination applicable to each region.

Where differences exists which do not result from the above factors, these should be mainly considered as poor application of the technique of planning, poor organization of the fields of activities for establishment of the scale of priorities, defective limitation of powers in the distribution of responsability to the various administrative units of the the country, and finally, insufficiency of resources in face of the needs of the region.

In concluding this study dealing with the economic value of health and demonstrating the possibility of establishing highly objective criteria for fixing national health plans according to the scale of activities to be developed in each region, we wish to point out, once again, that there is no doubt that public funds find no better reproductive application than when used to improve the health and education rates of the people.

The economy of a nation is measured by the degree of development of its technical labor organization and by the indices of health and instruction of its people.

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