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Estimation of Infant and Child Mortality : An Application of W. Brass's Method

IN the absence of complete recording of vital events it is difficult to know the actual levels and changes which are taking place with respect to the country's demographic parameters. Although in India during 1964-65 a registration system(SRS) was launched in order to obtain reliable estimates of births and deaths at both state and national levels, it is clear from the Scheme's name that estimates are derived only as a sample basis.

Given underreporting of deaths in the SRS, the approach adopted here is to estimate mortality by means of so-called "indirect methods of estimation."

In this paper we illustrate the application of W. Brass's child mortality method to rural and urban data for Rajasthan.

Data Sources

Data for this paper comes from the fertility survey of 1972. This provides information on numbers of children ever born and surviving by age of ever-married women at the time of survey. On the basis of data on children surviving by age of ever-married women, we have computed proportions of children dead for both rural and urban areas of Rajasthan. It is reasonable to assume that there were no births occurring outside marriage in Rajasthan. Therefore, the number of children ever-born and surviving from ever-married women could be used without seriously affecting results against the children ever born and surviving by age of women.

Methodology

The proportion of children dying usually increases with age of mother. This is because children of older women have been exposed to the risk of mortality over a longer period. Methods for converting the proportion of children dead into standard measures of infant and child mortality have been devised by Brass, 1968, Sullivan, 1972 and Trussell, 1975.

The proportions of children dead Di which have been affected by mortality also vary according to the age of onset of childbearing in the society. The children of mothers who on average started their childbearing at younger ages, will on average be older than the children of those who started their childbearing later. Therefore, to reiterate, age of onset of childbearing has to be taken into account in selecting appropriate multiplying factors. Brass suggested three possible location factors in selecting multiplying factors. The first index is P_1/P_2. (The ratio of the mean number of children born per woman in the 15-19 and 20-24 years age groups). The second index suggested was P_2/P_3 and the third measure is *m,* the mean of the age specific fertility distribution. This is generally calculated from age specific fertility rates. These are multiplyed by the mid-year point of the five year age groups of women in the reproductive span. The sum is then divided by the sum of the age specific fertility rates and outcome will be *m.* This *m* value again requires allowance for one half year displacement and we have to subtract 0.50 year from the actual *m* value because age specific fertility rates are based on the births occurred during last one year.

Brass suggested after several studies that the original rule suggested was that where possible, P_2/P_8 should be used to determine the factors for the first three age groups and *m* for the later ones. Subsequent studies have indicated that the single indicator P_2/P_s is an adequate choice of a location parameter since P_1 is sensitive to age reporting errors at the start of childbearing and also sample fluctuations due to the relatively small numbers of births to women aged 15-19 years. -P_2/P_3 is particularly satisfactory for the estimates q_2, q_3, and q_5 which are the most reliable estimates obtained by the procedure (Brass, 1976).

Here we have used P_2/P_3 index as a location factor in selecting Brass multiplying factors. Our P_2/P_3 values required linear interpolation between columns in Brass's table (Brass, 1968). The proportions of children dying for each age group of mothers was then multiplied by these multiplying *(k)* factors shown in column 5 to give column 6 of Table 1 and 2 for both rural and urban areas respectively.

As the q_1 value is based on reported children dead of the 15-19 age group of women it is highly sensitive to the shape of the fertility distribution. And children of very young mothers are liable to suffer higher than average mortality (i.e. introduce so-called age and parity effects).

The estimated q_1 q_z, q_3 and q_b values also suffer from age biases as well as time and sample fluctuations. To reduce these we have derived a 'graduated q_2. This was done using the logit life table system. The logits of the estimated q_z, q_3 and q_5 values were viewed with respect of the corresponding logits in a model

TABLE 1-ESTIMATING INFANT AND CHILDHOOD MORTALITY FROM FERTILITY DIFFERENTIALS SURVEY 1972 FOR RURAL RAJASTHAN

Age Group of Women	*Mean Children Born per Woman* *Pi*	*Proportion of Children Dead* *Di*	*Probability of Dying* q_x	*Multiplying of Factor* K^*_i	*Estimated Probability of Dying* q_x	*Fitted Model Life Table (Brass) General Standard*
1	2	3	4	5	6	7
15-19	0.34	0.142	q2	0.990	0.141	0.132
20-24	1.38	0.166	q_2	1.017	0.169	0.171
25-29	2.87	0.195	q_3	0.998	0.195	0.188
30-34	4.36	0.205	q_S	1.005	0.206	0.205
35-39	5.61	0.223	q_{10}	1.014	0.226	0.223
40-44	5.43	0.223	q_{15}	0.991	0.221	0.236
45-49	5.36	0.230	q_{20}	0.989	0.227	0.257

*Guide for selection of multiplying factors *(k)*

0) *Pull's* = 1.38/2.87 = 0.481

(ii) *k* multiplying factors taken from Brass and Coale, 1968 page 108.

TABLE 2—ESTIMATING INFANT AND CHILDHOOD MORTALITY FROM FERTILITY DIFFERENTIALS SURVEY 1972 FOR URBAN RAJASTHAN

Age Group of Women	*Mean Children Born Per Woman* *Pi*	*Proportion of Children Dead* *Di*	*Probability of Dying* q_x	*Multiplying Factor* kr	*Estimated Probability of Dying by Age x* *qx*	*Fitted Model Life Table General Standard (Brass)*
1	2	3	4	5	6	7
15-19	0.45	0.073	q_l	0.947	0.069	0.084
20-24	1.55	0.110q_2		0.993	0.109	0.110
25-29	2.99	0.119q_3		0.984	0.117	0.123
30-34	4.53	0.144q_5		0.993	0.143	0.135
35-39	5.20	0.140	q_{10}	1.002	0.140	0.147
40-44	5.17	0.167	q_{15}	0-977	0.163	0.157
45-49	5.31	0.213	q_{20}	0.975	0.207	0.173

*Guide for selection of multiplying factors *(k)*

(i) P_2/p_3 = 1.55/2.99 = 0.518

(ii) *k* multiplying factors were taken from Brass and Coale, 1968 page 108.

life table. Here in the absence of reliable detailed information on the precise age pattern of child mortality, we have used Brass's General Standard Life table to graduate the estimated results.

The logits of the estimated q_x values for ages 2, 3 and 5 were subtracted from the model logit values and the average differences obtained for rural and urban areas were —0.075 and —0.328 respectively. The procedure of calculation is shown in Tables 3 and 4.

TABLE 3—ESTIMATING GRADUATED q_t FOR RURAL RAJASTHAN AND FITTING THE MODEL LIFE TABLE ON THE BASIS OF BRASS GENERAL STANDARD LIFE TABLE

Survivors at age 1x	*Observed values 1x*	*Logit* $\frac{1}{2}\log e\left(\frac{1-1x}{1x}\right)$ *Y1x*	*Standard life table YS1x*	*Logit of standard life table*	$Y1x = \alpha + Ys1x$ $\alpha = Y1x - Ys1x$ *(col. 3-5)*
1	*2*	*3*	*4*	*5*	*6*
l_a	0.859	-0.844	0.807	-0.715	-0.098
1,	0.805	-0.741	0.788	-0.655	-0.054
]$_6$	0.794	-0.675	0.769	-0.602	-0.073
				Toial	-0.225

Average logit difference $= -0.225/3 = -0.075$

The graduate q_2 value is calculated as :

$$Y1_2 = \alpha + \beta YS1x \qquad \text{(where } \beta = 1.0 \text{ central value was fixed)}$$

$$Y1_2 = -0.075 + (-0.715)$$
$$= -0.790, ..$$

$\left(\text{logit retransformation by following formula : } 1x = \left(\frac{1}{1+e^{2Yx}}\right)\right).$

$$1_2 = 0.829 - q_2 = 0.171$$

Estimating infant mortality for rural areas of Rajasthan :

$$Y1_1 = \alpha + YS1_1$$
$$= -0.075 + (-0.867)$$

$= -0.942$— (retransformation of logit value -0.942 which will give us 1_1 and q_1).

$$1_1 = 0.868$$
$$q_1 = 0.132$$

TABLE 4—ESTIMATING GRADUATED q_2 FOR FITTING THE MODEL LIFE TABLE ON THE BASIS OF BRASS GENERAL STANDARD LIFE TABLE FOR URBAN, RAJASTHAN

Survivors at age x lx	*Observed values* lx	*Logit* $\frac{1}{2} \log e \left(\frac{1-lx}{lx}\right)$ Ylx	*Standard life table* Slx	*Logit of standard life table* $YSlx$	$Ylx=\alpha+YSlx$ $\alpha=Ylx-YSlx$ ((col. 3-5)
1	*2*	*3*	*4*	*5*	*6*
l_2	0.891	−1.050	0.807	−0.715	−0.335
l_3	0.883	−1.011	0.788	−0.655	−0.356
l_5	0.857	−0.895	0.769	−0.602	−0.293
				Total	−0.984

Average logit difference= −0.984/3= −0.328.

The graduated q_2 value is thus calculated as :

$Ylx = \alpha + \beta\ YSlx$ (Where $\beta = 1.0$ central value was fixed).
$Yl_2 = -0.328 + (-0.715)$
$= -1.043$
$l_2 = 0.890$ (retransformation of logit value -1.043 to l_2).
$q_2 = 0.110$

Estimating infant mortality for urban areas of Rajasthan :

$Yl_1 = \alpha + YSl_1$
$= -0.328 + (-0.867)$
$= -1.195$
$l_1 = 0.916$ (retransformation of logit value -1.195 to l_1 and q_1.
$q_1 = 0.084$

Brass's system is based upon the fact that the straight line relationship between the level of mortality and the shape of the mortality curve can be explained by two parameters α and β (Brass, 1976). The basic equation is as follows.

$$Ylx = \alpha + \beta SYlx \quad (1)$$

Where Ylx = logit of lx (persons survived at exact age x)
α = level of mortality,
β = shape of mortality curve
$SYlx$ = logit of lx value in model life table.

This has been reduced to one parameter by fixing (3 equal to the its central value of 1.0. So the final equation with the present observed values infant and child mortality becomes.

$$Ylx = -0.075 + SYlx \qquad \text{Rural} \quad (2)$$

$$YLx = -0.328 + SYlx \qquad \text{Urban} \quad (3)$$

On the basis of the above equation we have constructed full fitted life tables up to age 20 for rural and urban Rajasthan using General Standard Model Life table. The results are shown in columns 7 of Tables 1 and 2 for rural and urban separately.

Comments on the Results

The estimated results of urban early childhood mortality from the Brass multipliers exhibit reasonable consistency. The q_a estimation of child mortality by fitted model values clearly shows the satisfactory consistency with earlier estimates, and the deviation is quite small. However, the fitted values are greatly dependent upon the mortality pattern of selected model life tables and even when we apply other life tables such as the model life tables of Coale and Demeny (1966), it gives the small deviation in the results from the Brass's General Standard Life table. However, this deviation was not mainly due to the use of the method, but due to the mortality pattern of the model life tables.

The results obtained for the rural areas are shown in columns 6 and the graduated values in columns 7 of Table 1. The estimated q_l g_2, q_3 and q_5 mortality values with fitted model life table values exhibit small deviation except the q. This was possible due to the effects of age misreporting at the start of child-bearing or due to the relatively small numbers of births to women age 15-19 years. The deviation between the fitted model and the estimated values indicates that the mortality pattern was perhaps similar in rural Rajasthan as compared to the General Standard Life table. The second point which was more speculative relates to the results on average ever born alive children. The children per ever married woman in rural areas were lower than for urban areas in the 15-19 age group to 34-39 ages, that was highly suspected reporting in Fertility Differentials Survey 1972. Which again effected the fitted values on the basis of average « values. At the later ages it was clearly due to a higher rate of omission of births by older women.

Finally, it can be concluded that (i) the true infant mortality level q_L in rural Rajasthan probably falls between 0.132 and 0.141. This level of infant mortality was also supported by the sample registration system data independently with estimates as follows: 0.127 (1971) and 0.132 (1972) (Desai, 1979). In the case of urban areas it may well fall between the 0.069 and 0.084, and the corresponding

SRS estimates are 0.082(1971), 0.076 (1972) (Desai, 1979) and 0.078 (1974) (Govt. of India, 1980); (ii) the single locational factor P_2P_3 index provides good consistency especially for child and infant mortality estimates and; (iii) the method also provides good estimates with consistency.

Estimates of Infant Mortality and Years Prior to the Survey (Time Location)

The estimates of trends in infant mortality from child survivorship data by age of mother obtained using by Feeney's techniques (1976) are also based mainly on similar conditions as Brass's method. The only difference is that Feeney's techniques provide infant mortality rate trends over the period of approximately fifteen years prior to the survey and admit of mortality over time, although it does not require the knowledge of the rate of change.

The proportions of children dead were worked out from the number of children ever born and proportions dead by age of women at the time of survey. On the basis of the mean parity of children born to women aged 15-19 (P_1), 20-24 (.$P_{1+]}$) and so on. The ratio of the first two parities was calculated as 0.290 for urban areas of Rajasthan. This value was located in the left column of display 1 (Feeney, 1976) and the mean age at childbearing was estimated at 27.0 years with the help of display 1. The same procedure was repeated with the mean parities for the age groups 20-24 and 25-29; the estimated mean age at childbearing was 27.0 and 29.0 years respectively. The final estimated mean age at childbearing was taken as the mean of these three values i.e. 27.67 years. After obtaining estimates of the mean age of childbearing and proportions of children dead for rural and urban areas by using the formulae given in the display 2 (Feeney, 1976), we calculated the infant mortality estimates and results are shown in the Table 5 for rural and arban areas of Rajasthan. The child mortality time location comparative values are shown in the Table 6 by Feeney, 1976, Bamgboye (1982) and Brass (1982).

TABLE 5—ESTIMATING INFANT MORTALITY BY FEENEY'S TECHNIQUES FOR RURAL AND URBAN RAJASTHAN FROM FERTILITY SURVEY 1972

Age group of women	*Mean parity ratio*		*Mean age at child-bearing*		*Infant mortality rates (per 1,000 Births)*	
	Rural	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*
15-19	0.246	0.290	27.0	27.0	—	—
20-24	0.481	0.518	28.0	27.0	132	85
25-29	0.658	0.660	29.0	29.0	136	81
30-34					130	90
35-39					134	81
40-44					123	89
45-49			(Af=28.0)	W=27.67)	114	104

TABLE 6—TIME-LOCATION OF ESTIMATES OF CHILD MORTALITY FROM PROPORTIONS DEAD BY AGE OF MOTHER PRIOR TO FERTILITY SURVEY 1972 FOR RURAL AND URBAN AREAS OF RAJASTHAN

Age of women	*Feeney++*		*Bamgboye**		*Brass***	
	m=28.0 Rural	*m=27.67 Urban*	*m=30.9 Rural*	*m=29.4 Urban*	*m=28.6 Rural*	*m=28.2 Urban*
15-19	—	—	0.99	1.24	1.26	1.34
20-24	2.67	2.79	2.19	2.78	2.82	2.95
25-29	4.66	4.79	3.74	4.68	4.72	4.90
30-34	6.92	7.04	5.57	6.84	6.96	7.24
35-39	9.51	9.63	7.68	9.22	9.39	9.58
40-44	12.57	12.73	10.33	12.00	12.12	12.36
45-49	15.82	16.00	13.84	15.41	16.20	15.75

* Bamgboye *m* was calculated from births occurred in the last one year period to all women in the age group of 15-49.

** Brass *m* was based on the mean parity ratio of P_2/P_3 and this ratio for rural and urban areas was 0.481, 0.518 respectively in Rajasthan.

++ Feeney *m*, mean age at childbearing in rural and urban Rajasthan was calculated with the help of display 1.

Bamgboye time location values have been calculated on the basis of the *m* location parameter (mean age of age specific fertility distribution) and actual values needed linear interpolation, it was followed between two nearest model values. It seems that time location of estimates of child mortality on the basis of P_2/P_3 (mean parity ratio index) by Brass model gives consistently good results as compared to Bamgboye which under estimates the time location on the basis of births in the last year *m* values in the population as against *m* values derived from P_2/P_3 by Brass. Moreover, Brass time location estimated values are also showing good consistency with the Feeney's values.

Discussion

The estimated values by Feeney's method were plotted on a graph (Fig. 1). They suggest in rural areas there was not a decline in the infant mortality rate except in recent years which may be because of differential mortality or low parities of younger mothers. The rural and urban curve clearly indicates that data suffered badly in reporting

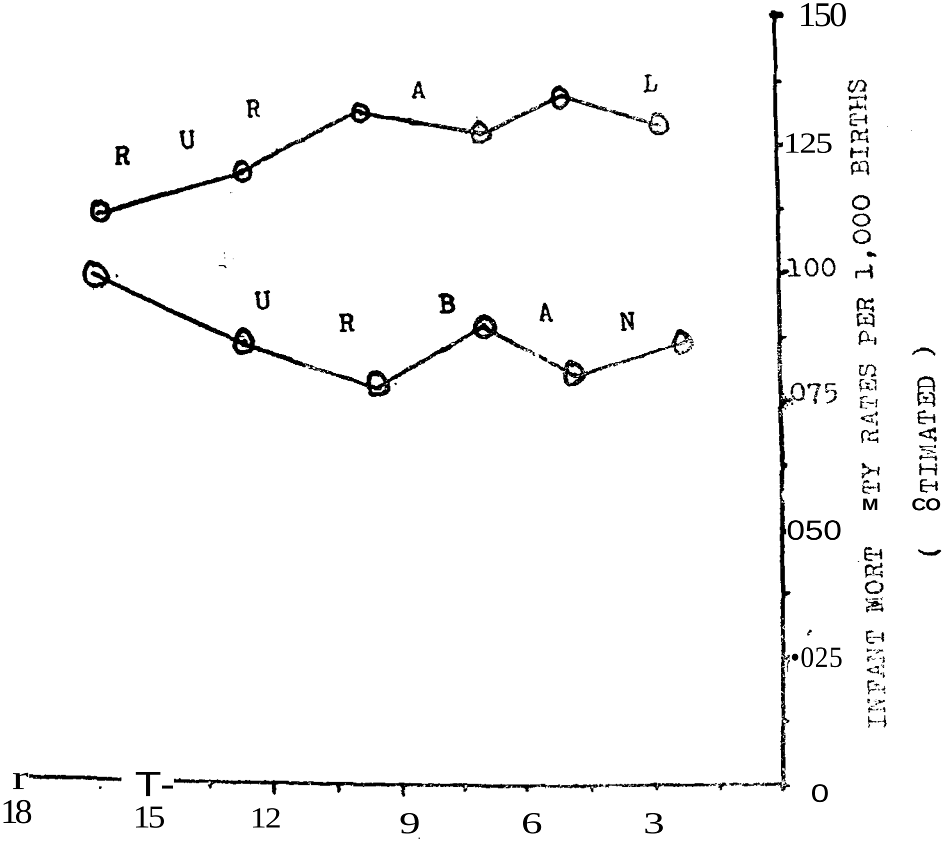

Fig. 1. Infant Mortality Trends in Rural and Urban Rajaslhan 1972 (Feeney's Trend Technique)

by the age of women. The relatively low mortality (IMR) implied by the proportion of children surviving to women aged 40-44 and 45-49 in rural areas reflect the fact that women have clearly failed to report some of their deceased children in response to the question on children ever born/dead. Feeney's method is also fully dependent upon the accuracy of data and levels of errors in reporting events by the mother to estimate the infant mortality rate and the measure of 'years prior to the survey' (Time location). However, Brass's model does not require the proportions dead by the age of mother and time location of estimates of child mortality derived on the basis of *m* values which is again calculated by using P_2IP_3 values rather than from births in the past one year. Therefore, the later ages reporting or omission of births/deaths does not make any impact on the time location estimates. This could be seen on the basis of *m* value calculated from two independent sources, i.e. last year births and P_2/P_3.

Both sources have given roughly 2.3 in rural and 1.2 years in urban as differences of m values which was rather on a little higher side for rural areas. Time location results differentials were mainly due to that discrepancy, otherwise both Bamgboye and Brass model is based on the Gompertz model. Therefore, it appears to u? that the $P_2/P3$ index gives better results as against the Bamgboyew index. In the absence of accurate reporting, in estimating births and deaths we really have to rely on models.

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