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## **The Effect of Declining Mortality on Family Dependency Burden and its Implications**

### **Introduction**

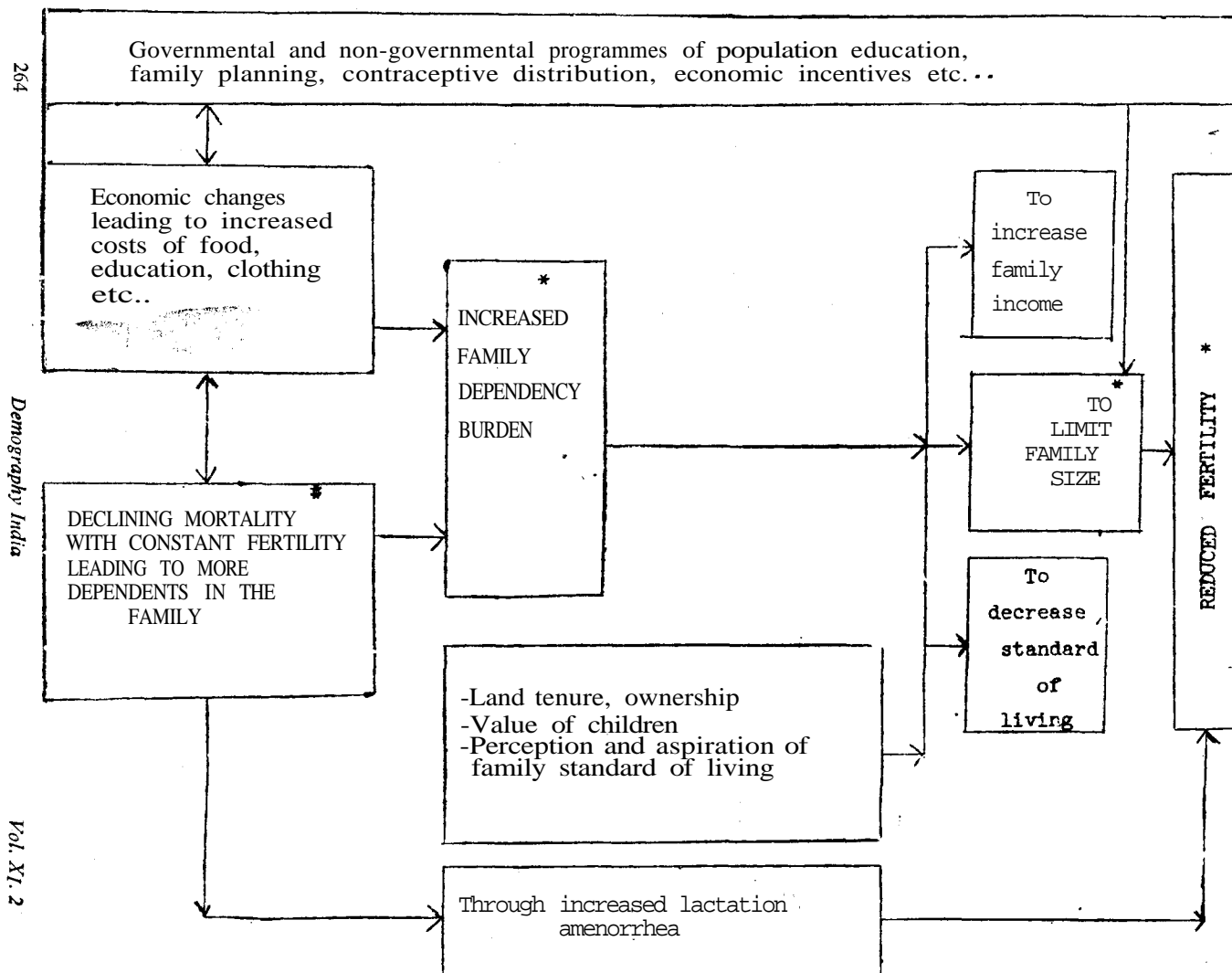
MOST developing countries have pursued efforts to reduce the incidence of mortality through public health and related socio-economic programmes; death rates in these countries have decreased and would decline in the future. The fall in mortality unaccompanied by a corresponding fall in fertility results in rapid population growth. A solution to ease this situation is to reduce fertility. Accordingly, many developing countries operate fertility control programmes both at governmental and non-governmental levels. The success of these programmes varies from country to country.

In this context, it has often been held that the failure to achieve anticipated reductions in fertility is due to the fact that until parents are sure of survival of their children to care for them in old age, they will not accept and practice family limitation.<sup>1</sup> Survival of children has been stressed in literature as an underpinning of the various fertility control programmes (Freedman 1963; United Nations 1972; National Academy of Sciences, 1971; Stycos 1965).

It is also argued that increased dependency burden on economically active (producer) family member, resulting from mortality decline leading to enlargement of family size, might motivate couples to adopt family planning methods. (Matras 1973; United Nations 1953).

1. Some evidence to the contrary is reported in M. Vlassoff and Carol Vlassoff, Old Age Security and The Utility of Children in Rural India, *Population Studies*, 34(3), 1930, p. 487-499; M. Vlassoff, Economic Utility of Children and Fertility in Rural India. *Population Studies*, 36(1), 1982, p. 45-49. Also see Rodolfo A. Bulatao, "Further Evidence of the Transition in the value of Children", papers of the East-West Population Institute, No. 6C-B, p. 45-49.

CHART I—FLOW DIAGRAM SHOWING RELATIONSHIP BETWEEN DECLINING MORTALITY AND FERTILITY THROUGH FAMILY DEPENDENCY BURDEN



\*The flow through these is investigated in the paper.

The effect of mortality decline on fertility operates in a number of ways and it is useful to distinguish between direct effects as against indirect effects that are conveyed through a number of socio-economic variables. Chart 1 attempts to show the relevant factors in the mortality-fertility relationship both through and without dependency burden. This paper is mainly concerned with demographic effects of declining mortality in increasing the dependency burden which might motivate couples to limit family size. A number of interactions between declining mortality and some of the socio-economic variables (e.g. family income, social status etc.) are excluded in the model which might probably have been incorporated but for the paucity of data.

Dependency burden can be measured in a number of ways. One way, as an economist might do, is to use the proportion of family income spent on dependents. The other way, as a demographer might do, is to use the ratio of the consumers (dependents) to producers of the family in measuring the family dependency burden. The Consumer-Producer ratio (CP-ratio) can be computed using either period data or cohort data. Here, we use cohort data on individual families.

While discussing the implications of a decrease in mortality and fertility from a high to a low level, Ryder (1975) noted that a decrease in mortality (West Model) from a level 3 to level 17 at constant fertility did not produce any impressive increase in the family dependency burden as measured by CP-ratios. Under the assumptions made in his paper a mean CP-ratio of .62 corresponding to level 3 (with NRR = 1) increased only to .72 corresponding to mortality level 17 (with NRR = 2.5). This increase of 16% in the dependency burden is meagre. Here the CP-ratios based on the model life tables and stable population are averaged over the entire life of the family. In deriving the above results Ryder makes some simplifying assumptions in regard to the definition of the family and uses an aggregate or macro model.

Muhsam (1977) has further investigated the impact of a decrease in mortality on CP-ratio with a view to examine whether a substantial decline in mortality resulted only in a small increase in CP-ratio. Basically, he used the same model of Ryder, but made some additional provisions by including widowers and widows in the producer component of the ratio. Using the same data of Ryder's model, he came out with a result that a decrease in mortality from level 3 to level 17 increased the CP-ratio from .54 to .69, an increase of 28%. Thus Muhsam by including widowers and widows in the definition of a family, arrived at a slightly more pronounced increase in CP-ratio compared to that of Ryder<sup>2</sup>. However, whether this amount of increase in CP-ratio will motivate couples to practice family limitation is a moot question. We will take up this point later.

2. Actually the methods of computation of CP-ratios adopted by Ryder and Muhsam are not the same and this contributes to some extent in the differences of their estimates.

## Model

The impact of decrease in the level of mortality on CP-ratios is re-examined with the help of a model which is more flexible and wider in scope than that used by either Ryder or Muhsam; the focus, however is on individual family rather than on the aggregate society. Two significant features of the model are : (i) it generates CP-ratios on the basis of individual family and not on the basis of aggregate families; (ii) it allows for chance factors to play a role on the individual CP-ratio and thereby helps to measure the variance in CP-ratio.

The model resembles many micro-simulation models developed in the past for the study of specific demographic problems and are reported in the literature. (Ridley and Sheps, 1966; Venkatacharya, 1977).

In the present model, every female beginning with her 15th birthday is exposed to such risks of marriage, conception, death, and widowhood. A husband is assumed to be five years senior to the wife. Marriage takes place between the female ages of 15-35 in accordance with the input probability distribution (Table A1, Appendix). Marriage is assumed to be universal and remarriages are excluded. The terminal age of reproductive life of a female is taken as the lowest of the three ages : age at death, age at becoming a widow and 50 years—which is assumed to be the age of cessation of fecundity. Beginning from the age at marriage to the terminal age of reproduction, live births are generated according to various parameters (Table A1, Appendix) that determine the occurrence of the birth. After the occurrence of the birth, the sex of the child is determined and the age at death of the child is obtained following specific life table probabilities.

For the purposes of this study a family is defined as one consisting of at least one ever-married adult along with their sons under 20 years and daughters under 15 years of age. An adult is defined as a male 20 years or more and a female 15 years or more. Thus an unmarried adult do not constitute a family till his/her marriage. Except for one parameter combination, a child is considered a net consumer if he/she is under 15 years and a net producer after this age.

A widow till her age of 60 years and a widower till the age of 65 years are considered as producers. In the context of developing countries these values appear to be on the high side. A male child is treated as a net producer in the family of orientation between ages 15-20<sup>3</sup>. In one parameter combination under medium

3. A male child should be treated as a net producer in the family of orientation from age 15 till his age at marriage and a net producer of his family of procreation after the age at marriage. However, in order to avoid the necessity of assigning age at marriage to each individual male child, it has been assumed in the model that all male children generated in the model get married at age 20. In the same way the contribution of females as producers in the family of orientation between age 15 and age at marriage (which averages 17 years) is ignored.

fertility, it is assumed that children under the age of ten are consumers and males between 10-20 are considered as producers. A female after the age of 15 and a male after the age of 20 are supposed to leave the family of orientation by marrying out and form a new family. For a female who gets married, CP-ratio and other relevant statistics are computed at the ages 20, 25, 30, . . . . 60 of the wife if she were alive at that age. In the case of the family where the wife is dead but the husband is alive tabulation is made with respect to the age of the husband minus five years. Thus the age of the family in the subsequent text implies the age of the living wife or the age of the husband minus five years. For each combination of parameter, and level of mortality and fertility a thousand family histories are simulated cohort-wise.

The treatment of full orphans in the model needs some explanation. In the case of a family where both the parents die before 60 years of the wife's age, the children of the orphaned family are supposed to have been taken care of by the next woman to be simulated, subject to certain rules. This woman (or her husband) is supposed to be a sister (or brother) of the dead husband or wife. Apart from this there are no linkages between any two families being simulated, and the fertility and mortality operate for each couple independently.

An orphaned family may have a child of producer age in which case he may take care of his brothers and sisters, and the burden is not passed on to the cohort of the couples under study. Alternatively an uncle or aunt of the orphaned children (even when there is a producer child in the group) may take care of the children and the burden is passed on to the cohort of families under study. In the model the latter case is considered. The producer/consumer children of the orphaned family are integrated into the family that is caring for them in computing CP-ratio of the family. If the children are orphaned at an age equal or greater than 60 years of age of the mother (65 years of father), then the family is supposed to have been taken care of by one of the children themselves who formed his/her new family. The rules used in determining whether or not a family accepts the orphaned children of the preceding family are as follows :

*Case A* : An orphaned family is supposed to have two brothers/sisters of the husband/wife who will take care of children. This number actually depends on the level of mortality, but in the present case the same number is used for all levels of mortality.

One of the two brothers (or sisters) is randomly selected and assuming that the birth spacing between the various brothers (or sisters) is 36 months, the age of the wife of the host family when she takes care of the orphaned children is worked out. However, if the mother of the orphaned children is aged less than 30 years, then it is assumed that the host is senior (brother or sister) otherwise the age of the host is selected randomly. In the case when the assigned age of the host is less than 17.5 years the host is considered senior. In the subsequent

text this case is referred as random allocation or symbolically 'RN'.

*Case B* : In this case the age of the host is always considered to be 10 years less than the age of the deceased wife whose children are taken care of. This case is referred in the text as systematic allocation and is symbolically denoted as 'SY'

As the simulation of the families is done sequentially, when a family is orphaned and the age of the host wife is assigned, in the simulation of the next woman it may happen that her own children might have been orphaned before this assigned age. In such cases the model ignores the previous orphaned family, subject to the rules mentioned above. This procedure seems reasonable, as it is unrealistic to assume that two orphaned families are to be taken care of by a single family. Thus there will be a loss of some of the orphaned families from the system. This loss is found to be 22% for mortality level 3 and for higher levels around 9%.

### **Input Values**

The various input parameters used in the model (Table A1 Appendix) in generating the medium fertility reflect closely the Indian experience. To obtain high fertility situation only the monthly chance of conception is inflated so as to give a high total fertility rate of 11.7 children per woman. As the crucial measure of fertility in our case is the age specific marital fertility (ASMFR), it is not important what parametric values are used so long as the simulated ASMFR is realistic. The medium fertility rates broadly reflect the average experience of several developing countries whereas the high fertility situation is intended to reflect the experience of high fertility sub-groups in these populations. In the model the post-partum non-susceptibility is assumed to be independent of infant and child mortality, as such association is found to have marginal effect on total fertility. (Venkatacharya, 1977; p. 246). All families are assumed to have been exposed to the same mortality risks. The survival probabilities used in the model are those of the West Model of Coale and Demeny Life Tables (Coale and Demeny, 1966) corresponding to levels 3, 8, 12 and 17. Some fertility indices that result by the use of the of Table A1 (Appendix) are summarized in Table A2 (Appendix).

### **Consumer-Producer Ratios**

CP-ratios are obtained for individual families and the results are averaged to give mean CP-ratios. CP-ratios of the ratio type estimators are used in obtaining sample estimates of total or mean whereas in the present case we are interested in estimating the ratio itself. We discuss below two ways of averag-

ing individual CP-ratios and their implications. This will help in analysing the results of the model:

Let  $C_{ij}$  the number of consumers at age  $i$  of family  $j$

$P_{ij}$  the number of producers at age  $i$  of family  $j$

then  $C_i = \sum_{j=1}^{n_i} C_{ij}$  = total number of consumers in all the families, say  $m$ , at age  $i$

$P_i = \sum_{j=1}^{n_i} P_{ij}$  = total number of producers in all the families, at age  $i$

$\bar{R}_i = C_i / P_i$  — mean consumer producer ratio at age  $i$  (1)

In computing  $\bar{R}_i$  we need consumers and producers at age  $i$  at aggregate level of families. We can also find mean of  $R_i$  for the entire family life, namely:

$$\bar{R} = \frac{\sum_i C_i}{\sum_i P_i} = \frac{\sum_{i,j} C_{ij}}{\sum_{i,j} P_{ij}} \quad (2)$$

$i = 15, 20, 25, 30, \dots, 60.$   
 $j = 1, 2, 3, \dots, n_i,$

If we are able to compute individual CP-ratios for each family then we aggregate these CP-ratios as follows:

$$\bar{R}_i = \frac{1}{n_i} \sum_{j=1}^{n_i} (C_{ij} / P_{ij}) \quad (3)$$

$$\text{and } \bar{R} = \frac{1}{n} \sum_i (n_i \bar{R}_i) = \frac{1}{n} \sum_i \sum_j \left( \frac{C_{ij}}{P_{ij}} \right) \quad (4)$$

The results of (1) and (2) will be different from those of (3) and (4). It is easy to see that while  $\bar{R}_i$  is a simple average of individual CP-ratios,  $\bar{R}_i$  is a weighted average of individual values. In the case of  $\bar{R}$  and  $R$  both turn out to be weighted means.

$$\bar{R}_i = \sum_j W_{ij} r_{ij} \quad \text{where} \quad w_{ij} = \frac{P_{ij}}{\sum (P_{ij})} \quad (5)$$

$$\text{and} \quad r_{ij} = \frac{C_{ij}}{P_{ij}}$$

$$\text{and} \quad \bar{R} = \sum_i w_i \bar{R}_i \quad \text{where} \quad w_i = \frac{P_i}{\sum P_i} \quad (6)$$

Examining equation (5) we note that families with smaller CP-ratios are given greater weight, whereas in equation (3) all families are given equal weight. Consequently  $\bar{R}_i$  tends to be lower than  $R_i$ . However,  $\bar{R}_i$  and  $R_i$  will be equal if (a)  $C_{ij} = \frac{1}{P_{ij}} R_i P_{ij}$  for all families at age  $i$ ; or (b)  $P_{ij} = \frac{1}{n_i} P_i$ . The first case is less probable especially in the early stages of family life where differences in age at marriage will have a significant effect.

## Results

1. *Consumer-Producer Ratios by Age of Families.* The CP-ratio has two dimensions of variation as mentioned earlier, namely, age and individual family. Thus in obtaining the mean CP-ratios, the double averaging can be done beginning with either age or family. For a given age of the family the mean CP-ratio can be obtained by using either  $\bar{R}_i$  or  $R_i$ . As decision on family limitation is to be taken at the family level  $\bar{R}_i$  is more logical, other things being equal. It has been indicated earlier that  $R_i$  has a tendency to underestimate mean CP-ratio as compared to  $\bar{R}_i$  although the magnitude of this could be small. The values  $\bar{R}_i$  and  $R_i$  for parameter combination (MF + OI + 15 + RN) are shown in Table 1. It is clear from the table that for the medium fertility the underestimation of  $R_i$  is more pronounced than for high fertility. In some instances especially at the terminal age  $\bar{R}_i$  was found to exceed  $R_i$ . There is another important point to be kept in mind while comparing the two means. It is assumed in the model that all fertility parameters, especially monthly chance

4. In the early part of the reproductive life, say 30 years of age some families have had no or very small number of children and this could be associated with the loss of a parent. In such cases we have a correlation between larger number of producers and consumers in the family which leads to  $R_i$  exceeding  $\bar{R}_i$  as happened in a couple of cases such as : for age 25, MF, level 3 and 8. In the early ages of family life when fewer number of parents are lost, especially under low mortality,  $P_{ij} = \frac{1}{n_i} P_i = 2$  leading to equality of  $\bar{R}_i$  and  $R_i$ . This has been evidenced under MF, for level 12 age 20, for level 17 age 20; for HF levels 12 and 17 at age 20.

TABLE 1—VALUES OF  $\bar{R}_i$  AND  $\bar{R}_i$  FOR CERTAIN PARAMETER COMBINATIONS AND AGE OF THE FAMILY

Parameter <sup>a</sup> combina- tion	Level of mortality	Age of the Family							
		20	25	30	35	40	45	50	
{ MF + OI + 15 + RN }	3	$\bar{R}_i$	.283	.609	1.017	1.041	.715	.425	.165
		$\bar{R}_i$	.283	.599	1.000	1.046	.743	.445	.176
	8	$\bar{R}_i$	.398	.880	1.345	1.140	.877	.553	.272
		$\bar{R}_i$	.400	.873	1.363	1.194	.928	.556	.258
	12	$\bar{R}_i$	.397	.943	1.387	1.328	.931	.655	.340
		$\bar{R}_i$	.396	.933	1.377	1.399	.979	.671	.344
	17	$\bar{R}_i$	.410	1.030	1.607	1.520	1.084	.796	.429
		$\bar{R}_i$	.410	1.033	1.625	1.572	1.113	.851	.467
{ HF + OI + 15 + RN }	3	$\bar{R}_i$	.522	1.037	1.551	1.406	1.072	.782	.585
		$\bar{R}_i$	.528	1.049	1.559	1.498	1.118	.763	.557
	8	$\bar{R}_i$	.564	1.250	1.991	1.742	1.317	.997	.697
		$\bar{R}_i$	.558	1.233	2.003	1.830	1.367	1.031	.653
	12	$\bar{R}_i$	.645	1.443	2.294	2.048	1.543	1.160	.782
		$\bar{R}_i$	.645	1.472	2.334	2.144	1.588	1.147	.751
	17	$\bar{R}_i$	.689	1.558	2.541	2.255	1.805	1.425	1.014
		$\bar{R}_i$	.689	1.565	2.558	2.387	1.912	1.513	1.088

<sup>a</sup>MF : Medium Fertility

HF : High Fertility

OI : Complete orphans taken care of by the families of the cohort

OE : Complete orphans excluded

RN : The orphaned children allocated randomly under certain ground rules

SY : The orphaned children always allocated to a family 10 years younger

15 : The age limit for a child to be dependent is 15 years

10 : The age limit for a child to be 10 years.

TABLE 2—MEAN CONSUMER/PRODUCER RATIO BY DURATION OF FAMILY LIFE

Mortality	Duration	of family (Family Life) Life (Since marriage)								
		0	5	10	15	20	25	30	35	40
High		0	0.73	1.08	1.40	0.66	0.42	0.25	0.12	0
Low		0	0.86	1.55	2.11	0.94	0.61	0.40	0.19	0

SOURCE : Muhsam, (1977).

of conception is equal for all women of the same age. Since this leads to smaller variation in individual CP-ratios the discrepancy between  $R_i$  and  $R_f$  will also be underestimated in the present model results. If populations are heterogeneous with respect to fertility and mortality, as it happens while studying large national populations, this discrepancy can increase. This follows from the inequality of  $C_{ij}$  and  $\bar{R}_i - Pa$  for families, a point discussed earlier.

One of the points stressed by Muhsam (1977, p. 508) is the variation in CP-ratio as the marriage duration increases. Based on his model results it was argued that the peak CP-ratio obtained at marriage duration 15 under mortality level 3 is surpassed at marriage duration 10 by 10% when the mortality decreased to level 17, and obviously this 10% increase is not enough for couples to resort to family limitation (See Table 2).

As the CP-ratios are observed at discrete intervals of duration of 5 years the actual duration when the peak is reached need not coincide with the observed duration. In other words, if we were to observe the mean CP-ratio at duration later than 10, this effect will increase culminating in a 51% increase at duration 15 years. At this point of 15 years of marriage duration, Muhsam argues that it could be too late to adopt family limitation and when it is adopted will result in smaller reductions in birth rates.<sup>5</sup>

The results of the present model shown in the Table 3 could be used to look at this aspect. For the parameter combination (MF 4 OI + 15 + RN), CP-ratio

5. While translating the effects of terminating fertility after a certain age, it is necessary to note that the reduction in birth rate derived through the use of steady state results such as stable populations will underestimate the true reductions in the *initial years of the programme* depending upon the type of contraception under use. See K. Venkatacharya, 'A Model to Estimate Births Averted due to IUD'S and Sterilizations', *Demography*, 8, 1971, p. 491-506.

Further as family planning acceptors in initial stages of family planning programme are supposed to have higher potential fertility than the non-acceptors their adoption of family limitation even after 15 years of marriage duration can contribute significantly to the eventual reduction of national birth rate.

TABLE 3—CONSUMER-PRODUCER RATIOS, BY AGE OF THE FAMILY, APPROXIMATE DURATION OF MARRIAGE; AND THE OVERALL CONSUMER-PRODUCER RATIOS FOR FIVE COMBINATIONS OF INPUT PARAMETERS

Input parameter combination	Level of mortality	CP ratios ( $\bar{R}_i$ ) by age of the family										Overall CP ratios <sup>a</sup> (averaged over age and families)	
		20	25	30	35	40	45	50	55	60	$\bar{R}_{..}$	$\bar{R}$	
		Approximate mean duration of marriage											
3.2	8.2	13.2	18.2	23.2	28.9	33.2	38.2	43.2					
MF + OI <sup>a</sup>	3	.283	.599	1.0	1.046	.743	.444	.176	.048	.022	.523	.512	
+ 15 + RN	1	.400	.87	1.363	1.194	.928	.556	.259	.077	.021	.646	.631	
	12	.396	.933	1.377	1.399	.979	.671	.348	.127	.017	.699	.687	
	17	.404	1.0497	1.625	1.580	1.109	.854	.442	.163	.036	.795	.792	
MF + OE <sup>a</sup>	3	.282	.596	.974	1.024	.725	.432	.174	.048	.012	.514	.502	
+ 15 + RN	8	.400	.873	1.362	1.185	.917	.551	.258	.077	.021	.612	.628	
	12	.396	.932	1.377	1.391	.973	.666	.340	.128	.017	.698	.685	
	17	.404	1.05	1.617	1.581	1.108	.854	.442	.165	.036	.779	.792	
MF + OI <sup>a</sup>	3	.283	.598	.712	.570	.314	.134	.049	.009	.000	.340	.320	
+ 10 + RN	8	.400	.873	.901	.618	.436	.212	.060	.014	.000	.407	.393	
	12	.396	.932	.931	.720	.481	.266	.099	.013	.000	.427	.423	
	17	.415	1.04	1.112	.796	.553	.332	.125	.026	.000	.476	.476	
MF + OI <sup>a</sup>	3	.289	.630	1.004	1.033	.727	.439	.174	.048	.012	.526	.512	
+ 15 + SY	8	.409	.889	1.365	1.192	.918	.544	.258	.077	.021	.648	.632	
	12	.399	.936	1.376	1.396	.970	.671	.338	.128	.017	.699	.686	
	17	.415	1.04	1.627	1.582	1.130	.862	.459	.166	.030	.800	.795	
HF + OI <sup>a</sup>	3	.528	1.049	1.559	1.498	1.118	.763	.557	.316	.126	.860	.854	
+ 15 + RN	8	.558	1.238	1.003	1.830	1.367	.031	.653	.333	.119	1.030	1.016	
	12	.645	1.472	2.334	2.144	1.588	1.147	.751	.383	.144	1.165	1.164	
	17	.689	1.565	2.556	2.387	1.912	1.513	1.088	.542	.200	1.313	1.347	

<sup>a</sup>For explanation of the parameter combination see footnote of Table 1.

<sup>b</sup>For ages 15, 20, 25, 30, 35, 40, 45, 50, 55, and 60.

reaches a peak of 1.046 at the marriage duration of 18.2 years and this peak is just surpassed under level 17 at marriage duration of 8.2 years, and at the duration 13.2 it increased to 1.625 by 55%. Thus between duration 8.2 and 13.2 the CP-ratios increased as mortality decreased. If we look at the parameter combination (MF + OI + 10 + RN) where children under age 10 are treated as consumers, we notice that the peak value of .712 reached at marriage duration 13.2 for level of mortality 3 is surpassed at marriage duration 8.2 by 46% and at marriage duration 13.2 by 56% under mortality level 17. Thus the upper age limit used for consumers is a critical factor. *A decrease in the limiting age of consumers brings down the age at the occurrence of peak CP-ratio*, and thereby favour greater scope for family limitation. In many developing countries the age 10 is more appropriate than age 15. In the case of high fertility combination (HF + OI + 15 + RN) the peak CP-ratio of 1.559 at duration of 13.2 under level 3 mortality is just surpassed at marriage 8.2 under mortality 17; and at marriage duration 13.2 it goes upto 2.556, an increase of 64%. From these observations it is clear that by decreasing the level of mortality the CP-ratios did increase though the magnitude depended on the duration of marriage, the upper age limit of the consumers and the initial birth spacing.<sup>6</sup> The age at which the dependency burden increases beyond the level consistent with low mortality occurs at slightly younger age in the present case than in the case of Muhsam. In societies such as those in Africa where premarital births are not tabooed, the dependency burden may occur sufficiently early in the family life and thus renders family planning practices, when used, more effective in terms of reducing birth rates. As no one really knows the level of CP-ratios that will stimulate couples to limit family sizes, it is difficult to translate model findings into policy implications.

There are a couple of other interesting points in Table 3. It can be seen that there is negligible difference between the CP-ratios of the two cases when orphans are included (OI) and when they are excluded (OE) under medium fertility. This is due to the fact that since most orphanhood occurs at late ages of parents there will be none or very small number of children who are dependents or producers at the family of orientation. Comparing the results for parameter combinations (MF + OI + 15 + RN) and (MF + OI + 15 + SY) we note that the effect of assigning orphaned children to younger host wives slightly increases the CP-ratio in the early ages of 20, 25, 30 and decreases them at later ages.

2. *Over-all CP-ratios.* In the above discussion we have controlled the age of a family. But if we wish to see the average effects on mean CP-ratio over entire life of a family, we could use the ratios such as  $\bar{R}_i$  or  $R_i$ . These are shown in Table 3 for some parameter combinations. While  $\bar{R}_i$  was by and large lower

6. A minor point of interest is that the age of occurrence of the peak CP-ratio depends mostly on the pattern of age specific fertility. A steeply increasing ASMFR in the early ages contributes for large increases CP-ratio.

than  $R_i$ , the corresponding overall ratio  $R_{..}$  tends to be higher than the values<sup>5</sup> of  $\bar{R}$  for almost all cases. This is so especially when mortality was high. Further it is only for mortality level 17, under (HF + OI + 15 + RN) that  $R_{..}$  fell short of  $\bar{R}$ . The increase in the overall CP-ratio by lowering mortality from level 3 to level 17, if measured through  $R_{..}$  is 52%, whereas through  $\bar{R}$  it is 55% for the combination (MF + OI + 15 + RN). In the case of high fertility, the increases are 53% and 58% respectively for  $R_{..}$  and  $\bar{R}$ .

The reason for  $R_{..}$  to be higher than  $\bar{R}$ , while  $R_{i..}$  was lower than  $R_i$  becomes clear if we look at equation (4) and (6). Both are weighted means of their corresponding CP-ratios by age. The observed differences are found to be due to the differences in the weighting schemes i.e.  $(f_i/n_i)$  and  $(P_i/SP_i)$ .

As mentioned earlier, the per cent increase in the family dependence burden brought about by declining mortality from level 3 to level 17 as estimated by Muhsam and Ryder are 28% and 16% respectively. Ryder used an estimator of the type  $R_{..}$  where as Muhsam used an estimator of the type  $\bar{R} = (R_i + R_2 + \dots + R_k)/k$ . On the basis of the simulated data of the present study, the following values for  $R_{..}$  and  $\bar{R}$  are obtained for some parameter combina-

TABLE 4—PERCENTAGE INCREASE IN CP-RATIO WHEN MORTALITY DECLINED FROM LEVEL 3 TO LEVEL 17 FOR SOME PARAMETER COMBINATIONS : USING  $R_{..}$  AND  $\bar{R}$  ESTIMATORS

Estimator used	Parameter combination				
	MF + OI + J5 + RN	MF + OE + 15 + RN	MF + OI + 10 + RN	MF + OI + 15 + SY	HF + OI + 15 + RN
$\bar{R}_{..}$	52	52	40	52	53
$\bar{R}'_{..}$	67	70	65	68	66

\*See foot note of Table 1.

tions. If we can assume that the pattern observed in Table 4 is applicable to the model results of Muhsam and Ryder, it appears that the higher estimate obtained Muhsam compared to Ryder could have resulted from the estimator he used and to a lesser extent from the inclusion of widows and widowers in his family definition.

The estimate obtained by us turned out to be around 50%, which is much higher than Muhsam's estimate. Some of this difference is due to the use of  $\bar{R}$  in the present study as against  $R_{..}$ . In the models of Muhsam (and Ryder) a NRR of unity is assumed for level 3 mortality where as in our study we assume a NRR of 1.24 (Table A2, Appendix) although total fertility rate in both cases is approximately equal. Another important difference is that in both Muhsam

and Ryder models fertility begins at age 20 and ends by age 45, but in our case it extends between ages 15 and 50. This difference particularly explains our higher NRR.

In the study of CP-ratio by age of family, the age pattern of fertility plays an important role. Thus the differences in the age patterns of fertility in our model and those of Ryder and Muhsam will also have contributed to the higher percent increase in the CP-ratios observed by us.

3. *Absolute Increase in CP-ratios.* There is another way of looking at the impact of declining mortality on CP-ratios. This is to consider the absolute increase in CP-ratio at specific ages or durations of marriage. For example, under the parameter combination (MF + OI + 15 + RN), say, at age 30, CP-ratio increases by .625 per producer if mortality declined from level 3 to level 17. If we look at the high fertility case, this increase is equivalent to one consumer per producer, which might be a sufficient increase in the dependency burden to motivate couples to consider family limitation.

4. *Variance of CP-ratios.* Muhsam (1977, p. 509) states that '... it is certain that, with high mortality, family sizes and consumer/producer ratios vary more than with low mortality. Thus, in view of the extremely high consumer/producer ratios, they may not notice the increase in the average consumer/producer ratio when mortality decreases.

In other words, even under high mortality conditions, many couples had say, eight children, and when, under low mortality conditions more couples have eight children, this still remains a common experience which does not call for as extreme a reaction as desiring family limitation. That the average size of the family increased as a consequence of the higher frequency of eight-child families escapes the observation of individual couples : only the demographer is impressed. Looking at the Table 5 we notice that although the variance of the individual CP-ratios by age of the family tended to decrease between level 3 and level 17 at the middle ages, in general the trend is neither regular nor substantial. Between levels 3 and 8 the variances have increased and between levels 8 and 17 tended to decrease. In the case of overall CP-ratio the trend is reversed though with some fluctuations from level to level. The variance of overall CP-ratio of a family is the sum of the two components, namely, the variation due to families of the same age and the variation between ages of the same family. The variances by and large tend to decrease as mortality falls. This pattern is quite clear for the mid-reproductive range. In the early and later reproductive ages the pattern is not clear. This is due to the fact that the distribution of CP-ratio is very skewed at the terminal reproductive age ranges, and is symmetric at the mid-reproductive range.

But the overall variance tends to roughly increase as mortality falls, due to the fact that the variation of CP-ratio by age tends to increase as mortality falls.

TABLE 5—THE VARIANCES IN CP RATIOS ( $\bar{R}_i$ ) OBTAINED ON A FAMILY AT VARIOUS AGES, LEVEL OF MORTALITY AND INPUT PARAMETER COMBINATION BASED ON 1000 SIMULATED FAMILIES

Input <sup>a</sup> parameter combination	Levels/ Mortality	Age of the family									Over <sup>b</sup> all ages
		20	25	30	35	40	45	50	55	60	
MF+	3	.12	.30	.65	.84	.62	.37	.14	.04	.01	.496
OI+	8	.15	.35	1.07	.86	.73	.41	.15	.05	.02	.638
15+	12	.12	.36	.57	.75	.56	.39	.22	.09	.01	.580
RN	17	.14	.32	.64	.62	.49	.47	.26	.11	.03	.646
MF+	3	.12	.29	.60	.83	.62	.36	.14	.04	.01	.480
OE+	8	.15	.35	1.06	.79	.70	.40	.15	.05	.02	.625
15+	12	.12	.36	.56	.74	.54	.39	.22	.09	.01	.575
RN	17	.14	.32	.58	.62	.49	.47	.27	.11	.03	.642
MF+	3	.12	.29	.41	.42	.19	.11	.04	.01	.00	.256
OI+	8	.15	.35	.50	.38	.27	.12	.03	.01	.00	.314
10+	12	.12	.36	.38	.35	.22	.15	.06	.02	.00	.306
RN	17	.13	.32	.34	.31	.19	.16	.07	.02	.00	.325
MF+	3	.13	.35	.63	.82	.61	.37	.14	.04	.01	.497
OI+	8	.17	.38	1.08	.83	.71	.40	.15	.05	.02	.638
15+	12	.12	.36	.56	.75	.53	.39	.22	.09	.01	.578
SY	17	.13	.32	.64	.61	.48	.48	.28	.12	.02	.652
HF+	3	.18	.54	.90	1.21	1.12	.73	.55	.32	.10	.882
OI +	8	.19	.60	1.38	1.44	1.18	1.03	.47	.26	.08	1.142
15+	12	.21	.72	1.33	1.30	1.07	.90	.63	.33	.12	1.282
RN	17	.18	.53	.90	.92	.80	.71	.53	.33	.10	1.198

<sup>a</sup>For explanation of the combinations see footnote of Table 1.

<sup>b</sup>For age  $i$  variance is computed as  $\frac{1}{J} \sum_j (r_{ij} - \bar{R}_i)^2$  and for all ages as  $\frac{1}{N} \sum_i \sum_j (r_{ij} - \bar{R})^2$

This is a consequence of the increased life span of family brought about by falling mortality.

5. *Selectivity of Women.* It is well known that fertility control begins with a selected group of women, especially those who are highly fecund, and later on it diffuses to other strata of the society. If so, one should consider the impact of mortality decline on high fertility sub-groups, where it is likely to trigger the desire to limit children faster. This also leads us to doubt the ability of *mean CP-ratios* (macro indices) obtained on a group of families, heterogeneous with respect to their CP-ratios, in measuring the impact of mortality decline on dependency burden that is of consequence to family limitation. With this in view the parameter combination (MF + OI + 15 + RN) is included, so as to see the effect of mortality decline on sub-groups of families with high fecundability. The mean *CP-ratio* conceals the effect of mortality decline on those families with higher dependency burden; in other words it does not show how families with high CP-ratios are affected by mortality decline. In order to see the impact of declining mortality on proportion of families with high CP-ratios, families have been tabulated according to their individual CP-ratio and summarized in Table 6. This table shows the per cent of families with CP-ratios greater than a specified value. Taking the ages 30, 35 and 40 as crucial with regard to the decision to limit family size, we can see the impact of declining mortality on CP-ratios. Under the parameter combination (MF + OI + 15 + RN) at the age 30, for mortality level 3 only 4% of families had a CP-ratio 2 or more, but when mortality declined to level 17 this percentage goes up to 16. At ages 35 and 40 the effect is less significant. In the case of high fertility, 16% of families having a CP-ratio of 2 or more under mortality level 3 goes up to 61% when mortality declines to level 17. This later increase is substantial which certainly should stimulate couples to resort to family planning methods. While in per cent terms (i.e. four-fold increase in the % of families with CP-ratios greater than or equal to 2) the increase in families with CP-ratios greater or equal to 2 is the same in both medium and high fertility cases, it is the absolute increase in the per cent families that is more striking.

### Discussion and Conclusion

In the foregoing, an attempt has been made to study the impact of mortality decline on CP-ratios in isolation of other fertility reduction programmes and related socio-economic changes in the environment of the family. Although this would give us an idea of the direct effect of mortality decline on CP-ratios, in real world situation one is interested in the total effect of mortality decline, which includes the interactions of mortality decline and other fertility reducing factors under way simultaneously in the population.

The exclusion of economic factors (e.g. family income and changes in family

TABLE 6—PERCENT OF FAMILIES WITH CONSUMER-PRODUCER RATIOS ( $\bar{R}_i$ ) LESS THAN OR EQUAL TO 1, AND MORE THAN 1, 2, 3, 4 AND 5 FOR SOME INPUT PARAMETER COMBINATIONS

Input parameter combination	Mortality level	Age	% families with CP-ratio					
			Less than or equal to 1	1	2	3	4	5
MF OI 4-15 IRN	3	30	69	31	4	1	0	0
		35	70	30	8	1	0	0
		40	82	18	3	0	0	0
	8	30	54	46	10	3	1	0
		35	57	43	8	1	0	0
		40	74	26	5	0	0	0
	12	30	48	52	8	1	0	0
		35	45	55	11	1	0	0
		40	69	31	4	0	0	0
	17	30	36	64	16	1	0	> 0
		35	35	65	15	0	0	0
		40	62	38	4	0	0	0
HF + OI + 15 + RN	3	30	46	54	16	1	0	0
		35	49	51	17	4	1	0
		40	68	32	10	2	1	0
	8	30	29	71	34	9	3	1
		35	37	63	28	7	2	1
		40	50	50	10	8	0	0
	12	30	20	80	49	15	3	1
		35	23	77	42	14	2	1
		40	40	60	23	4	0	0
17	30	13	87	61	20	2	0	
	35	12	88	52	16	1	0	
	40	21	79	30	5	0	0	

income over the family life etc.) that influence the family dependency and the assumption that families are homogeneous with respect to a number of variables including fecundity is a limitation of the model. Further, the CP-ratio is highly influenced by the *relative decreases* in mortality of consumers and producers. Whatever results are obtained in this paper are, therefore, subject to the assumption that the real mortality declines from level 3 to level 17 follow the same age patterns implicit in the West Model. If we were to use, say, East Model we would obtain different results.

A study that takes care of all these aspects and measures the total effect of mortality decline on dependency burden would be fascinating, but is wrought with a number of problems including those of data. Agreeing then to limit to the direct effect of mortality decline on family dependency burden, the results obtained through our model still pose problems in translating them into policy implications, mainly due to the inadequacy of our present knowledge on the decision making process of families with regard to the number of children they would like to have. Recent efforts to study the value of children in the total decision making network of fertility have helped our understanding of the problem, though the limited cross-country studies could not establish beyond doubt of parents desiring large number of children as security against high mortality (Bulatao, 1979).

However the value of children to parents is only one aspect in the complex decision making process of families to limit family size and on many other aspects our knowledge is weak (Hull, 1981, Simmons, 1977).

As mortality declines the dependency burden increases, the magnitude varying between families. It is necessary to know the threshold value of this burden, say, as measured through CP-ratio, which will stimulate couples of resort to some method of family limitation. However, this threshold is not necessarily the same for all couples, or for the same couple at different ages. Further, this threshold level can go up or down under the influence of other events continually taking place both within and without the family. Thus a realistic interpretation of the model results is severely hampered until knowledge accumulates on the mechanisms underlying the perception of couples of their family dependency burden and the decision making processes leading to family limitation.

Having said this, within the narrow scope of the model results discussed earlier, we could still make some tentative conclusions. Declining mortality brought about at some ages more than 50% increase in CP-ratios (for high fecund sub-groups even more) and if we assume that this is a sufficient pressure on families to lead to family limitation then, provision of ancillary facilities such as family planning information, easy availability of contraceptives, incentives and dis-incentives will go a long way in motivating couples to practice family limitation. Thus mortality decline could have a more significant catalytic effect on fertility reduction via other fertility reducing forces.

Also the model has illustrated that the proportion of families with high CP-ratios increased significantly as mortality declined, especially for the high fecund sub-groups, which should contribute immensely in increasing the perception of couples for the need to limit family and thereby pave the way for reduction in fertility.

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## APPENDIX

TABLE A1—MONTHLY CHANCE OF CONCEPTION (MCC) PRESENTED BY FIVE YEAR AGE GROUPS AND FOR DIFFERENT LEVELS OF FERTILITY; AND PROBABILITY OF TERMINATION OF CONCEPTION IN LIVE BIRTH, STILL BIRTH AND ABORTION

Age <sup>a</sup> group	MCC		Probability Live birth	termination of pregnancy in	
	High fertility (HF)	Mea fertility (MF)		Still birth	Abortion
15-19	.1227	.0476	.806	.078	.116
20-24	.2000	.0599	.879	.048	.073
25-29	.1751	.0464	.895	.058	.023
30-34	.1253	.0363	.875	.050	.075
35-39	.0755	.0208	.829	.068	.102
40-44	.0374	.0074	.760	.096	.144
45-46	.0120	.0051	.760	.096	.144
				<i>Mean</i>	<i>Variance</i>
2 <sup>b</sup>	Age at marriage			16.8 years	7.4
3 <sup>b</sup>	Gestation period leading to				
			Live birth	9.6 months	.5
			Still birth	8.2 months	.6
			Abortion	3.7 months	1.4
4 <sup>b</sup>	Post-partum Non-susceptible period following				
			Live birth	10.6 months	4.1
			Still birth	2.9 months	1.3
			Abortion	1.5 months	0.5
5.	Sex Ratio at birth (Male/100 females) 103				
6.	% and infant mortality ( $q_0$ ) be level for Model West :				
	<i>Level</i>	3	8	12	17
	Male %	22.9	34.9	44.5	56.5
	$q_0$	.351	.227	.155	.086
	Female $^{\circ}e_0$	25.0	37.5	47.5	60.0
	$q_0$	.305	.195	.132	.071

<sup>a</sup>In the model the values of MCC vary by month.

<sup>b</sup>For these the probability densities vary by months/years having the specified means and variances.

TABLE A2—SOME FERTILITY AND MORTALITY INDICES BASED ON  
SIMULATED COHORT FAMILY HISTORIES

1. The age-specific marital fertility rates (per thousand married women)

<i>Age-group</i>	<i>High Fertility (HF)</i>	<i>Medium Fertility (MF)</i>
15-19	332	195
20-24	476	303
25-29	469	271
30-34	418	248
35-39	332	160
40-44	208	68
45-49	112	15

2. Rates per woman

	<i>High Fertility (HF)</i>	<i>Medium Fertility (MF)</i>
Total fertility rate	11.74	6.3
GRR	5.78	3.10
NRR for mortality		
level 3	2.243	1.240
level 8	3.262	1.786
level 12	3.996	2.175
level 17	4.838	2.618