ESTIMATION ON FERTILITY AND MORTALITY IN MEXICO (1979)

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INTRODUCTION

In view of the high population growth in Mexico during the last decades and considering the demographic and socioeconomic implications that this population growth brings along, it has become the center of exhaustive analyses and deep thought.

Three surveys at national level have been conducted in Mexico, tending to provide more information on the population dynamics. In 1976 the Mexican Fertility Survey was carried out, and in the years 1978 and 1979 the Coordinación del Programa Nacional de Planificación Familiar conducted two more.

This brief summary refers to the fertility and mortality estimations at national level, derived from the 1979 survey.

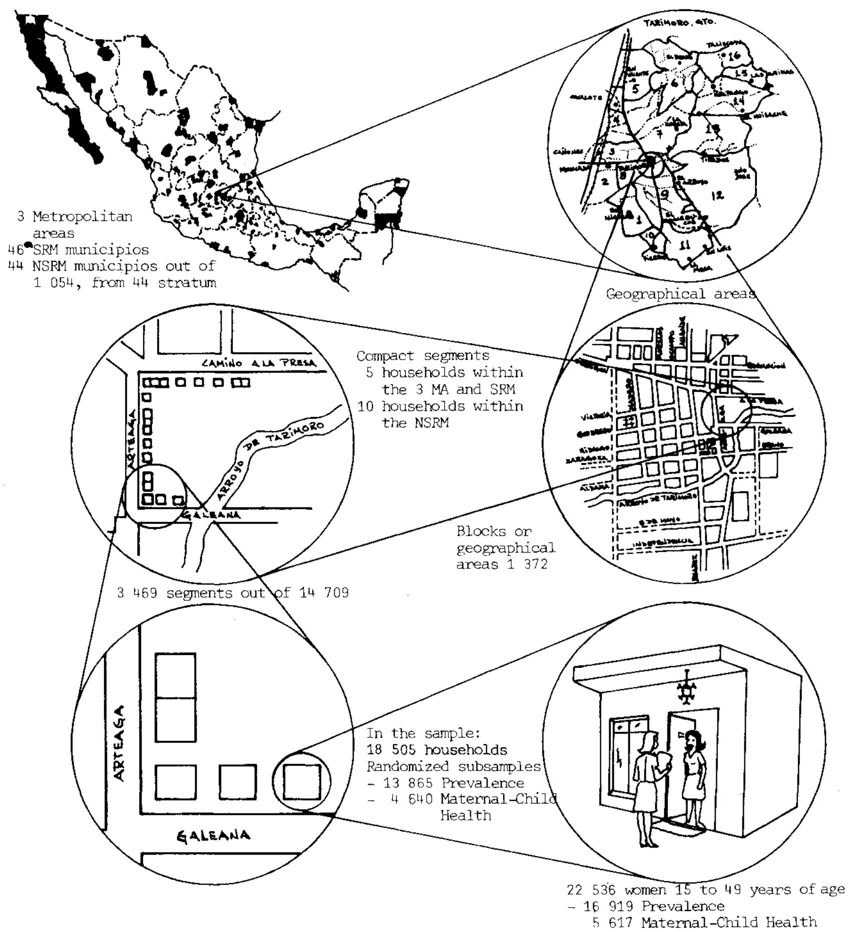
In the first place, an evaluation of the information is made and, subsequently the direct estimations obtained from the survey are presented accompanied by corrections, in order to consider response error. Further on, estimations derived from the use of alternative estimation methodologies are presented (indirect methods).

Sampling Design

This survey is specifically oriented to obtain data on mortality, fertility, continuity in the use of contraceptive methods and maternal child care. In addition, questions destined to relate these thematic aspects with socioeconomic variables were included.

The sampling scheme was based on a probabilistic sample of the geographic areas of the national territory, independently selected for each of the 32 federal entities.

SAMPLING METHODOLOGY



The total sample consisted of 18,505 households; also, two ramdomized subsamples were considered (one with 13,865 for prevalence in the use of methods and another with 4,640 for maternal child care). From the first subsample, processable information was obtained for 16,919 women, as compared to 5,617 from the second one.

Validation of Information

In order to validate the information obtained from the survey, the structure by age and sex of the whole population and the structure by age for women between 15 and 49 years of age, were compared with the data from the Mexican Fertility Survey and the 1970 Population Census. In addition, the whole women sample structure was compared to its two samples. The results obtained reflected a substantial information consistency.

With data derived from the total population, the Myers, Whipple and masculinity indices were calculated, having found that: Men's age is better reported than women's, although both have preference for ages ending in digits 0 and 5. The proportion between both sexes for the age groups does not differ from the previously observed pattern.

The non-response, at national level, was 8.7% which, after analyzing the reasons, showed the following porcentages: Absent women after 4 visits 5.4%; refused to give information 0.5; inadequate informant 1.6% and other reasons 1.2%.

Analyzing the available information about non-interviewed women, in the household questionnaire for 3 field regions, we reached to the conclusion that these women's fertility is lower than the interviewees'.

FERTILITY ESTIMATION

Direct Method

The survey was carried out from september 15th to december 31st, 1979 and the reference period for recent births which was considered more adequate for the calculation of fertility estimations was november 1978 to october 1979. Once this period was determined, an adjustment was made to women's age in order to obtain their approximate age at the time of giving birth.

The specific fertility rates and the global fertility rate obtained were the following:

Age groups	f_i
15 - 19	0.1099
20 - 24	0.2389
25 - 29	0.2143
30 - 34	0.1993
35 - 39	0.1411
40 - 44	0.0567
45 - 49	0.0058
TGF	4.83

Indirect Methods

Coale-Demeny Method

This method estimates fertility annual rates, by age, based on information on the mean number of live-born children.

Through this procedure which presents two variants, extremely high global fertility rates are obtained: 5.6 and 7.5 children per woman respectively.

Brass Method

i) Method on all births, and

ii) Method for first births

These techniques estimate specific fertility rates, establishing a comparison between the retrospective fertility data and the current fertility information.

There are some implicit assumptions in the applications of these methods, such as:

It is assumed that fertility has remained constant in recent years; it is accepted that younger women's (under 30 years of age) response is more reliable than that of the rest of the women between 15 to 49 years of age, and that unimportant omissions can be overlooked. It is then assumed that the structure by age of the fertility rates obtained, starting from information on the births occurred during the last 12 months, can be considered correct, although the general level may not be so.

With data about recent births, it was found that for the 20-24 and 25-29 age groups the P_i (average of children per woman) exceeds in 17% the F_i (accumulated fertility calculated with data on recent births), which means to adjust the global fertility rate of 4.83 to 5.66 children per woman.

Considering information about the first births only, this porcentage comes down to 13% and, therefore, the global fertility rate is 5.54.

The assumption of constant fertility in the last years, established by the indirect methods, does not apply to the case of Mexico. This conclusion comes from two facts:

i) The global fertility rate tendency considering the Mexican Fertility Survey and the Prevalence Surveys.

ii) The quotients P_i/F_i obtained with information on all births occurred in the last year, increase with age.

MORTALITY ESTIMATION

Direct Method

With data on deceases occurred during the 12 months prior to the interview date a gross mortality rate of 6.0 °/oo 1/ and an infant mortality rate of 46 °/oo were calculated. This confirms the result obtained by other surveys as regards detection of mortality through direct methods, that is, through this technique there is always an under-estimation of mortality.

A correction was made taking into account the omission percentage of deceases obtained with preliminary data of the decease follow-up project (obtained in the survey's household questionnaire) which was developed by the Dirección General de Bioestadística of the Secretaría de Salubridad y Asistencia. The resultant rate of this correction was 7.8 °/oo.

Indirect Methods 2/

To measure infant mortality and, in the first years of live, methods based on data about live-born children and surviving children were used. 3/

The first method considers the previously mentioned data for the total of live born children and surviving children for women between 15-49 years of age, while the second method considers only the live borns and surviving children in the year prior to the survey.

The first method developed by Brass presents three variants: Sullivan, Trussell and Feeney. These authors (with the exception of Feeney) assume that mortality has remained constant.

These methods were applied to the four families of the regional tables developed by Coale-Demeny and it is observed that in general, the West family is better adjusted to the case of Mexico.

The resultant estimations for both sexes, in terms of infant mortality rates (°/oo) which imply the $_1q_0$, $_2q_0$, $_3q_0$ and $_5q_0$ according to Coale-Demeny's West model

Method	$_1q_0$ resultant from:			
	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$
Brass	96	61	69	71
Sullivan	-	61	68	68
Trussell	96	62	69	70
Feeney	-	55	60	61

These data are not referred to the year prior to the survey, but to variable periods.

The method of the live-born children in the year prior to the survey considers the decease separation factor for infants under one year of age 4/, and gives an infant mortality rate for 1979. The resultant rate was 5.4 °/oo, which is almost identical to the estimation obtained by Feeney (55 °/oo) based on $_2q_0$ (see above chart).

The father, mother and first spouse (husband or wife) survival methods and that of decease structure by age, were applied to estimate adult mortality levels.

Considering the mother orphanhood method as more consistent, an approximate gross mortality rate of 8.5 °/oo was estimated, only that it is not referred to the year 1979.

The decease structure method gives a gross mortality rate estimation, for the population over 5 years of age, of 7.4 °/oo. The indirect methods applied show consistency, as the survival probabilities from birth, which were obtained, are always higher for women than for men, which is in accordance with the fact that the male mortality level is higher than the female mortality one. The precise period to which said estimations refer is unknown until this moment.

CONCLUSION

From the fertility analyses presented in this document, the following remarks can be made:

To obtain an estimation of the level and fertility structure in populations where birth control is being increasingly practiced, a more and more complex analyses demanding the use of complementary tools, is necessary. Such is the case of Mexico, which shows evidence of a fast fertility reduction in recent years. Hence, the necessity of using alternative sources and most of the estimation techniques thus far applied.

For this, the direct estimation provides more adequate results for our reality, based on two affirmations:

1. Fertility has not remained constant during the last years.

2. These methodologies were designed to estimate fertility results when the quality of information gathering is deficient. The introduction of probabilistic sampling schemes, with higher efficiency in the information gathering control systems, makes the correction of the indirect methods consistently greater.

From the foregoing, it is suggested that the survey's direct estimation, corrected by different concepts, in accordance with the previous explanation, is more convenient.

For the year 1979 it was estimated that, when the specific calculated fertility rates were applied to the female population structure determined by the survey itself, a gross birth rate of 35 births per each one thousand inhabitants was found.

The data on mortality obtained about deceases occurred in the household provide, as vital statistics do, an under-estimation of the mortality level. Directly from the survey, a gross mortality rate of 6.0 °/oo and an infant mortality rate of 46 °/oo were estimated. Probabilities of dying, calculated by 5-year age groups show irregularities due to deficient response and to an under-estimation in the expected decease sample size.

From the estimations obtained through direct methods, the one calculated by the method of decease structure by age, also referred to the year prior to the survey, provides an estimation of 7.4 °/oo for the gross rate (estimation referred to the population over 5 years of age), which represents 23% of under-estimation as related to direct findings: through the live-born children survival method in the year prior to the survey, an infant mortality rate of 54 °/oo was obtained. The estimations obtained through the others methods give an average value of 62 °/oo, only that this last estimation is referred to the year 1979, approximately. Therefore, the infant mortality rate obtained directly (47 °/oo) is clearly under-estimated, at least in 17%.

Regarding adult mortality, the nature of the methods applied and the fact that the estimation reference period is not well defined, do not allow to reach, for the moment, a solid conclusion about the under-estimation levels.

However, the results of the indirect mortality methods suggest that mortality is well represented for Mexico in 1979, by level 19 of the West model of Coale-Demeny's life tables, which represents a gross mortality rate of 8 °/oo approximately.

As opposed to the conclusion reached for fertility estimation, the indirect estimation was considered more reliable, due to three facts:

1. There is an unquestionable under-estimation in direct methods.
2. The robustness of indirect methods makes estimations less sensible to fertility changes.
3. Mortality has not decreased so drastically in the last years.

In spite of changes in the traditional questions and the efforts in the field operation for obtaining reliable information, it has been demonstrated that the question on mortality is more sensitive than the one about fertility. Hence, if we want to obtain a reliable estimation through a direct method, efforts must be made in the technique and methodology for information gathering, or another type of survey, such as the continual one, must be considered.

METHODOLOGICAL BASIS

Since most of the indirect techniques applied in this document are based on similar theoretical propositions, and the interesting point here is to illustrate the idea of how, starting from established mortality and fertility laws, expressions associated with determined functions of the life table can be established, following the mathematical foundation of two methods are presented, as an example.

Method of Live-born Children - Surviving Children

Fundamentally, what the method does is to convert the deceased children proportion of the total number of live-borns from women classified by 5-year age groups into probabilities of dying, of a life table, between birth and a determined age x. This method was originally developed by William Brass.

Starting from the following assumptions:

That fertility be a continual function of age f(x).

That the decease proportion between birth and certain age x be also a continual function q(x), and that these two functions remain constant in time.

With these conditions, age structure (in the absence of mortality) of live-born children from mothers of certain age x, for example, 25 years of age, can be expressed as follows:

$$c_{25}(a)=\frac{f(25-a)}{\int_s^{25} f(x)\,dx} \quad ..... (1)$$

where:

$f(25-a)$ = represents fertility at age 25-a

$\int_s^{25} f(x)dx$ = is the total number of children from women of 25 years of age, and

s = is the age at which fertility initiates

Thus, the above mentioned expression can be understood as: the proportion of children at an age a, born from mothers of 25 years of age, is equal to said mothers' fertility at the exact age (25-a), divided by the fertility accumulated by these mothers up to age 25.

However, from the number of live-borns the deceased proportion can be determined starting from the age structure (in the absence of mortality) of the live-born children: $c_{25}(a)$, and of the population mortality law: q(a), that is:

$$d_{25}=\int_0^{25-s} c_{25}(a)\, q(a)\, da \quad ..... (2)$$

where:

d_{25} = symbolizes the proportion of deceased, among live-born children, from mothers of 25 years of age.

25-s = is the maximum age children can reach $c_{25}(a)$.

To refer expressions (1) and (2) to five-year age groups since -as previously presented- data are classified at exact ages, we have:

For women in the 20-25 year age group, for example:

$$c_2(a) = \frac{\int_{20}^{25} f(x-a)\,dx}{\int_0^{25-s}\int_{20}^{25} f(x-a)\,dxda} \quad ..... (3)$$

where:

$c_2(a)$ = represents the distribution in the absence of mortality of children from women in the 20-25 year age group.

$f(x-a)$ = is the fertility function.

The under-index i of $c_i(a)$ varies according to the 5-year age group considered; the result will be i=1 for the 15-20 group; i=2 for the 20-25, etc.

Thus, the proportion of deceased children will be:

$$D_2 = \int_0^{25-s} c_2(a)\ q(a)\ da \ \ldots\ldots (4)$$

Finally, with the fertility function:

$$f(t) = k(t-s)\ (s+33-t)^2$$

To the West-European mortality standard calculated by Brass and with the expression (4), the deceased proportions D_i can be related to probabilities of dying $q(a_i)$.

Decease distribution method, by age

Theoretical Development

The equation on which the technique application is based is:

$$N(x) = r.\ N(x+) + D(x+)$$

where:

- N(x) = represents the number of persons at an exact age x.
- N(x+) = the number of persons at an age equal or over x.
- D(x+) = the number of deceases among persons at an age equal to or over x.
- and r = the growth rate in a stable population.

This equation is reached through two relations that are met in a stable population, i.e.:

$$N(x) = Be^{-rx}\ l\ (x) \ \ldots\ldots (1)$$

where:

B = symbolizes the number of annual births

and

$$D(x+) = \int_x^{\omega} N(x)\ \ \mu(x)\ dx \ \ldots\ldots (2)$$

where:

$$\mu(x) = \frac{-l'(x)}{l\ (x)} = -D\ \ln\ l(x);$$

that is, the derivative (with a negative symbol) from the natural logarithm of the survival function (l(x)), and represents the instantaneous mortality rate or mortality force.

Substituting in (2) the value of N(x) given in (1), we obtain:

$$D(x+) = \int_x^{\omega} Be^{-rx}\ l(x)\ \ \mu(x)\ dx \ldots\ldots(3)$$

but as: $\mu(x) = \frac{-l'(x)}{l\ (x)}$

$$D(x+) = -B \int_x^{\omega} e^{-rx}\ l(x) \frac{l'(x)}{l\ (x)}\ dx$$

$$= -B \int_x^{\omega} e^{-rx}\ l'(x)\ dx \ \ldots\ldots (4)$$

Integrating this last expression, in parts, we obtain:

$$D(x+) = \Big[-Be^{-rx}\ l(x)\Big]_x^{\omega} - r \int_x^{\omega} Be^{-rx}\, l(x) dx \ \ldots(5)$$

but as by definition l(ω)=0, and given the relation (1), the following is reached:

$$N(x+) = \int_x^{\omega} Be^{-rx}\ l(x) \ \ldots\ldots (6)$$

Substituting (1) and (2) in (5), we obtain:

$$D(x+) = N(x) - r\ N(x+)$$

from where:

$$N(x) = r.N(x+) + D(x+) \ \ldots\ldots (7)$$

which is the fundamental equation of the technique established at the beginning of this exposition.

Starting from this equation, the two expressions which permit the method application are reached, that is:

The one which represents the first variant which permits to estimate mortality based on information in absolute values, and the one which represents the second variant which considers relative values.

That is:

dividing (7) by N(x+), we obtain:

$$\frac{N(x)}{N(x+)} = r + \frac{D(x+)}{N(x+)} \ \ldots\ldots (8)$$

which is the equation of the method's first variant.

Now, if we divide (7) by N which represents the total of persons in the population under study, we have:

$$\frac{N(x)}{N} = r.\ \frac{N(x+)}{N} + \frac{D(x+)}{N} \ \ldots\ldots (9)$$

and on the other side:

$$\frac{D(x+)}{N} = \frac{D(x+)}{D} \cdot \frac{D}{N}$$

$$= \frac{D(x+)}{D} .. \ d \ \ldots\ldots (10)$$

where:

- D = symbolizes the total number of deceases in the population under study, and
- d = the gross mortality rate

Substituting (10) in (9) and dividing the resultant expression by $\frac{N(x+)}{N}$ we obtain:

$$\frac{N(x)}{N} \Big/ \frac{N(x+)}{N} = r. \frac{N(x+)}{N} \Big/ \frac{N(x+)}{N} + d \frac{D(x+)}{D} \Big/ \frac{N(x+)}{N}$$

$$\frac{N(x)}{N(x+)} = r+d \frac{D(x+)}{N(x+)} \frac{N}{D} \quad \ldots\ldots \quad (11)$$

which is the technique's second variant.

The application of this method is a very simple one, as all necessary function to solve the equations can be directly calculated, except for the number of persons at an exact age x (N(x)). This information is not available, in general.

An estimation that can be considered as acceptable may be obtained from the population distribution by age groups which in the case of the 5-year age groups, is as follows:

$$N(x) = \frac{N_{(x-5,x-1)} + N_{(x,x+4)}}{10}$$

That is, a simple assumption is made, "It is assumed that the number of persons at a determined age is equal to the tenth part of the sum of the population contained in the two succesive 5-year age groups whose central age is the age for which the population is to be calculated".

In general, the most significant proof that these are reliable data and that they can be used to provide a mortality estimation, is the fact that when the quotient values N(x)/Nx+ are graphed in the ordinates axis, and the quotient values Dx+/Nx+, $\frac{Dx+}{Nx+} \frac{N}{D}$ are graphed in the abscissas axis, whether it is the first or second variant the points that may result indicate an approximate lineal tendency.

REFERENCES

1/ Indicates one per thousand
2/ Most methods assume constant fertility and mortality
3/ See methodological basis
4/ This factor was obtained with data on age at the time of dying

BIBLIOGRAPHY

BRASS, W., Hill, K., "Estimating adult mortality from orphanhood". International Population Conference, Vol. 3, Lieja, Unión Internacional para el Estudio Científico de la Población, 1973.

BRASS, W., Métodos para estimar la fecundidad y la mortalidad en poblaciones con datos limitados, CELADE, Serie E, No. 14, Santiago de Chile, 1974.

BRASS, W., Cuatro Lecciones de William Brass, CELADE, Serie D, No. 91, Santiago de Chile, 1977.

CASTELLANOS, R. Adrián, Honduras: Estimaciones demográficas a partir de la estructura por edad de las defunciones. 1971, Centro Latinoamericano de Demografía. San José, Costa Rica, junio, 1976.

COORDINACION GENERAL DEL SISTEMA NACIONAL DE INFORMACION, ISUNAM, Encuesta Mexicana de Fecundidad, Secretaría de Programación y Presupuesto, México, 1978.

COORDINACION DEL PROGRAMA NACIONAL DE PLANIFICACION FAMILIAR, Encuesta Nacional de Prevalencia en el Uso de Métodos Anticonceptivos con Módulo Fecundidad/Mortalidad: Documento Metodológico, México, 1980

COORDINACION DEL PROGRAMA NACIONAL DE PLANIFICACION FAMILIAR, Encuesta Nacional de Prevalencia en el Uso de Métodos Anticonceptivos, México, Resultados Nacionales, México, 1979.

DIRECCION GENERAL DE ESTADISTICA, Anuarios Estadísticos, Resumen General, Secretaría de Industria y Comercio, (various).

DIRECCION GENERAL DE ESTADISTICA. IX Censo General de Población, 1970. Resumen General, Secretaría de Industria y Comercio, January 28, 1970, México, D.F., 1972

FEENEY, Griffith. Estimación de Tasas de Mortalidad Infantil a partir de Información de Sobrevivencia de Hijos Clasificados por Edad de la Madre, CELADE, Santiago de Chile, June, 1977, Serie D, No. 87.

HILL, H. Kenneth and Trussell, James. Nuevos adelantos en la estimación indirecta de la mortalidad, CELADE, Santiago de Chile, Serie D, No. 89, 1977.

JOHNSON, D. Peter. Estimating Infant Mortality Using Information on the Surviv al Status of Births in the Year Prior to a Census or Survey, 1980. (Mimeographed).

NACIONES UNIDAS, Métodos para Establecer Mediciones Demográficas Fundamentales a partir de datos incompletos, Manual IV, New York, 1968.

SULLIVAN, J.M. "Models for the Estimation of the Probability of Dying between Birth and Exact Ages of Early Childhood" Population Studies 26(1), 1972, pp. 79-97

TRUSSELL, T.J. "A Re-Estimation of the Multiplying Factors for the Brass Technique for Determining Childhood Survivorship Rates". Population Studies 29(1), 1975, pp. 97-108.