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Longitudinal Analysis, Potential Demography and Demographic Accounts (I)

"Researching the causes of phenomena is the fundamental aim of all sciences and the social sciences-demography in particular — may not omit this imperative".

ROLAND PRESSAT

Demography, as any other social science, broaches its subject by stages: on the basis of the collected data, it *describes* the population and the vital phenomena, using especially to this end the means of the *descriptive statistics*; then examines them multilaterally, with a view to pointing out the connections, causal determinations and growth tendencies, a stage which is being achieved by help of the method of *population analysis*; finally, on the basis of the generalization of digested informations and abstracting, demography proceeds to the elaboration of demographic models, schematized and abstracted representations of certain concrete populations and actual demographic processes, a task assumed by the *theory of descriptive, analytical and previsional demographic models.*

Along the three centuries of existence, demography has sistematically imposed its conceptual and methodological apparatus. If we divide conventionally demography into "classic" and "modern" and consider that the latter covers the last two or three decades, i.e, aproximately the period which is marked by the "demographic explosion", we have to admit that the most significant methodological acquisitions are due to modern demography *).

A short reiteration of the history of the main methods of demography is most conclusive in this sense. In the year 1662, the famous study of John

*) The affirmation should not surprise: the situation is applicable to the whole contemporary science, whose development observes an experimental law, with very accelerated paces in the last decades.

Graunt formulates — *inter alia* — the life table idea, enlarged and substantiated mathematically, a little later (1693), by the astronomer Halley. The idea of a "mortality law" is expressed by the mathematician A. de Moivre as far back as in 1725, the life table in modern conception, due to the Swede Pehr Wargentin, dating from 1755; the first formulation of the stable and stationary population model is linked to the name of the mathematician L. Euler (1760); the idea of a life table through a continuous study of a generation was expressed by the mathematician P.S. Laplace (1814); the logistic curve as an instrument for the description of a "law" of the population growth was discovered by the Belgian mathematician P.V. Verhulst (1838), improvements of the life tables and of the population analysis methods being brought by the representatives of the German demography in the latter half of the 19th century: F.G. Knapp, G. Zeuner, K. Becker, R. Böckh, to whom we owe the first formulation of the population net reproduction index for the population (1884), later enlarged by R.R. Kuczynski (1931) and, especially, by W. Lexis, to the name of which there is connected the "demographie network" ("Lexis diagram"), exposed in definitive form in 1903; remarkable contributions to the progress of demography are brought by the actuaries, among whom an important place is occupied by the Englishmen Gompertz (1825) and Makeham (1860); of great significance for demographs there was the creation of biometrics by the Englishmen Fr. Galton and K. Pearson, as well as the improvements of its methods; the idea of the "standardization" of vital rates, contribution of the English demograph W. Ogle, of the Hungarian demograph J. Körösi, and of the German demograph L. von Bortkiewicz (1907), has brought important benefits to population analysis; the Norwegian demograph A. Kiaer carries out the first investigations by sample survey on the population, opening a new chapter of the statistics; an important moment is the "rediscovery" of the logistic curve by the Americans R. Pearl and L.J. Reed (1920), the development of demographic projections through the elaboration of the component method by the Englishman G. Yule (1926) (improving a method suggested by his fellow countryman E. Cannan (1895); the methods of demography are being enriched with the estimations of the world population by the American demograph W.F. Willcox (1931) and the English demograph A.M. Carr-Saunders (1936); a particularly important contribution was brought by the American demograph A.J. Lotkam, with the stationary and stable population model (first formulation — 1907; final exposition in 1939).

This heritage of "classic" demography has been considerably enriched by the "modern" demography, to which added, in the last three decades, new methods and modes, both with regard to the informational system, as well as to the population analysis.

There has to be remarked the application of the method of survey within the population census, due to the American demographs A. Hansen, Hurwitz and Madow (1940), which has led to the theory of "phase survey"; the concept and methods of "potential demography" whose founder is the Swiss demograph Liebmann Hersch (1944); the method of observation and longitudinal analysis, formulated mainly by the American demograph P.K. Whelpton (1947); the biometric analysis of infant mortality of the French demograph J. Bourgeois-Pichat (1951); the method of rating the parity-progression ratio

elaborated by the French demograph Louis Henry (1954); the diversification and improvement of life tables through the elaboration of U.N. type life tables (1957); improvement of stable and quasi-stable population models, related to the names of the American demographs A. Coale and P. Demeny (1966); elaboration of active life tables as well as of those of school life, elaboration and development of matricial models of the economically active population, of the school age population and of migration according to the general "input-output" model; improvement of demographic projection methods, by their diversification and increase of time horizon; the method of demographic accounts.

The modern demography can be generally characterized by the considerable extension of the background of demographic surveys, introduction of permanent registers of the population, by help of computing machines, utilization on a large scale of mathematical models, which has led to the application of mock-up methods and models; finally, the demographs' efforts are nowadays concentrating towards the elaboration of the "*Integrated system of the demographic statistics, labour force and demographic statistics*", with the prospect of its integration into the "System of national accounts".

This is the context in which have to be examined the new concepts, such as those of longitudinal analysis, potential demography and demographic accounts.

LONGITUDINAL ANALYSIS

Before exposing this modern method of statistical observation and population analysis, it is proper to recall a few specific notions to the classical method.

The vital events falling under the notion of vital statistics—births, deaths, marriages, divorces — registered in the corresponding individual reports are being centralized and converted into "statistic masses"; the total number of live born children, of deaths, marriages and divorces are usually shown by calendar years. In this way, the Statistical Yearbook of the Socialist Republic of Romania, 1972, informs us that during 1970 there were registered: 427034 live born children, 193255 deaths, 145531 marriages and 7865 divorces. The most general description of these "masses" is made by help of "classical vital rates, both general and specific, using to this end the number of average population (on the lst of July of the year concerned *). We will get:

a) birth rate

$$n_{1970} = \frac{N_{1970}}{P_{1.\text{VII}.1970}} \cdot 1000 = \frac{427034}{20253000} \times 1000 = 21.1\%;$$

b) birth rate

$$m_{1970} = \frac{M_{1970}}{P_{1.\text{VII}.1970}} \cdot 1000 = \frac{193255}{20253000} \times 1000 = 9.5\%$$

*) The notations are those proposed by Vl. Trebici in "Dicţionar demografic multilingv (VI)" in Revista de statistică, no. 5, 1972.

c) nuptiality rate

$$Ma_{1970} = \frac{Ma_{1970}}{P_{1.VII.1970}} \cdot 1000 = \frac{145531}{20253000} \times 1000 = 7.2\%;$$

d) divorce rate

$$d_{1970} = \frac{D_{1970}}{P_{1.VII.1970}} \cdot 1000 = \frac{7865}{20253000} \times 1000 = 0.39_0/^0$$

The specific rates — by ages and sexes — are being calculated according to the same general method. For example, the specific mortality rates by age years are established as follows:

$$m_0 = \frac{M_0}{P_0} \cdot 1000; \; m_1 = \frac{M_1}{P_1} \cdot 1000; \text{ and, in general,}$$

$$m_i = \frac{M_i}{P_i} \cdot 1000,$$

where

m_i represents the mortality rate at the age $i (i = 0,...., 100)$;
M_i — absolute number of deaths of age i;
P_i — number of average population (on July lst) of age i.

In a similar way, there may be established the special birth rates, i.e., the general and specific fertility rates of the fertile female population:

$$F = \frac{N}{P_f \; 15 - 49 \; years} \cdot 1000; \qquad f_{15} = \frac{N_{15}}{P_{f15}} \cdot 1000 \text{ and, in general,}$$

$$f_i = \frac{N_i}{P_{fi}} \cdot 1000,$$

where

F represents the general fertility rate;
f_i — specific fertility rate at the age i;
N_i — number of live born children by the females of the age i;
P_{fi} — number of female population of fertile age $i (i = 15, \ldots, 49 \; years)$.

There is no obstacle in establishing according to the same plan the specific rates of nuptiality and divortiality.

This method of presenting and describing the vital phenomena has several characteristics:

a) the vision is *static* or temporary, because the events are being presented during a calendar year;

b) there is not provided the possibility of knowing the *generations* to which the respective events belong to;

c) the respective vital rates describe the *intensity* and not the *frequency* of vital events, in relationship with an undifferentiated population by generations;

d) the respective vital events are considered *independent.*

Such a concept of the statistical observation and population analysis bears the name of current analysis; it is also called *temporary* analysis. A more general term would be that of *synchronic* observation and analysis.

The intuitive representation of this modality, resorting to Lexis diagram, with reference to the deaths during 1970, is shown in Fig. 1.

It can be noticed that in this presentation of mortality, we do not know the generations the deaths belong to. Now, the deaths aged 2 years, for instance, are provided by the generation 1968 and generation 1967, probably in different proportions.

The possibilities of knowledge offered by current analysis and, correspondingly, by current vital rates are limited enough. Its main quality, as "temporary" analysis, lies in the fact that presents us the vital phenomena, so as they are established by the factors which operate in the respective moment

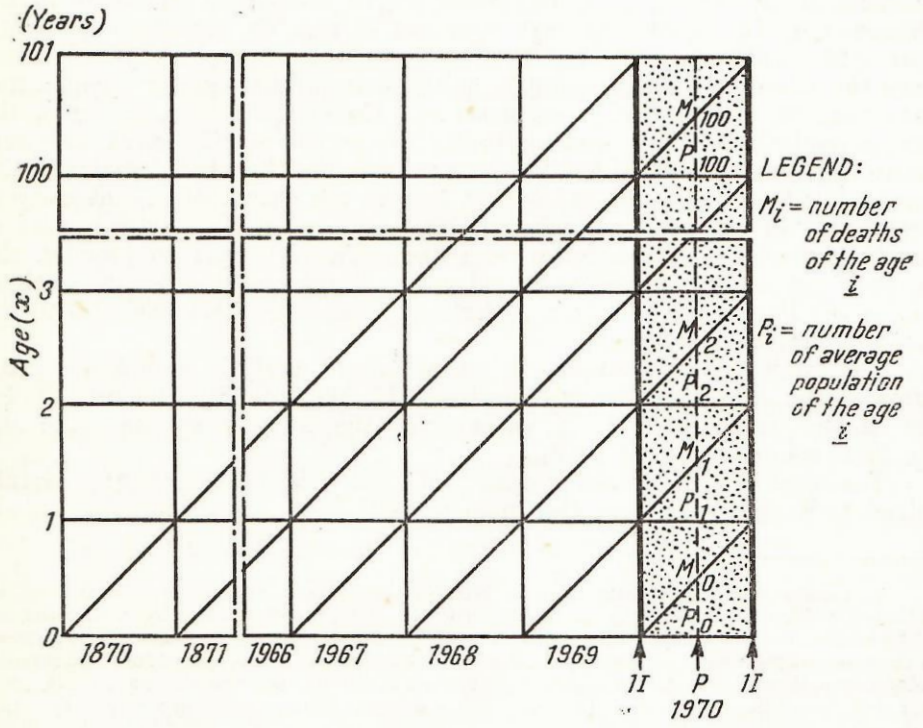

Fig. 1. Mortality current analysis of Romania's population in 1970.

(in the corresponding calendar year). The natality in the year 1967 is a typical example,as well as the divortiality of same year, both influenced strongly by the wellknown measures of demographic policy adopted in the autumn of 1966.

With all its limits, the current observation and analysis is used on a large scale, to this contributing in a decisive measure the fact that informational system of demography does not provide for the moment possibilities for a longitudinal analysis.

The longitudinal analysis is characterized, in relation to the current one, by increased possibilities of knowledge. As a matter of fact, its presence in the history of demography, marking the break of a methodological deadlock, is mostly significant.

One of the demographic processes of vast proportions and with important implications and consequences with which the population of Western Europe was confronted on the eve of the World War II was the strong decrease of fertility, whose proportion can be appreciated from the fact that in some countries, such as France, the natural increase began to be negative. Immediately after the end of the war, in these countries there was recorded a strong recorvery of natality known under the suggestive name of "baby-boom". It was thought initially — which partially was true — that it is the well-known phenomenon of recovery, so characteristic for the immediate postwar periods: concluding of marriages postponed during the war and, as a consequence, the sudden increase of natality, attributing a temporary character to the phenomenon. In reality, the high standard of natality installed during the years 1945, 1946 and 1947 has been still continued for many years, which draw the attention that the point in question was quite another phenomenon than that of recovery and compensation. Under these circumstances, the current analysis of natality and nuptiality has proved insufficient: the characterization, year by year, of fertility by age years, for the whole female population of fertile age, did not succed but to give the extent of the intensity of fertility as an age function, with no explanations on the particularities of female generations, of their entire history. The attempts to broaden the frame of the analysis have finally led to the development of a new method, i.e., of the longitudinal analysis of fertility, extended afterwards also to the study of further phenomena.

The method of longitudinal observation and analysis is linked to the name of the American demograph Pascal K. Whelpton[1]), who used it for the analysis of cohort fertility, establishing the fertility specific rate and the final cohort total fertility[2]).

The sense of this method, formulated briefly, is the following: a certain cohort *) is observed, from the moment of its formation, up to a certain

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[1]) According to Paul Flaskämper (in *Bevölkerungsstatistik*, Verlag von Richard Meiner, Hamburg, 1962, page 403 and fol.) the expression of "cohort analysis" was used by P. K. Whelpton at the session of the International Statistical Institute which was held in Washington, in 1947. In the same way pronounces also his opinion Louis Henry (in the study Analyse et mesure des phénomènes démographiques par cohortes, published in the journal "Population", no. 3, 1966, page 468), according to whom: "*The longitudinal analysis has appeared approximately twenty years ago*".

[2]) A study which has become classic is: Pascal K. Whelpton: *Cohort Fertility (Native White Women in the United States)*. Princeton University Press, Princeton, 1954.

*) The "cohort" notion in demography is being defined as follows: population of people living the same vital event, in the limits of a period of time. The cohort of those born in the same year is called "generation"; the cohort of those married in the same year is the "marriage cohort". In the same way, one can say about the "cohort of deaths" during a year etc.

moment, usually up to the moment a, when its last representative dies out, in realationship with a certain vital event. The most typical example is the observation of a certain generation from the mortality viewpoint: there are

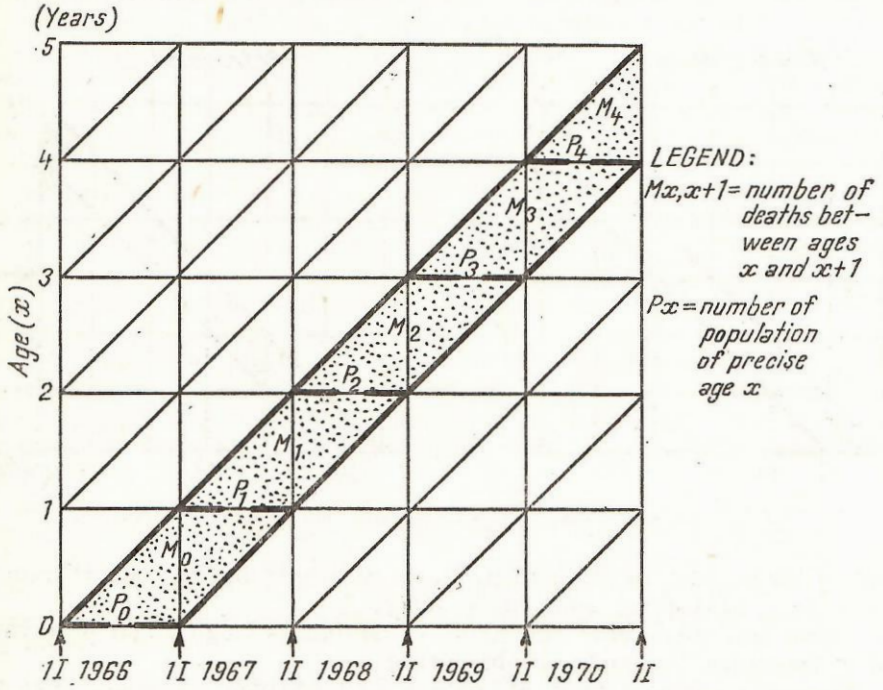

Fig. 2. **Longitudinal analysis of the mortality of male generation 1966 during the years 1966—1970**

registered year by year the deaths recorded by the respective generation until the loss of the last member of this generation (approximately after 100 years). In the Lexis diagram (Fig. 2), the longitudinal observation of the mortality of male generation 1966 is presented in fragments (period 1966—1970) up to the age of 4 complete years (without reaching 5 years).

We can easily imagine the observation of generation 1966 till the year 2066, when will become extinct, as it may easily intuit the advantages of such a way of observing and analysing the population. Indeed, we have the possibility to be aware of the history of a cohort, of the events related to its passing in time, as well as to characterize these particularities as a time function. That is why, the longitudinal observation is also called "diacronic" (along the time); it is equally called "historical" observation, "cohort" observation; there is used too, the suggestivety expression of "chronicle of a cohort".

It results clearly that in the case of fertility, the current analysis relates us its particularities through age years in the limits of a calendar year, whereas the longitudinal analysis tells us the "history" of the fertility of each generation in part, the separate contribution of generation fertility to the general fertility, as well as, to the total number of live born children.

The longitudinal observation can follow an actual cohort from the moment of its formation, further on, year by year, recording the events which occur within it. There is however another modality too: starting from the cohort numbers in a certain moment of observation (for instance, at the mo-

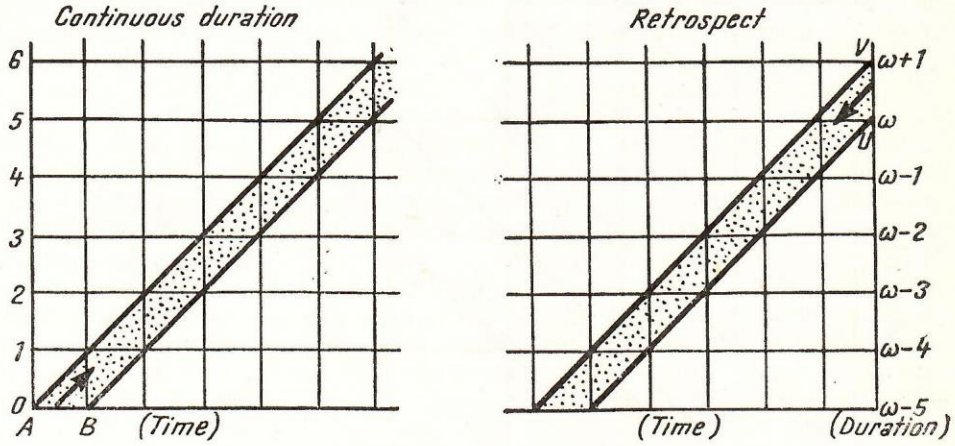

Fig. 3. The continuous and retrospective longitudinal observation.

ment of the census), to reconstitute the vital events and the cohort numbers in the past, at various moments of time.

These two ways bear the name of *continuous* longitudinal observation and *retrospective* longitudinal observation.

The Lexis diagram (Fig. 3) conveys us intuitively the sense of each of these observation methods.

The continuous longitudinal observation refers, in our diagram, to the generation AB, which will be sistematically followed, as the vital events we associate to it will occur; the retrospective observation *) refers to the generation which has reached to a given moment of the observation, with the numbers UV reiterating its "history". The most characteristic example is the retrospective registration of female generations fertility, on the occasion of a population census, when each woman is asked to give information with respect to the number of live born children she had during her past life, the data when they were born etc.

In this way there is "reconstituted" the female generations fertility of fertile age in existence at the date of the census.

We exemplified the application of longitudinal analysis by the mortality of a generation, by the fertility of a female generation. In the initial case, we have the observation of a certain generation from the death viewpoint; in the latter, the female generation is followed in relationship with the "birth" event. The field of application of the longitudinal observation is however incomparably much larger. A male or female generation

*) The retrospective longitudinal observation is also called "anamnestic", a term used especially in the Soviet demography and which means "from memory".

can be followed in relationship with the "marriage" vital event, in view of the analysis of nuptiality. A special cohort like the marriage cohort can be observed from the standpoint of "divorce" vital event; a divorce cohort can be registered longitudinally for the analysis of remarriages.

By extension, there can be observed a generation in relationship with the school life: enrolment in the general culture school, in lyceum, in the university etc. The same thing is true for a generation which is followed in relationship with the admission in the economically active population — some enter at a certain age, others remain inactive — acceptance in a profession, retiring from the respective profession etc.

From the above, as well as from the cited exemplifications, there can be easily grasped the characteristics of longitudinal analysis and its advantages.

1. By the observation of the evolution of a cohort, in a longer period of time, there is provided the knowledge of the "*historical*" factors, of their particularities on the vital events associated with the respective cohort, with the same importance which "etiology" has (history of a disease) in medicine. The female generation, for instance, 1955, reached in the fertile population in 1970, will have a certain fertility, making part of the generations born in a period of demographic upsurge; the generation 1946, in the hard conditions of the period, will have certain particularities with respect to the specific mortality of each age.

2. The vital events are not any longer considered — as in the case of current observation — as independent; on the contrary, they are *dependent* and *conditioned*. Thus, for instance, following longitudinally a female generation from the moment in which this becomes nuptiable (at the age of 16 years), we will have to deal with the probability of two vital events: marriage and death.

In this way, in the period from the age of 16 years up to 17 years, a woman from the respective generation can marry herself, passing from the status of "unmarried" to that of "married" and at the same time keep the status of survivor. In the instance in which in this period, the respective person dies, there cannot either be achieved the "marriage" event. In a similar way there is put the question of fertility: two events are possible for each female of the respective generation, reached to the fertile age (15 years), that of "birth" and "death". But if the death event occurs, there cannot take place that of birth, consequently existing a univocal conditioning.

3. The longitudinal analysis imposes a probabilistic vision of vital events, which is a natural one to these. A cohort (generation, marriage cohort) can be assimilated to Bernoulli's box with two or more states. Continuing the mortality example, one can say that the generation 1966, reached to the age of 2 complete years, in order to reach to 3 years is exposed to the "death" risk: a person can die in the period comprised between 2 and 3 years and consequently not to be alive at 3 or to reach the age of 3 years. Accordingly there is a "probability" of dying and another of "surviving", so as from a box with white and a black balls there is a certain probability to choose a white ball ("life") or a black one ("death"). But we can imagine that the same "ball" may participate in several extractions: a married person can divorce, then marry again etc., which leads to the notion of "repeated" and "unrepeated" extractions, perfectly adaptable to vital events.

In longitudinal vision, the meaning of vital events being probabilist, the notion of their intensity is substituted by that of "risk": a person is "exposed to the risk of death", an unmarried person is "exposed to the risk of

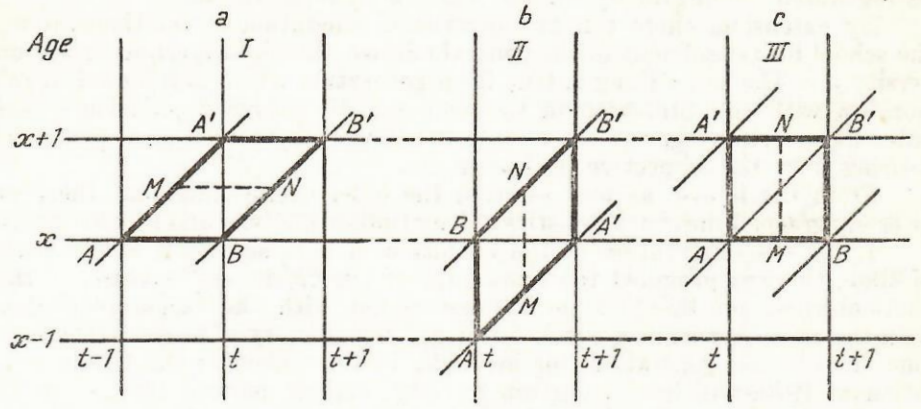

Fig. 4. Main populations of deaths of first, second and third order.

marriage", and a married one is "exposed to the risk of divorce". In a corresponding manner, the extent of this risk is given by the respective probability: the death probability having as complementary probability that of survival, marriage probability and the probability to remain single.

The two fundamental ways of population observation and analysis find their correspondent in two types of rates interpreting and building of *vital tables* *). In the briefest formulation, the current analysis has its correspondent in the *classical vital rates*, which measure the intensity of vital events in relationship with an *average* population numbers and the current tables *rates*, drawn up for a *fictitious cohort*, while the longitudinal analysis has as its characteristic the *probabilities*, which measure the frequency of vital events in relation to an initial population (according to the box principle), i.e., estimates the probability of the development of the respective events and the *cohort or generation tables*, that have in view *real cohorts*.

To illustrate the above, we will refer to mortality. To this end in view, we will recall a few fundamental notions. A mass of deaths ("mortuary points") can be represented in three distinct ways: number of generation deaths during an age year, but in two years of observation, number of deaths of a generation watched in a calendar year, however divided into two age years and a number of deaths in an age year and a year of observation, but belonging to two generations. They are the well-known "main populations of deaths" of first, second and third order, whose repesentation in the Lexis diagram is the following (Fig. 4):

It is to be noted that the first population of deaths (I) includes the deaths of generation AB, aged of x, $x + 1$, but watched in two years: $t - 1$, t and

*) The proper expression would be "Tables of disparition or extinction". We use the term of "vital table" for its generality.

t, $t+1$; the second population (II) includes the deaths of same generation, but which occurred in two age years: $x-1$, x and x, $x+1$, in a single calendar year: t, $t+1$; finally, the third population of deaths (III), includes the deaths of a single calendar year: x, $x+1$, watched in a single year: t, $t+1$ but which come from two generations.

The average numbers of the respective population, being MN, the *classical* vital rates are calculated according to the general formula:

$$m = \frac{AA'BB'}{MN}$$

Each of the three rates has its significance; it is evident however that they measure the *intensity* of mortality. In *the classical demography the most frequently used rate is the rate established fot the population of deaths of third order.* In this way, there is calculated every year the rate of general mortality, that of infant mortality, the rates of sex and age specific mortality.

At a more conspicuous glance we notice that each main population of deaths consists of two elementary populations of deaths. For example, the population I consists of $AA''B$ (generation deaths in the calendar year $t-1$, t and of age x, $x+1$) and $A''BB''$ (deaths of same generation of age x, $x+1$, in the calendar year t, $t+1$). This delimitation of a main population of deaths — as well as of other masses of vital events — has a particular importance for the population reckoning and analysis.

The cohort or generation rates, with probability value*) therefore in the longitudinal vision, are established as follows:

— for population I:

$q = \frac{AA''BB''}{AB}$, being the age death probability (between ages x and $x+1$)

— for population III:

$q = \frac{AA''BB''}{AB}$, being the generation death probability (between years t and $t+1$)

The distinction between the „usual vital rates" and the "probabilistic rates" is manifest: in the first case, the deaths are being related to an average population, in cross conception; in the latter, the deaths are related to the generation numbers from which they come and consequently the calculation is done in longitudinal vision.

The significance of both categories of rates as well as their value for the current and longitudinal population analysis can be derived from the examples built on the basis of the following data concerning the mortality of male population in the Socialist Republic of Romania during the years 1967—1970.

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*) The distinction between an "usual vital rate" and a "probability" is done, in French, by using the expressions of "taux" and "quotient". If the first has been translated by "rate" (replacing the inadequate expression of "coefficient"), for the latter, the Romanian translation of "probabilistic rate", adopted by Dicţionarul statistic economic, second edition, page 392), is not the best. There may be used directly the expression of "probability", because this is the meaning.

Table 1

Male deaths during the years 1970 at the ages of 2—5 years

Age	Number of deaths	Number of population		
		on 1.I. 1970	on 1. I. 1971	on 1. VII. 1970
2	540	253 780	251 028	252 404
3	251	133 074	253 376	193 225
4	155	138 185	132 882	135 534
5	142	136 168	138 033	137 100

Using the Lexis diagram, the data in the table 1 are presented as follows (Fig. 5):

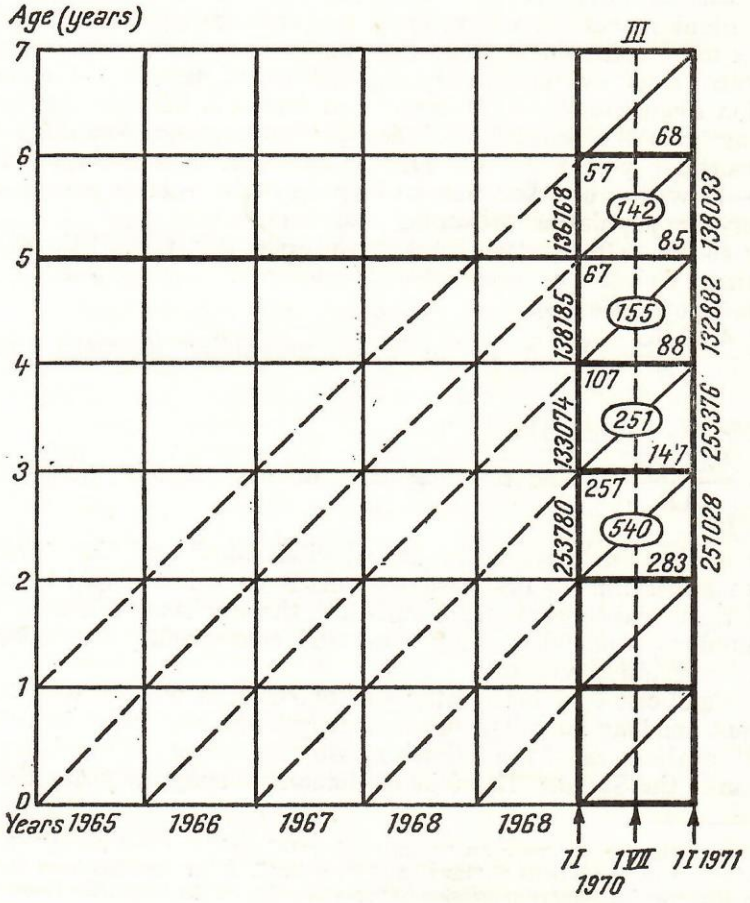

Fig. 5. Populations of deaths of third order from the male population aged between 2 to 5 years in the year 1970.

We recall that the specific mortality rates in cross conception are calculated as follows:

$$m_2 = \frac{540}{(253780 + 251028) : 2} \cdot 1000 = \frac{540}{252404} \cdot 1000 = 2.13\%$$

$$m_3 = \frac{251}{(133074 + 253376) : 2} \cdot 1000 = \frac{251}{193225} \cdot 1000 = 1.29\%$$

$$m_4 = \frac{155}{(138185 + 132882) : 2} \cdot 1000 = \frac{155}{135534} \cdot 1000 = 1.14\%$$

$$m_5 = \frac{142}{(136168 + 138033) : 2} \cdot 1000 = \frac{142}{137100} \cdot 1000 = 1.03\%$$

We point out however that the deaths in each age year consist of deaths belonging to two generations; for example, the 540 deaths aged 2 years include 283 deaths which come to the generation 1968 and 257 deaths belonging to the generation 1967. These are the elementary populations of the main populations of deaths of third order. We can rally the elementary populations: for instance, the elementary population of 257 deaths at the age of 2 years together with the elementary population of 147 deaths of same generation, but at the age of 3 years makes the main population of deaths of second order of the generation 1967 in the calendar year 1970, divided however by two ages: 2 years and 3 years. In this instance too there may be calculated vital rates in current vision for the year 1970 which are however generation rates:

$$m_{2,3(1967)} = \frac{257 + 147}{\frac{253780 + 253376}{2}} \cdot 1000 = \frac{404}{253578} \cdot 1000 = 1.59\% \text{ O}$$

$$m_{3,4(1966)} = \frac{104 + 88}{\frac{133074 + 132882}{2}} \cdot 1000 = \frac{192}{132978} \cdot 1000 = 1.44\% \text{ O}$$

$$m_{4,5(1965)} = \frac{67 + 85}{\frac{138185 + 138033}{2}} \cdot 1000 = \frac{152}{138109} \cdot 1000 = 1.10\% \text{ O}$$

Graphically, the data have the following aspect (Fig. 6).

Two remarks are indispensable. The usual generation rate is related to the intensity of generation mortality in a calendar year by two close ages, being inferred on the basis of generation average number between the two ages; secondly, the generation numbers at the moment $t + 1$ is equal to the generation number at the moment t, from which the deaths are subtracted. For example, the numbers of the generation 1967 on January the 1st, 1970 was 253780, and on January the 1st, 1971 lowered to 253376, the difference of 404 representing the deaths.

We can imagine too usual vital rates for populations of deaths of first order, whose calculation is shown in Fig. 4. This requires two calendar years. There are generation rates too, but on single age year, in the limits of two years of observation.

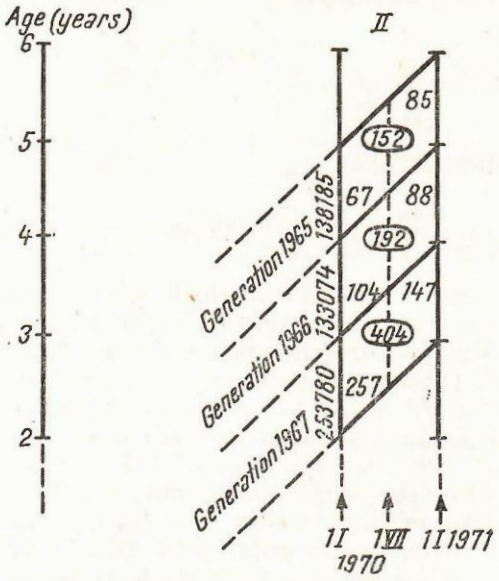

Fig. 6. Populations of deaths of second order.

Let us examine now the deaths of a generation in a period of several years and establish the death "probabilistic rates" (respective probabilities), taking as support the data below on the male generation 1964 during the years 1967—1970.

Table 2

Deaths of male generation 1964 in the period 1967—1970

Year	Age (years)	Number of deaths	Number of population	
			of the respective age	on 1. I. of the respective year
1967	3	181	136 676	
1968	3	100		
	4	77	136 395	136 495
1969	4	73		136 318
	5	77		
			136 245	
1970	5	57		
	6	68		136 168
			136 111	
1971	6			136 043

The deaths at the age of 3 years mean 281, consequently a main population of first order; those at the age of 4 years — 150, at 5 years — 134. The population number at the age of 4 years is 136395, i.e., 136676 — 281 deaths;

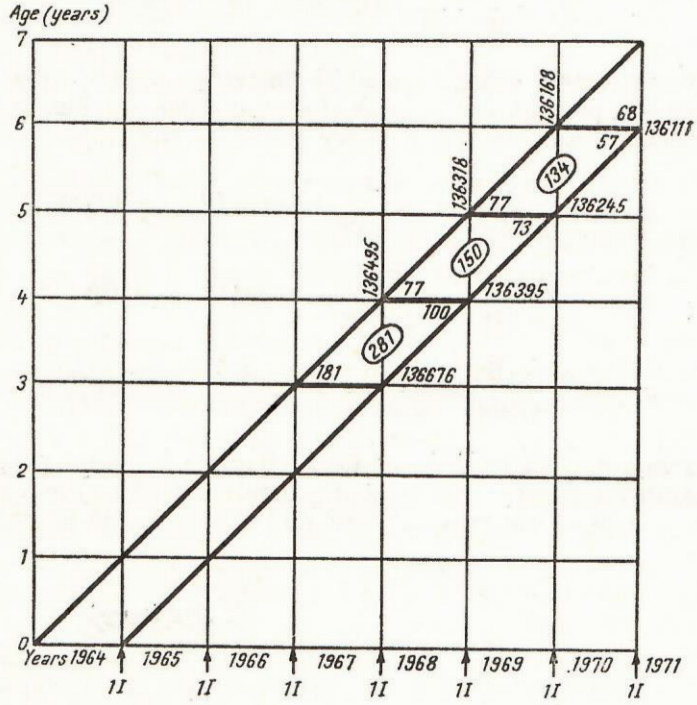

Fig. 7. Deaths of male generation 1964 during the years 1967—1970 by ages.

the population number on January the 1st, 1969 is 136318 = 136595 — 177 etc. It is clearly felt the need to make operations with elementary populations of deaths.

The Lexis diagram gives us the possibility to intuitively imagine the relations between the respective data (Fig. 7).

In this typical longitudinal conception there may be established two categories of "probabilistic rates":

a) age "probabilistic rates" (in French "quotient par âge");

b) generation "probabilistic rates" (in French "quotient par génération").

a) Age death "probabilistic rates" in a generation means rates established on the basis of a population of deaths of first order (see Fig. 4), however not related to an *average* population, but to an *initial* one (from which there are "extracted" the respective deaths), namely to the population number of the respective age. In this case, we will have:

$$q_3 = \frac{281}{136676} = 0.00205, \text{ or } 2.05\%\ 0$$

$$q_4 = \frac{150}{136395} = 0.00109, \text{ or } 1.09\%\ 0$$

$$q_5 = \frac{134}{136245} = 0.00096, \text{ or } 0.96\%\ 0$$

b) The generation death "probabilistic rates" are the rates established on the basis of a population of deaths of second order (see Fig. 4), but related to the generation numbers on January the 1st of the respective year:

$$q_{3,4} = \frac{100+77}{136495} = \frac{177}{136495} = 0.00129, \text{ or } 1.29\%\ 0$$

$$q_{4,5} = \frac{73+77}{136318} = \frac{150}{136318} = 0.00110, \text{ or } 1.10\%\ 0$$

$$q_{5,6} = \frac{57+68}{136168} = \frac{125}{136168} = 0.00091, \text{ or } 0.91\%\ 0$$

An exemplification by help of Lexis diagram is useful (Fig. 8)

In the first instance, the deaths of generation 1964 at the age of 4 years concern two years of observation (1968 and 1969); in the latter, the deaths

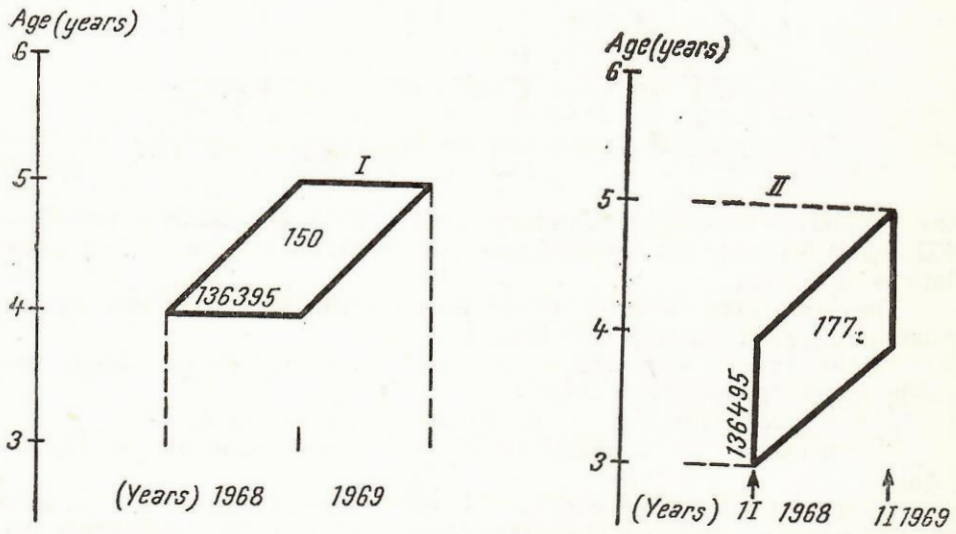

Fig. 8. Populations of deaths of first and second order of the male generation 1964 during the years 1968 and 1969 at the ages of 3 and 4 years.

of generation 1964 regard a single year of observation (1968) but include two age years (3 and 4). The probabilist meaning appears however clearly in both instances: the 150 deaths, 177 respectively, are "events" extracted from

an initial mass: 136395, 136495 respectively; therefore, the respective rates are demographic rates and are read as follows:

a) the probability for a live person of the generation 1964 at the age of 4 years (of the 136395) to die before reaching the age of 5 years is of 0.00109 (that is, 150 cases); hence, the probability of her reaching the age of 5 years is of 0.99891, inferred as complementary probability: 1.00000—0.00109.

The first is a death probability, the second a probability to survive, and the generation number at the respective age is the number of survivors;

b) the probability for a person of the generation 1964 at the age of 3 years, alive on January the 1st, 1968 (of the 136495) to die before reaching January the 1st, 1969 is of 0.00129 (that is 177 cases); hence, the probability of being alive on January the 1st, 1969 and, therefore to reach the age of 4 years, is of 0.99871.

To draw up a life table for a real generation there are established the death probabilities from the age x to $x + 1$ (population of first order); for the demographic projections there are used the death probabilities from the moment t to $t + 1$ (population of second order).

The modern demography holds the longitudinal analysis as a main method, ahead of which lies a particular prospective. One can ask: why the concern for this method is turned to profit only now? The answer is plain: the conditions for the application of this method are being created just now. Firstly, the informational system of demography is being considerably improved through the setting up of permanent registers of the population ("data banks"); secondly, the electronic computers provide special possibilities for the processing of information on the populaton; thirdly, the system of demographic accounts will create a framework which objectively will necessitate longitudinal observations.

Promising preoccupations for the utilization of longitudinal method do also exist in our statistics. There has to be mentioned, above all, the particular role played by the population and house census of March 15, 1966 for two reasons: there has been registered the date of birth, which allowed the establishment of generations and, also, there have been recorded information concerning the live born children of women aged 15 years and over, alive at the date of the census, which made possible the determination of the *retrospective longitudinal fertility*. To this there has to be added the high advantage of the automatic processing of census data. In the current demographic statistics the data concerning some vital phenomena are being processed since several years by cohorts (generations and marriage cohorts), a premise for longitudinal analyses. The method of longitudinal observation and analysis has started to be also used in other social sciences.

In the next issue we shall examine the concepts of potential demography, the demographic accounts and the position of longitudinal observation in relationship with a permanent register of the population.

ANALYSE LONGITUDINALE, DEMOGRAPHIE POTENTIELLE ET COMPTES DEMOGRAPHIQUES (I).

On y donne un bref aperçu historique sur la création et le développement des conceptes et des méthodes de la démographie, présentant par la suite quelques notions spécifiques à la méthode classique, ainsi que certains taux. Sont discutées ensuite l'analyse transversale et l'analyse longitudinale et on relève les caractéristiques et les avantages de chacune.

Cette première partie de l'ouvrage s'achève par la comparaison des catégories d'indices pouvant être formées à l'aide des deux genres d'analyse et mettant en evidence leur valeur pour la recherche démographique.

ПРОДОЛЬНЫЙ АНАЛИЗ, ПОТЕНЦИАЛЬНАЯ ДЕМОГРАФИЯ И ДЕМОГРАФИЧЕСКИЕ СЧЕТА (I)

В настоящей статье делается краткий исторический обзор создания и развития понятий и методо в демографи, и после чего приводится несколько специфических понятий классического метода, а также некоторые показатели. Затем автор говорит о поперечном и продольном анализах и выявляет как их характеристики, так и преимущества каждого из них.

Эта первая часть статьи заканчивается сопоставлением категорий показателей, которые могут быть разработаны при помощи указанных двух методов анализа, и выявляется их значение для демографических исследований.