Colección

Statistical Methodologies

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Methodology for the Calculation of Mortality Indicators

EDITORIAL

In demography, the concept of mortality is used when death or the action of death occurs on the members of a population.

Death is a risk to which a person is exposed throughout life. Obviously, it is a one-time event, so the entire population is exposed to the risk of dying.

In fertility, on the other hand, only part of the population is exposed to the risk of having children. Under this circumstance, a woman of childbearing age, that is, between 15 and 49 years of age, may have several children in her lifetime.

There are three components that determine changes in the size and composition of a population: mortality, fertility and migration. Each plays an important role in population dynamics. Thus, mortality is part of the population outflows, while fertility is part of the inflows, and migration can provide inflows and outflows through immigration and emigration, respectively.

The importance of studying mortality derives from aspects related to its levels, its impact on the age and sex structure and its causes, which are frequently used as indicators of the state of health and living conditions of the population. Likewise, its study is important in the analysis of the components of demographic dynamics, and in the comprehensive understanding of the change in the structure and magnitude of the population.

Before addressing the issue related to the measurement of mortality, it should be noted that its calculation is related to the sources of information used, which generally come from administrative records, population censuses and surveys.

The calculation of mortality gives rise to two types of estimates: measurement by the direct method and that referring to indirect techniques. These measurements have the advantage of carrying out mortality studies related to socio-economic variables that are not always obtained with data from vital statistics. In this opportunity the direct measurement of mortality is discussed.

CONCEPTUAL ASPECTS

The topic suggests the familiarisation of terms to be used in this methodology document. Let's see:

<u>Age in completed years</u>: This is the age a person reached on his or her last birthday, even if he or she is about to turn one year older. This concept is also used to refer, for example, to the duration of marriage.

<u>Age in exact years:</u> This concept expresses a more precise quantity. It indicates the age measured in years and fractions of a year. For example, a person born on 1 January 1970 is exactly 25.5 years old on 30 June 1995. Consequently, a person is exactly 25 years old for only one day in a lifetime, whereas he/she is 25 completed years old for one year.

<u>Time lived</u>: This concept refers to a period of time and a specific population. In theory, to calculate it, the time of each individual who was part of a population during a given period must be counted and added up. For example, a person who lived the entire year within a study population contributes "one" year to the time lived by that population. Whereas a person who lived at the beginning of the year and dies on 30 June of the same year contributes "0.5". If there were no births, deaths or migrations in a population during a year, the time lived by that population would be equal to the number of its inhabitants.

<u>Cohort</u>: A group of individuals who have experienced a similar event in the course of the same period of time. For example, the birth cohort of 1950 refers to people born in that year. This type of cohort is also called a generation.

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SOME DEMOGRAPHIC MEASURES

In order to analyse demographic facts, some indicators are constructed that allow studying their incidence and behaviour in a comprehensible way.
These relative measures can be classified according to the type of data they relate to:

Ratio: quotient in which the numerator and denominator belong to different categories; for example, the masculinity index.

Proportion: A quantity that represents a part of the whole. It is calculated by using the same type of category in the numerator and denominator. For example, the proportion of deaths of children under one year of age out of the total number of deaths.

Percentage: Proportion expressed as a percentage of the total. For example, the percentage of deaths of children under one year of age out of the total number of deaths.

Rate or coefficient: This refers to the relative frequency with which certain events occur in the population during a given time, usually a year. However, the word rate has acquired a broader meaning and is used to designate indicators obtained through complex operations or even as a synonym for ratio, proportion or percentage.
Often, a constant, 100 or 1000, is used to give meaningful values.

In demography, a distinction is made between crude and specific rates. The former refer to the entire population as a whole, while specific rates refer to subgroups of the population, such as those calculated by age group and sex.

It is interpreted as the frequency of occurrence of a demographic event relative to the population. For example, if the mortality rate of the male population aged 15-19 years in Peru between 1995-2000 is 0.00126, we can say: In the Peruvian population, 1.26 persons aged 15-19 years died for every thousand residents in the country.

Probabilities, on the other hand, have in the denominator, the population that is initially exposed to the event occurring to them. It is interpreted as the proportion of the population that suffers an event during the course of a year. The probability of death indicates the relative frequency with which members of a population die during a year. For example, the probability of dying between the ages of 15 and 20 indicates the proportion of people who turn 15 and die before their 20th birthday.

SOURCES OF INFORMATION FOR MEASUREMENT

The most important basic source for the demographic analysis of mortality is the vital registration system, which contains the deaths registered according to some characteristics such as age, sex, cause of death, among others.

These data alone are insufficient to say anything about the level of mortality. It is necessary to have a reference population in order to construct some relative measure. This information is taken from the Population Census when the date for which mortality is being measured is very close to the census survey (after adjustments to move the population to the desired time and even after some evaluation work to correct the estimated omission). When a population census is not available at the time when mortality is to be studied, data from a population projection or estimates from the nearest population census can be used.

Before the data are used, they should be examined, because death statistics are often affected by factors such as under-registration, late registration, misreporting of age or misreporting of cause of death. Population censuses have omissions and misreporting of age, among other errors.

In the event that the information provided by these natural sources on mortality analysis is not very reliable, or does not exist, or is affected by various factors that reduce its quality, there is a series of estimation techniques that use data from the population censuses and specialised demographic surveys.

MORTALITY MEASUREMENT

El estudio de la mortalidad se realiza a través de indicadores que permiten medir su incidencia y comportamiento. De un lado, es posible su estudio con datos absolutos, es decir, de los hechos ocurridos, en este caso, defunciones y la población expuesta al riesgo de morir.

De otro lado, su estudio se basa en medidas relativas, que pueden ser expresadas en Tasas. A continuación, se presentan los indicadores más utilizados:

The crude death rate is the most widely used indicator for measuring mortality. It is derived from the ratio of the number of deaths occurring in a given period of time (usually a year) to an estimate of the population at risk of dying in the same period.

The population estimation involves calculating the time lived by the population during that period. Given the difficulties involved in its calculation, the population is estimated in the middle of the period. Then:

$$d^Z = \frac{D^Z}{N^{30-VI-Z}} * 1000$$

Where:

d^z is the Crude Mortality Rate

D^z are Deaths occurring in year z

$N^{30-VI-z}$ the estimated population as of 30 June of year z

The rate multiplied by a thousand represents the relative frequency with which deaths occur in a population during a year.

Example

$$d^{1999} = \frac{158500}{25232226} * 1000 = 6.28$$

Thus, it can be stated that in 1999, slightly more than 6 persons died for every 1,000. Normally, there are factors that produce random variations in the number of deaths recorded in vital statistics. They must be smoothed out by calculating the numerator as an average of the deaths of three consecutive years, one year before, one year after and the year for which the crude death rate is to be calculated, which is expressed as follows:

$$d^Z = \frac{1/3 * (D^{Z-1} + D^Z + D^{Z+1})}{N^{30-VI-Z}} * 1000$$

As mortality is a "process of departures", the crude mortality rate expresses the relative annual reduction of a population, which is attributed to the deaths of a part of the population.

This measure is useful to understand the evolution of mortality in a country over short periods of time. However, it does not allow comparisons to be made between different populations and is not useful when trying to make a statement about the level of mortality. It should also be noted that it is affected by the age structure of the population.

The values of the crude mortality rate vary between 4 and 30 per thousand. When mortality is very high, the rate usually has high values. But it often happens that in countries with low mortality, there are cases of high mortality.

MORTALITY BY SEX AND AGE

As indicated above, mortality varies with age. Also, in the case of variables such as sex, causes of death, place of residence, and socio-economic variables such as level of education, socio-economic stratum, poverty, among others, allow us to show the differentials in mortality.

These differentials, when analysed by social strata, show that mortality in the lower social classes is higher than in the upper classes. It is also higher in the uneducated population than in the population with some years of education. Rural mortality is higher than urban mortality. And thus, a distinction could be made according to the variable with which it is analysed.

MORTALITY RATES BY AGE

One of the most important variables in the study of the population is age. All demographic variables without exception, have a different behaviour through the ages. In the case of mortality, the study begins with the calculation of age-specific rates,

which, when analysed, show how the age structure of the population affects the behaviour of the crude mortality rate.

The rates here serve to differentiate mortality behaviour at different ages or to analyse changes in mortality over time. It is also important for the construction of indices, such as life expectancy at birth, which is not affected by the age structure of the population.

Age-specific mortality rates are also called central rates. They are calculated with the following formula:

$${}_nm_x{}^Z = \frac{{}_nD_x{}^Z}{{}_nN_x{}^{30-VI-Z}} * 1000$$

Where:

${}_nm^z{}_x$ is the mortality rate for age group x to x+n-1 in year z

${}_nD^Z{}_x$ is the number of deaths occurring in year z of persons aged x to x+n-1

${}_n{}^{30-VI-Z}{}_x$ is the population in age group x to x+n-1 on 30 June of year z

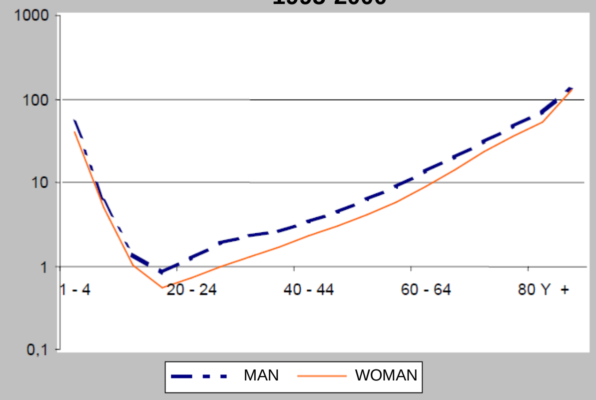
Like the crude death rate, these rates can also be calculated, using the average number of deaths for three consecutive years to smooth out irregularities in the basic information. On the other hand, the mortality rate is also presented by five-year age groups. The exception is the first age group, which is divided into under 1 year and 1-4 years, due to the relatively large variation in mortality at the beginning of life.

BEHAVIOUR

Analysis of mortality by age shows that it is high in the first moments of life. After the first week of life, it declines rapidly. It is relatively low during childhood, that is, from 5 to 10 years of age. It then rises gently until around the age of 40-50 years old. Subsequently, it increases its growth rate and reaches high levels in later life.

When graphically representing the age-specific mortality rates of a population with high mortality, it takes the form of the letter U, while a population with low mortality, it resembles the letter J. The following table exemplifies the first consideration.

PERU: MORTALITY RATES BY SEX AND AGE; 1995-2000



PERU: MORTALITY RATES BY SEX, BY AGE GROUP: 1995-2000

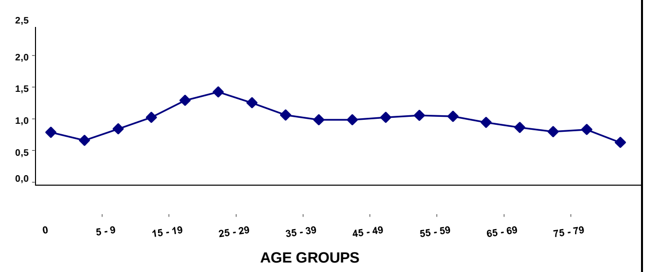
AGE GROUPS	MEN	WOMEN	ABOUT MALE MORTALITY
e0	67,34	72,42	
TOTAL	6,43 a/		
0	52,21	40,92	1,3
1-4	5,78	5,04	1,1
5-9	1,37	1,03	1,3
10-14	0,83	0,55	1,5
15-19	1,26	0,71	1,8
25-29	2,26	1,30	1,7
30-34	2,58	1,67	1,5
35-39	3,33	2,26	1,5
40-44	4,42	3,00	1,5
45-49	6,26	4,14	1,5
50-54	8,99	5,83	1,5
55-59	13,54	8,87	1,5
60-64	19,96	13,94	1,4
65-69	31,07	23,05	1,3
70-74	46,7	36,34	1,3
75-79	69,98	53,11	1,3
80 Y +	142,35	127,63	1,1

a/ The crude mortality rate corresponds to both sexes.
SOURCE: INEI - Population projections for Peru 1995-2025.

ABOUT MALE MORTALITY

Mortality is gender-differential. Generally, women have lower mortality than men. The male population appears to be biologically weaker than the female population and is also more exposed to death by accidents and violence.
When mortality is in a process of decline, female mortality falls faster than male mortality, increasing the differential. Male excess mortality is highest around the age group 20-24 years and in the age group around 60 years. Normally, these differences are present in all age groups, especially in situations of low mortality.

PERU: MALE OVERMORTALITY BY AGE



Exceptionally, when mortality is relatively high, (at some ages) female mortality rates are higher than male mortality rates. For example, in the 25-29 age group, this is due to the effect of relatively significant maternal mortality.

MORTALITY BY CAUSE

The main element in measuring mortality is the occurrence of deaths. This has a cause, which may be natural, disease, trauma or injury leading to death.

The basic information for such a study is the deaths registered and classified and disaggregated by sex and age, and can only be found in the Vital Statistics Registers.

Apart from registration problems, expressed in terms of coverage errors (caused by unregistered deaths), there are also problems of content, that is, those caused by non-professional certification, and also those for which there is no certification of the causes of death. Causes of death can be classified into two main groups, according to their nature:

1. Endogenous causes: these arise from the genetic constitution of the individual, congenital malformations, birth trauma or degeneration caused by the ageing of the organism.

2. Exogenous causes: these correspond to circumstances or factors external to the individual, such as infectious and parasitic diseases and accidental trauma.

When mortality decreases, deaths due to exogenous causes lose relative importance and those due to endogenous causes increase.

Also, the distribution by cause depends on the age structure. Thus, a population with an age structure tends to have a higher proportion of deaths due to degenerative diseases, such as cancer and cardiovascular diseases.

A young population will have a higher proportion of deaths due to exogenous diseases such as accidents and infectious diseases.

Mortality rates by cause are calculated using the following formula:

$$_n dc^Z = \frac{D_c^Z}{N^{30-VI-Z}} * 100000$$

Where:
$_n d^z_x$ is the mortality rate for cause c.
$_n D^Z_c$ is the number of deaths due to cause c, occurring in year z.
$_n N_x^{30-VI-Z}$ is the total population on 30 June of year z.

Example:

$$d_{IRA}^{1991} = \frac{13313}{21966403} * 100000 = 60{,}61$$

In 1991, for every 100,000 people, 61 died from acute respiratory diseases.

INFANT MORTALITY

Mortality that occurs before the age of one year is called infant mortality. It is clear that the first year of life has higher mortality rates than subsequent ages. Life expectancy at birth is lower than life expectancy at exact age 1, which would be another indicator of mortality intensity.

Infant mortality is considered a focus of attention for all health policies, as well as an indicator of the health and mortality conditions of a population.

One of the most important considerations is to differentiate between a live birth and a stillbirth. A "live birth" is when, at the moment of birth, the baby shows some sign of life, such as breathing, heartbeat, crying, etc.

On the contrary, a "stillbirth" is when the death occurred before the expulsion or extraction of the being, product of conception that has reached 28 weeks of gestation.

Secondly, it should be noted that deaths occurring in one calendar year correspond to two generations. For example, children who died in 1999 may have been born in the same year or in the previous year. Therefore, in the measurement of infant mortality, it is necessary to specify and identify both generations in order not to distort the final estimate of its level. It is calculated as follows:

$$IMR = \frac{D_0^Z}{B^Z} * 1000$$

Where:
IMR is the Infant Mortality Rate
D^Z_0 is the total number of deaths of children under the age of one year
B^Z is the number of live births in year Z.

It can be seen that the components for calculating the IMR are different from the age-specific mortality rate. The denominator is the number of births occurring in the year, the equivalent of which is "persons aged 0 years exactly". Meanwhile, age-specific mortality rates have as their denominator the average population under the age of one year, that is, persons of attained age. Consequently, these two measures are different in nature, because of the denominator used in each case. It can also be stated that the infant mortality rate is lower than the central under-one-year-old mortality rate, because the number of births in a year is larger than the average zero-year-old population. This represents the total number of survivors of births occurring in the 12 months beginning on 30 June of the previous year.

Example

$$TMI^{1999} = \frac{25917}{609800} * 1000 = 42.5$$

In other words, in 1999, there were approximately 43 deaths of children under one year of age for every thousand live births.

For a better analysis of mortality, in the first year of life it is divided into:

NEONATAL MORTALITY: This comprises mortality occurring within the first month of life (from birth to before the age of 28 days). This rate is calculated by dividing the total number of deaths under 28 days by the total number of live births registered in a year.

POST-NATAL MORTALITY: This refers to mortality occurring between the age of 28 days and the first birthday. In this case, deaths occurring between 28 days and one year of age are divided by the total number of live births registered in a year.

With these considerations, the infant mortality rate is equal to the sum of the neonatal and postneonatal mortality rates:

$$\frac{D^Z_{-28}}{B^Z} + \frac{D^Z_{28-365}}{B^Z} = \frac{D^Z_{-28} + D^Z_{28-364}}{B^Z} = \frac{D^Z_0}{B^Z}$$

Where:
D^Z_{-28} is the total number of deaths occurring in a year Z up to the first 28 days.
D^Z_{28-365} is the total number of deaths occurring in a year Z after 28 days but before the first birthday.
B^Z is the total number of live births in year Z.
D^Z_0 is the total number of deaths of children under one year of age occurring in year Z.

It should be considered that, because of the decreasing function of mortality intensity with age during the first years of life, particularly in the first year, neonatal mortality rates are significantly higher than would be expected, if one considers that the numerator includes only deaths occurring during one month of the 12 months of the first year of life.

Also to be considered are the differences in trends between the two mortality rates when infant mortality decreases. Postneonatal mortality, which is linked to exogenous causes, is easier to prevent than neonatal mortality. The latter is linked to diseases or malformations that are difficult to avoid and expensive to treat. Therefore, reducing mortality in the first year of life is more difficult.

PERU: INFANT AND CHILD MORTALITY, ACCORDING TO CHARACTERISTICS: 1996

CHARACTERISTICS	NEONATAL	POST NEONATAL	INFANT
TOTAL	**26**	**24**	**50**
MAN	29	27	56
WOMAN	23	20	43
AREA OF RESIDENCE			
URBAN	19	16	35
RURAL	36	35	71

SOURCE: INEI - Demographic and Family Health Survey, 1996.

LIFE EXPECTANCY AT BIRTH

It is a summary measure, with which the mortality of different populations can be compared and also to see the evolution of the same population over time, as it is not affected by the age structure. It is calculated from age-specific mortality rates.

Life expectancy at a given age "x" is an estimate of the average number of years a person would have to live if current mortality conditions remained constant. It is a hypothetical measure and a good indicator of health. In order to obtain it, a mortality table is required to provide life expectancy at different ages. However, as an indicator of the level of mortality, it is common to use Life Expectancy at Birth, which is the exact age 0, that summarises the effect of mortality across all ages.

In general, life expectancy at exact age "x" is the average number of years that the members of the hypothetical cohort who survive to exact age "x" would live between this age and the death of the last member of the cohort. Always under the assumption that they remain subject to the prevailing mortality of the population under study.

It has been observed that when mortality is relatively high, life expectancy at birth is lower than life expectancy at exact age 1, because mortality in the first year of life is very high.

PERU: LIFE EXPECTANCY AT BIRTH AND AT AGE 1, BY SEX, BY FIVE-YEAR PERIOD: 1985-2000

FIVE-YEAR PERIODS	LIFE EXPECTANCY				DIFERENCE	
	MAN		WOMAN			
	AT BIRTH	1 YEAR OLD	AT BIRTH	1 YEAR OLD	MAN	WOMAN
1985-1990	62,08	65,98	66,77	70,01	3,90	3,24
1990-1995	64,40	67,62	69,20	71,74	3,22	2,54
1995-2000	65,91	68,38	70,85	72,76	2,47	1,91

SOURCE: INEI - POPULATION PROJECTIONS OF PERU

OTHER MEASURES OF MORTALITY

Besides the indicators mentioned above, there are other measures related to mortality, such as the Maternal Mortality Ratio, which measures the incidence of maternal death and others that refer more directly to morbidity or disease.

The **Maternal Mortality Rate** represents the number of deaths of women due to complications during pregnancy and childbirth that occur in a given year per 100,000 births.

$$MMR = \frac{D_M^Z}{B^Z} * 10000$$

Where:

MMR is the Maternal Mortality Rate
D^Z_M is the total number of maternal deaths in year Z.
B^Z is the number of live births in year Z.

To accurately determine the risk of death due to this cause, it should be clarified that the denominator should contain the number of pregnancies in the year under consideration. In practice, it is impossible to obtain this information, so the number of pregnancies that result in a live birth is taken as an approximation. In other words, the births that occurred in year Z.

Incidence rate is the number of people who contract a disease during a given period of time, per 1000 people.

Prevalence rate is the number of people who have a specific disease at a given time per 1000 people.

Case fatality rate is the proportion of people who die from a given disease out of the total number of people who have the disease.

MORTALITY TABLES

The Mortality Table or Life Table is a tool that allows a more complete analysis of the mortality of a population.

Its study is of interest to demographers as well as other professionals involved in public health and planning.

Definition and main features of the Mortality Table

Definition: A mortality table, also called a life table, is a theoretical instrument or scheme for measuring the probabilities of life and death of a population according to the age.

Main characteristics:

1. Describes the age-specific behaviour of mortality and is differential by this variable. It is high at the beginning of life, then falls rapidly to almost zero between the ages of 10 and 12, then increases slowly towards the age of 35 or 40, and will rise strongly thereafter. In many cases, it exceeds the levels of the early ages, describing the characteristic shape of the letter U.

2. The table allows to obtain **probabilities** and other conventional measures of mortality, being more appropriate than mortality rates (nmx), either to calculate the survivors of a population, to combine them with probabilities of other age groups, or to derive analytical relationships between the various demographic variables.

3. It provides a summary measure of mortality, Life Expectancy at Birth, which is the best indicator of the overall level of mortality in a population.

4. The mortality table can be assimilated to a theoretical population model, called a "stationary population". It is done by keeping age-specific mortality and births constant over time. These assumptions result in the total population and age distribution remaining unchanged. The birth rate is equal to the death rate, so the natural growth rate is zero.

5. Finally, the life table allows for a variety of applications in a wide range of problems, such as estimation of mortality level and trend, evaluation of health programmes, fertility studies, migration, structure and growth. It can be used in the analysis of various socio-economic population variables, such as economically active population, school-age population and elderly population.

Types of Mortality Tables

According to the period of time or reference period they cover, they are classified as follows:

- Generational mortality tables, which are those in which a generation or cohort of people is followed over time, determining at each age the number of survivors, until it dies out. To construct these tables, a generation must be followed for a long time, until the last survivor dies out. Therefore, their use is very limited. However, it is important for specific purposes, such as the study of mortality conditions in people aged 60 years and older.

- Moment or contemporaneous mortality tables, which are based on the mortality experience observed over a short period of time by all generations of a real population. This time may be one year or an average of two or three years. Generally, when talking about mortality tables, this type of table is referred to.

According to the extension of the age range in which the data are presented, the tables can be:

- Complete tables, in which the different functions are elaborated for each year of age.

- Abbreviated tables, in which the different functions are calculated by age groups, usually five-year age groups. However, within the 0-5 age group, simple age functions are included, as in the full tables, because in this interval, mortality varies greatly with age. This information is important for the study of the living conditions of the child and youth population, in health planning, among other purposes.

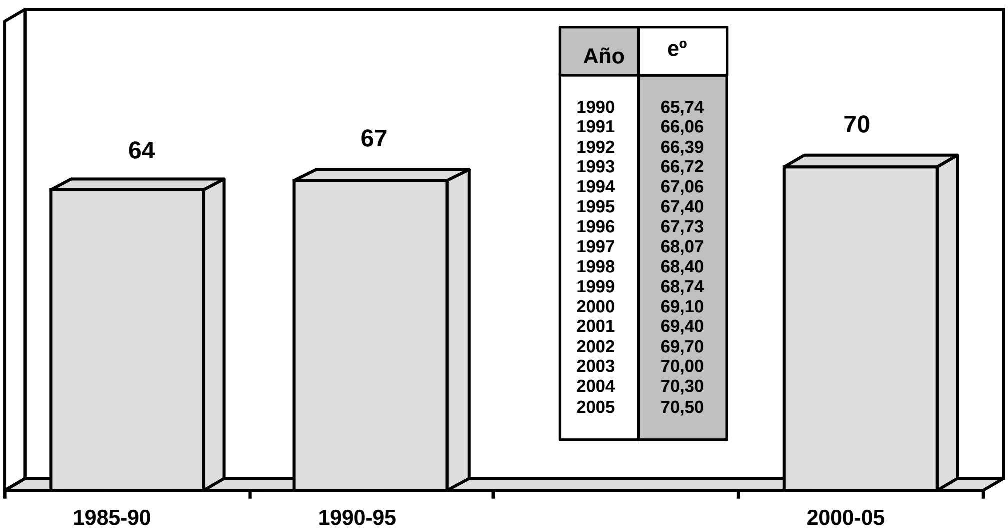
PERU: MORTALITY INDICATORS

YEARS	MORTALITY		LIFE EXPECTANCY AT BIRTH (in years)			INFANT MORTALITY RATE (per thousand live births)		
	ANNUAL BIRTHS: (in thousands)	CRUDE MORTALITY RATE (per thousand)	BOTH SEXES	MAN	WOMAN	BOTH SEXES	MAN	WOMAN
1990	156,2	7,2	65,6	63,3	68,1	61,6	68,2	54,6
1991	154,9	7,0	66,1	63,8	68,5	59,1	65,6	52,2
1992	153,9	6,9	66,5	64,2	69,0	56,7	63,0	49,9
1993	153,8	6,8	66,9	64,6	69,4	54,4	60,6	47,8
1994	154,7	6,7	67,3	64,9	69,8	52,1	58,1	45,8
1995	156,0	6,6	67,6	65,2	70,1	50,0	55,7	43,9
1996	156,8	6,5	67,9	65,5	70,4	47,9	53,3	42,1
1997	157,5	6,5	68,2	65,8	70,7	45,9	51,2	40,4
1998	158,5	6,4	68,5	66,1	71,0	44,1	49,1	38,8
1999	159,9	6,3	68,8	66,3	71,3	42,5	47,3	37,4
2000	161,3	6,3	69,1	66,6	71,6	40,9	45,6	36,0
2001	162,4	6,2	69,4	66,9	72,0	39,5	44,0	34,7
2002	163,6	6,2	69,7	67,2	72,3	38,1	42,5	33,5
2003	165,2	6,1	70,0	67,5	72,6	36,7	41,0	32,3
2004	167,0	6,1	70,3	67,8	72,9	35,5	39,5	31,2
2005	168,9	6,1	70,5	68,0	73,2	34,3	38,2	30,1
2006	170,6	6,0	70,8	68,3	73,5	33,1	36,9	29,1
2007	172,4	6,0	71,1	68,5	73,8	32,0	35,7	28,2
2008	174,4	6,0	71,4	68,8	74,0	31,0	34,5	27,3
2009	176,8	6,0	71,6	69,1	74,3	30,0	33,4	26,4
2010	179,2	6,0	71,9	69,3	74,6	29,1	32,4	25,6

SOURCE: Population Estimates and Projections by Calendar Years and Simple Ages: 1970-2025

PERU: LIFE EXPECTANCY AT BIRTH (e^o)

(Years)



SOURCE: INEI

Life expectancy at birth is one of the indicators that best summarises the standard of living of a population. In Peru, average life expectancy is undergoing an appreciable improvement. Between 1985-90, life expectancy at birth was 64 years, having increased to 67 years in the period 1990-95. Life expectancy is estimated at 70 years for 2000-2005.