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An Assessment of the Method of Adult Mortality Estimation from Information on Widowhood

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Abstract

In less developed countries, both traditional and non-traditional methods of mortality estimation have not been successful in providing complete and accurate information on mortality. To substitute these methods Demographers have tried to develop indirect methods of mortality estimation. For estimating adult mortality two methods based on orphanhood data and widowhood data are being developed. There is a fair literature on the theoretical background and practical application of these methods and by critically reviewing this scattered literature, the suitability and applicability of them can be assessed. The information for the method of widowhood can be collected by asking the simple question "Is your first husband/ wife alive". The proportion can be converted to life table probabilities using model schedules of mortality, fertility, and nuptiality. The robustness of the method depends largely of the assumptions of the method. Some assumptions are not crucial. However the assumption on the independent of the mortality risks of respondent and spouse should be examined critically. Further development of the method should be carried out using computer simulation rather than depending on plausible estimates achieved by application of the method.

Introduction

Mortality rates classified by age and sex are important for several reasons for both developed and developing countries. Particularly, they are essential for calculating population growth, making population projections, economic and social planning, assessing the effects of health programmes, and for taxation and insurance purposes. The traditional way to obtain information about mortality is through vital registration system combined with regular population censuses and surveys.

In developed countries these systems yield sufficiently accurate estimates of mortality, so there is no need to seek for alternative ways of deriving mortality estimates. However, only a few developing countries have established registration systems. As Blacker (1977: 107) mentions, “Until recently virtually nothing was known about the levels and patterns of adult mortality in Tropical Africa. There is no country in the region which has a reliable system of vital registration”. Even in some remote sectors of Asian countries like Bangaladesh, Pakistan, India reliable data on mortality is not available.

The non-traditional methods of obtaining information on mortality have also been not successful in many developing countries due to several reasons:

- The method of Inter Censual Survivorship introduced by the United Nations (UN) (1967) and established by Carrier and Hob Craft (1971) has failed because of poorly recorded international migration, the absence of censuses, the poor quality of coverage, and errors of age reporting.
- The method of retrospective demographic enquiry requires long interviews and highly trained interviewers. Since the reporting of ages and dates is involved, the return may be in very poor quality.
- The method of sample vital registrations is a direct substitute for complete registration of vital events. The selected areas may contain a majority of families who see no advantage in reporting vital events (Brass 1971). For the effectivenessof the method the registrar must know the people in his area well, which implies the population must be small.

- In serial-visit vital-event surveys enumerators, who visit the households in the sample at regular intervals, report the vital events which happened in those intervals. This method is expensive and requires highly skilled manpower. A large number of visits may be required to record relatively few events.
- The dual systems of obtaining information on vital events combine continuous registration and periodic household surveys. The information provided by a census or a survey is matched with the records of continuous registration. Coale (1975) points out that if the two systems are not independent, the number of events is subject to under-estimation. The determination of matched vents may be difficult. Other versions of dual systems consist of two sets of surveys one conducted frequently and the other less frequently.

Since both the traditional methods and non-traditional methods have not been successful in providing complete and reliable data in some less developed countries, Demographers have developed indirect methods of mortality estimation to supplement these methods. Some of these methods have already been established but some methods need further examination. Two important indirect methods which have been developed for estimating adult mortality are the method based on information on orphanhood and the method based on information on widowhood. The aim of this paper is to critically assess the method based on widowhood and examine the possibility of applying this method widely paying special attention to the assumptions. The method will be compared with the orphanhood method where appropriate.

Theoretical Foundation

The indirect methods of mortality estimation are based on the information obtained on variables which are closely related to adult mortality. One such variable is the proportion of married adults in an age, or marriage-duration group whose spouses are alive. This proportion is largely determined by adult mortality rates although age patterns of first marriage and remarriage rates also have an effect. If the effects of these other factors can be allowed for, then it is possible to use information on widowhood to estimate adult mortality.

The effect of remarriage can be removed by confining attention to first spouses. For simplicity, I shall use the term ‘widows’ rather than ‘married adults whose first spouses are dead’. Also I shall use the term ‘marriage duration’ for the time elapsed since the date of first marriage, even in the case of widowed or remarried persons.

The method was first proposed by Hill (1975). In a subsequent paper in 1977, he described the theoretical basis of the method and applied it to data from Bangladesh. Application of the method when the information is tabulated according to duration of marriage rather than age was considered by Hill and Trussell (1977) who also developed a regression approach rather more general than the approach by Hill (1977). Some encouraging results about the determinates of mortality in Russian Federation were obtained by Martin et al (2002) applying indirect technique using widowhood data after the Russian mortality crisis.

The Relation between Widowhood and Adult Mortality

Formulae will be developed for the widowhood of male respondents; the arguments for female respondents are entirely analogues (although the method is more robust when applied to female respondents.)

The following are assumptions of the method:

(1) Age- specific mortality and fertility rates and first-marriage frequencies have remained constant for a reasonably long period;

(2) The survivorship of the respondent is independent of the survivorship of the spouse;

(3) All men marry at the same age m*, the mean age of the female first-marriage;

(4) Mortality is independent of marital status, that is the same age-specific rates apply to unmarried, married, widowed, and divorced adults.

Let the age distribution of women z years ago be $A_z(y)$; let g(y) be the first-marriage frequency of women at age y (the ratio of the number of first marriage at age y to the total number of women aged y); and let (u,v) be the age range over which female marriage take place. Then the number of women who married z years ago can be written

$$\int_u^v A_z(y)\, g\,(y)\, dy. \qquad (1)$$

The number of these women now alive, after z years of marriage, will be

$$\int_u^v A_z(y)\, g\,(y)\; \frac{\ell(y+z)}{\ell(y)}\, dy \qquad (2)$$

where $\ell\,(y)$ is the probability of surviving from birth to age y in the female life table. The number of presently alive men who married z years ago is

$$\frac{\ell^*(m^*+z)}{\ell^*(m^*)} \quad \int_u^v A_z(y)\, g\,(y)\, dy \qquad (3)$$

where $\ell^*(.)$ refers to survivorship in the male life table, and the number of these whose first wives are still alive now is

$$\frac{\ell^*(m^*+z)}{\ell^*(m^*)} \quad \int_u^v A_z(y)\, g\,(y) \quad \frac{\ell(y+z)\, dy}{\ell(y)}. \qquad (4)$$

Thus, the proportion of men married z ago who are not presently widowed is

$$S^*(z) = \frac{\int_u^v A_z(y)\, g\,(y)\, \frac{\ell(y+z)}{\ell(y)}\, dy}{\int_u^v A_z\,(y)\, g\,(y)\, dy}. \qquad (5)$$

Because of the assumptions (2) and (3), the survivorship factor for the men has cancelled out. On the basis of assumption (1) we may substitute a stable form for

$$A_z(y) = B\, e^{-r(z+y)}\, \ell(y) \qquad (6)$$

where B is the number of female births in the current year and r is the natural rate of increase of the female population. Thus, (5) becomes

$$S^*(z) = \frac{\int_u^v e^{-ry} g(y)\, \ell\,(y+z)\, dy}{\int_u^v e^{-ry}\, g\,(y)\, \ell\,(y)\, dy}. \tag{7}$$

Now consider a group of men who first married between i and i+5 years ago. The number of such men now alive is

$$\int_i^{i+5} \frac{\ell^*(m^*+z)}{\ell^*(m^*)} \int_u^v B e^{-r\,(y+z)} g\,(y)\, \ell\,(y)\, dy\, dz \tag{8}$$

and the number of them not presently widowed is

$$\int_i^{i+5} \frac{\ell^*(m^*+z)}{\ell^*(m^*)} \int_u^v B e^{-r\,(y+z)} g\,(y)\, \ell\,(y+z)\, dy\, dz \tag{9}$$

Thus the proportion not widowed in the group is

$${}_5\overset{*}{S}_i = \frac{\int_i^{i+5} \ell^*(m^*+z) \int_u^v e^{-r(y+z)}\, g(y)\, \ell\,(y+z)\, dy\, dz}{\int_i^{i+5} \ell^*(m^*+z) \int_u^v e^{-r(y+z)}\, g\,(y)\, \ell\,(y)\, dy\, dz} \tag{10}$$

For a group of ever-married men aged between n and n+5 years, duration of marriage will be between n-m* and n-m*+5 thus the proportion not widowed will be

$${}_5\overset{*}{S}_n = \frac{\int_{n-m^*}^{n-m^*+5} \ell^*(m^*+z) \int_u^v e^{-r(y+z)}\, g(y)\, \ell\,(y+z)\, dy\, dz}{\int_{n-m^*}^{n-m^*+5} \ell^*(m^*+z) \int_u^v e^{-r(y+z)}\, g\,(y)\, \ell\,(y)\, dy\, dz} \tag{11}$$

Equation (10) and (11) is used according as information on date of first marriage or age is obtainable from respondents.

Hill (1977) calculated some model values of ${}_5\overset{*}{S}_n$'s for different values of two variables, (i) the respondents' age at marriage, determining exposure to risk at a given age, and (ii) their spouses' age at marriage, determining widowhood probabilities for a given exposure to risk.

He used the female first marriage distribution as $g\,(y) = y^{\frac{1}{3}}(30-y)^4$ which is intended to represent the middle ground between the rapid first marriage in parts of South East Asia to much leisurely rates for South America. One advantage of using a simple polynomial to represent the first marriage distribution is that only one parameter need to be specified, that is the mean age of first marriage. But for using model nuptiality schedules, two fitting parameters are required, one for mean, and one for the rate at which marriages then occur. The survivorship probabilities were taken from Brass's two parameter model life tables and the rate of population growth was assumed to be two percent per annum.

The multiplying factors for converting ${}_5S_n$ values into conventional life table measures can be calculated by equating the model life-table survivorship probabilities to the weighted mean of proportions not widowed in two adjacent age groups. The exposure to risk of widowhood for a respondent at a particular age varies with the mean age at marriage, so it is sensible to use different estimating equations for very different means. Hill (1977) suggests the equation for male respondents whose mean age at first marriage is below 25, as

$$\frac{\ell\,(n-5)}{\ell\,(17.5)} = W^*(n)\ {}_5\overset{*}{S}_{n-5} + (1 - W^*(n))\ {}_5\overset{*}{S}_n \qquad (12)$$

For age groups 25 – 29 and 30 – 34 years, n equals 30, so the survivorship ratio is $\frac{\ell\,(25)}{\ell\,(17.5)}$, a survivorship of $7\frac{1}{2}$ years from age $17\frac{1}{2}$. When the mean age of first marriage for males is between 25 and 30 he suggests the equation

$$\frac{\ell\,(n-5)}{\ell\,(22.5)} = W^*(n)\ {}_5\overset{*}{S}_{n-5} + (1-W^*(n))\ {}_5\overset{*}{S}_n \qquad (13)$$

which has a different starting point and duration of exposure, more suitable for situation where most of the males' first marriage occur at later ages.

The values of W(n) 's were calculated by Hill (1977) for both male and female respondents. For male respondents calculations were for two different values of mean age of male first marriage, m*, :23 and 27 years. These values have been published for n=25, 70 (5) and mean age of female first marriage , m=15,22(1) when m* is 23 years, and for n=25, 70 (5) and m=17, 24 (1) when m* is 27 years.

Applying the Method

For the application of the method, required information can be collected by asking the simple question "Is your first husband/wife alive?". Difficulties may be expected only in populations where prolonged separation of couples is common. Responses may be grouped by age of respondent of according to the date of first marriage, although the latter is likely to be difficult to determine in some population. The observed proportion of male respondents who are not widowed, ${}_5\overset{*}{S}_n$, can be converted into conventional life-table measures by use of either.

$$\frac{\ell\,(n-5)}{\ell\,(17.5)} = W^*(n)\ {}_5\bar{S}^*_{n-5} + (1-W^*(n))\ {}_5\bar{S}^*_n \qquad (14)$$

or

$$\frac{\ell\,(n-5)}{\ell\,(22.5)} = W^*(n)\ {}_5\bar{S}^*_{n-5} + (1-W^*(n))\ {}_5\overset{*}{S}_n \qquad (15)$$

depending on whether the value of m* is below 25 or between 25 and 30 respectively. The relevant values of w*(n) 's can be selected form table appropriate to the values of m and m* estimated approximately for population in question. The same procedure can be followed for the estimation of adult male mortality from observed proportions of female respondents not widowed, ${}_5\bar{S}_n$. The estimating equation suggested by Hill (1977) in this case is:

$$\frac{\ell^*(n+5)}{\ell^*(22.5)} = W(n)\ {}_5\bar{S}_{n-5} + (1-W(n))\ {}_5\bar{S}_n \qquad (16)$$

when m is below 20, and

$$\frac{\ell^*(n+5)}{\ell^*(27.5)} = W(n)\ {}_5\bar{S}_{n-5} + (1-W(n))\ {}_5\bar{S}_n \qquad (17)$$

when m is above 20.

Further Developments of the Method

Hill and Trussell (1977) used regression techniques to obtain survivorship probabilities from proportions not widowed according to the age of respondents, and according to the data of first marriage of respondents. The probability of survival to age 2, ℓ (2), was taken into account amongst the explanatory variables, both in the age model and in the duration model so that survivorship from birth could be taken as the dependent variable.

For the age model, the other explanatory variables employed were the proportion not widowed in five-year age-groups, the mean age of first marriage for males, and the age of first marriage for females (as in section 3.4.2). Thus for female respondents, an equation of the form

$$\ell(n) = a + bm + cm^* + d\ {}_5\overset{*}{S}_n + e\,\ell(2) \qquad (18)$$

was fitted, where a, b, c, d and e are regression coefficients. For each of eight values of n, n =25, 60 (5), nine hundred sets of values of the variables in this equation were generated using all possible combinations of the following model schedules.

(i) Ten schedules of females nuptiality obtained by combining two possible values for the earliest age of first marriage, 13 and 15 years, with five possible values for the mean age of first marriage, m = 16, 24(2)

(ii) Fifteen schedules of male nuptiality obtained by combining three values for the earliest age of first marriage, 15, 17 and 19, with five values for the mean age of first marriage, m = 20, 28 (2)

(iii) Six schedules of mortality from Brass's two parameter logistic life-table system, corresponding to the expectation of life at birth. The equation (18) was then fitted by least squares, using 900 model values and an excellent fit was obtained in all cases.

For the duration model, the equation fitted for female survivorship was of the form

$$\ell\,(n) = a + bm + c\ {}_5\overset{*}{S}_i + d\ \ell\,(2) \qquad (19)$$

The important difference between this equation and equation (18) is that the mean age of first marriage of the respondent was not included as an explanatory variable. Hill and Trussell (1977) argued that the mortality factor for the respondent within a five-year duration group could be ignored in calculating proportions not widowed. Thus the age of respondents cannot be expected to be effective explanatory variable in the duration case. As in the age model, the equation (19) was fitted by least squares using 648 sets of values of the variables as generated from various combination of the schedules. The equation (19) was also found to give an excellent fit for each value of n.

The regression coefficients in both equation (18) and (19) have been estimated by Hill and Trussell (1977) and in practice tables provided by them can be sued to convert proportions of male respondents not widowed into conventional female life-table survivorship probabilities. The same approach can be adjusted to estimate adult male mortality from ${}_5S_n$ or ${}_5S_i$ values without any difficulty.

Suitability of the Method for Less Developed Countries

Widowhood has certain advantages over orphanhood on which the other indirect method is based as a source of information about adult mortality. There is generally only one response per person. The assumption of constant vital rates is not very serious in this case, since the method can give reasonable mortality estimates for short exposure to risk at recent vital rates. There is no equivalent for widowhood of the adoption effect in orphanhood. The estimates are likely to be most satisfactory for male mortality where the orphanhood method is most doubtful. Although the mortality experience of never-married persons is not represented, the results may not be much affected since in developing countries, in general, a very high proportion of the total population is married. The method proves to be satisfactorily robust to variations in levels and patterns of mortality and nuptiality. Using Irish data, Hill (1977) concludes that the drastic simplification of using a marriage mean instead of a distribution has a serious effect only for young respondents.

As in the orphanhood method, the widowhood method has some potential biases. The robustness of the method to deviations from the assumption has not yet been fully investigated. Both the widowhood and orphanhood methods have some potential bias. In the orphanhood method mortality experience of the childless population is totally unrepresented. This may be higher than the mortality of the fertile population. If this is the case the mortality for the population as a whole is underestimated. The proportion of surviving mothers is estimated by proportion of surviving children with surviving mothers. Thus, a mother with two surviving children (within a 5-year age group) is reported twice and a women with one surviving child only once. This will introduce a bias if mother who bear several children within a 5-year interval have different survivorship from those who bear only one child. In the widowhood method the relationship between the mortality risks of respondent and spouse will introduce a bias. Unlike in the orphanhood method, the determination of the exposure to risk is not very easy unless the information about widowhood is available by duration of marriage. However, this involves the sort of dating of events that indirect method are intended to avoid. Also the information on marriage in developing countries is very often suspected, because of difficulties of definition.

This method is based on information which has very rarely been obtained from censuses and surveys. The necessary information has been collected in only two surveys, one in Bangladesh (1974) and one in Honduras (Hill 1977). Hill (1975) has obtained very plausible and consistent mortality estimates for Bangladesh by applying this method. More applications and experiments are required before it can be accepted as an alternative method of estimating adult mortality in developing countries.

During the Russian mortality crisis of the early 1990s concerns had been raised about the validity of official mortality data. The indirect technique based on widowhood data have been applied to study mortality pattern in Russian Federation and results are consistent with the mortality pattern observed in official mortality data. The main conclusion of this project is the indirect technique is useful tool to study the determinations of mortality in the Russian Federation and other populations, where reliable or sufficiently extensive data are not available. The applications of the widowhood method so far in less developed countries have resulted some encouraging results.

However to examine the robustness of this method a simulation study would be a better approach. It seems farther research would be useful based on computer simulation in order to assess the capability of the method in producing better mortality estimates.

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