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Cost Effectiveness of Health and Family Welfare Programs in India

Introduction

HITHERTO, the existing literature and empirical evidences suggest a strong interaction between fertility and infant mortality. This paper purports to highlight the impact of the interaction, if any, on the cost-effectiveness of health and family welfare programmes in the Indian context.

The positive linkage between fertility and mortality has often been argued in the theoretical formulations and aptly demonstrated by the empirical evidences in the literature. The inbuilt presumption of positive linkage between the two[2] in the demographic transition model gets depicted by the phases of demographic changes in the model i.e. from the primitive phase or the high stationary stage, characterised by higher mortality and higher fertility, to the modern phase or the low stationary stage, characterised by lower mortality and lower fertility, with mortality declines followed by fertility declines in different stages of demographic transition.

The positive effects of infant mortality and fertility has often been established in several empirical studies[3]. The infant mortality rate has often been used as proxy for overall socioeconomic development in the society as higher levels of socio-economic development leads to lower incidence of morbidity and mortality during infancy and childhood.

However, the synergistic relationship between fertility and infant mortality has also been often highlighted in the theoretical and empirical literature (Bamum, 1988). Logically it has been argued that higher infant and child mortality leads to higher fertility because of higher

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[2] Many scholars like Thompson (1929) and Notestein (1953) have generalised the demographic evolution in the industrialised countries.

[3] Some important empirical studies depicting the positive linkage between the two in the Indian context are Wyon (1971),€handershekhar (1972), Mandlebaum (1974), Jain (1988), Khan (1988), and several others in edited volume 'Infant Mortality in India: Differentials and Determinants' by Anrudh Jain and Pravin Visaria.

demand for children for replacement of infants died to achieve a given target family size and the effect has been characterised as replacement effect on fertility. Furthermore, for insuring the future uncertainties of children's death under high mortality conditions one would normally end up with higher than the targeted family size and the effect has also been characterised as insurance effect. Thus, these pronatalistic effects of infant mortality on fertility have been aptly analyzed in the empirical literature (Khan,1988). On the other hand an infant's death leads to cessation of breastfeeding and thus shortens the post partum ammenohrea period and thereby exposes the mother to the risk of pregnancy comparatively earlier. This helps in increasing the period of exposure to the risk of pregnancy and thus leads to higher fertility (Bongaarts, 1978).

Similarly, higher fertility results into higher infant and child mortality such as higher fertility implies generally shorter birth intervals implying quick deliveries resulting into poor health of the mother due to frequent child-bearing and also resulting into births of underweight babies resulting into higher infant and child mortality. Furthermore, higher number of children also results into reduced quality of child care because of higher competition for limited parental time and material resources, which in turn results again into higher infant and child mortality. Thus, we find that higher levels of fertility also generate conditions conducive for higher infant and child mortality.

The interaction between fertility and infant mortality have often been argued and empirically demonstrated in several studies, including the one by the author through formulation of simultaneous structural system and it's parametric estimation by the systems method[4]. However, the strong interaction between the two i.e., fertility and infant mortality, seems to have some important policy implications in terms of appraisal of health and family welfare programs. Alternatively, cost effectiveness of health and family welfare programs is expected to be much higher if the significant interaction effect between the two is also accounted for. Thus, apart from the direct effects of health and family planning expenditures aimed basically to reduce mortality and fertility, respectively, the total effects are expected to be still higher because of the strong interaction between the two.

Objectives of the Study

The basic objectives of the study are to highlight the extent of interaction between fertility and mortality in the Indian context and it's impact on the changes in the cost effectiveness of health and family welfare programme which are basically intended to reduce mortality and fertility, respectively.

The structural analysis of fertility and mortality behaviour does not constitute the part of the present study. Thus, perfection in the specifications in the fertility and mortality structural relations is not the primary objective of the study. However, the structural formulation of the simultaneous equation system is to highlight the interaction between the two. The formulation involves some theoretically important exogenous predictors in the system. However, the basic formulation of the system is intended to highlight the extent of interaction between

[4] Some of the empirical studies eliciting a strong interaction effect between fertility and mortality have been reviewed by Bamum (1988) and Gulati (1992).

fertility and mortality and thereby it's effect on the cost effectiveness of the health and family welfare programs towards reduction in mortality and fertility, respectively.

The system comprises two equations with fertility and infant mortality as two endogenous variables. The system method deployed for estimation of the structural parameters is three-stage least squares (3SLS) to elicit consistent parametric estimates of the structural coefficients.

Simultaneous Structural System

The simultaneous equation system comprising two structural relations is formulated to highlight the extent of interaction between fertility and mortality. The two structural equations comprise two endogenous variables viz. total fertility rate (TFR) and infant mortality rate (IMR); alongwith other important exogenous predictors. The estimated structural parameters by the system methods of estimation and thereby simultaneous solution of the two equations provides mutually consistent levels of TFR and IMR. Thereby, the reduced form coefficients elicited out the estimated structural parameters would provide total effects of the exogenous predictors on the two endogenous variables viz. TFR and IMR.

Procedurally, the estimated structural coefficients basically provide direct effects of different exogenous predictors on the two endogenous variables. Whereas, the reduced form estimates provide their total effects comprising direct and indirect effects on the endogenous variables. Basically the difference between direct and total effects is primarily on account of the interaction between the two endogenous variables in the system viz. fertility and infant mortality.

Two structural relations are specified as follows:

$$TFR = f(IMR, URB, PWEOS, PCEFW) \quad (1)$$

$$IMR = f(TFR, URB, FLIT, PCEH) \quad (2)$$

The functional form of the two structural relations is assumed to be intrinsically linear i.e. linear in terms of parameters. All the variables are taken up in logarithmic form so as the elicited structural coefficients provide elasticities. A perusal of the system reveals that both the structural relations are overidentified and thus three stage least squares estimational procedure (3SLS) shall provide consistent estimates.

Fertility Equation

In first structural relation, fertility (TFR) is specified as a function of infant mortality (IMR), extent of urbanization (URB), female employment in organised sector (PWEOS), and government's per capita expenditure on family welfare (PCEFW)[5].

Infant mortality derives its effect on total fertility through physiological factors such as an infant's death shortens the lactation period and thereby shortening the post-partum ammenohrea period exposes the mother to the risk of pregnancy earlier and thus may lead

[5] The factors influencing fertility are reviewed in Andorka (1978) and Bulatao (1984).

to higher fertility. Moreover, behaviourally a mother will generally go for earlier pregnancy to replace the lost child. This effect is generally viewed as replacement effect. Furthermore, to insure for future uncertainties of losing a child in high mortality conditions generally a mother is likely to end up with higher number of children than the targeted family size at the beginning of her reproductive career. This effect is generally viewed as insurance effect. Thus, replacement and insurance effects of higher infant mortality conditions are expected to lead to higher fertility (Khan, 1988).

Coming to other exogenous variables in the fertility equation, we find that extent of urbanization, possibly a single catch-all variable for host of sociological changes concomitant to the process of urbanization, such as higher education in urban areas, non-agricultural employment structure, better recreational facilities, better communication network, better transport, better health and family welfare infrastructural facilities, and so forth, is expected to lead to lower fertility.

Furthermore, female employment in organized sector renders the opportunity cost of mother's tune to be higher in bearing and rearing the children and thus is expected to lead to lower fertility. Finally, higher per capita expenditures on family welfare ensures more and better availability of quality contraception techniques and infrastructural facilities and thus being helpful in lowering fertility. For given infant mortality levels, the three exogenous variables viz. urbanization, female employment and family planning expenditures, are expected to bear negative impact on fertility.

Mortality Equation

The second structural relation specifies infant mortality rate (IMR) as a function of total fertility rate (TFR), extent of urbanization (URB), female literacy (FLIT) and per capita expenditure on health (PCEH)[6].

Higher fertility is assumed to effect infant mortality through shortening the birth intervals resulting into unhealthy births in terms of under-weight babies, etc. Also, higher fertility generally results into increased competition for limited parental time and resources, and thereby results into lesser child care and thus higher infant mortality.

Similarly, the impact of other exogenous factors on infant mortality in the second structural relation viz. urbanization, female literacy and per capita expenditure on health, are expected to be negative. For given level of fertility, we expect that higher female literacy, higher extent of urbanization and higher health expenditures, are expected to lead to lower infant mortality.

Data and Structural Estimates

The data for all the exogenous and endogenous variables discussed earlier pertaining to 17 larger states of India are basically drawn from Census and SRS reports of 1981 and CMIE report of 1982. Most of the north-eastern states have been dropped basically because of non-availability of the required data for 1981 census. A list of the selected variables, their definitional aspects and summary statistics are provided in Appendix Tables 1 and 2.

[6] The determinants of infant mortality are surveyed in Cochrane (1983), Mosley (1984) and Jain (1988).

Theoretically, OLS estimational procedure is expected to yield not only biased but also inconsistent parametric estimates of the structural coefficients (Intriligator 1980). Nevertheless, it may be of interest to mention that the OLS estimates presented in Table 1 depict that the directions of effects of all the predictors turn out to be consistent with the general expectations such as urbanization, female employment, and per capita family welfare expenditures depict significant and negative impact on fertility. Similarly, female literacy and per capita health expenditure depict significant and negative effects on infant mortality.

The 3SLS estimational procedure is expected to yield consistent and asymptotically efficient estimates of the structural coefficients (Kmenta, 1971). The estimates are provided in the following Table 1.

TABLE 1: OLS AND 3-SLS ESTIMATES OF THE STRUCTURAL COEFFICIENTS

Variable	*OLS Estimates*		*3SLS Estimates*	
	LTFR	*LIMR*	*LTFR*	*LIMR*
Constant	1.467 (2.67)	3.490 (1.94)	1.117 (1.79)	3.694 (1.69)
LTFR		1.246 (2.12)	1.176 (2.14)	
LIMR	.215 (2.65)		.271 (2.67)	
LURB	-.081 (1.72)	-.016 (.12)	-.075 (1.83)	-.016 (.14)
LFLIT		-.017 (2.07)		-.044 (1.96)
LPWEOI	-.249 (4.09)		-.221 (3.45)	
LPCEH		- .199 - (1.84)		-.202 (2.16)
LPCEFW	-.227 (3.23)		-.208 (3.32)	
R^2	.872	.733		

(1) Figures in brackets are t-values and the values > 1.96 depict significance at one percent level.
(2) All the variables are in logarithmic forms and thus the coefficients can be interpreted as elasticities.

A perusal of 3SLS estimates reveals significant interaction between fertility and infant mortality as the structural coefficients pertaining to mortality in fertility equation and fertility in mortality equation, turn out to be positive and highly significant.

Interestingly, we find that the directions of associations between fertility and infant mortality also turn out to be consistent with the general expectations such as both the estimated coefficients have turned out to be positive and significant depicting significant and positive linkage between fertility and mortality. Alternatively, higher infant mortality leads to higher fertility and vice versa.

Furthermore, the directions of associations between the exogenous variables and the endogenous variables have also turned out to consistent with the general expectations. The structural coefficients are expected to provide the intensity of direct effects of exogenous variables on the endogenous variables. As expected, we find that all the exogenous variables depict direct effects to be negative both on fertility as well as mortality. Interestingly we find that higher extent of urbanization and higher female employment in organised sector depict negative effects on fertility as well as mortality.

Perusal of Table 1 reveals that per capita expenditure on health as well as family welfare help in reducing infant mortality and fertility, respectively. The impact of per capita health expenditures on infant mortality turns out to be significant and negative. Also we find that the effect of per capita expenditure on family welfare also turns out to significant and negative on fertility.

Reduced Form Estimates

Solving two simultaneous equations for fertility and infant mortality in terms of exogenous variables provide reduced form estimates, which can also be interpreted as total effects of the exogenous predictors on the endogenous response variables. Since the reduced form coefficients account for the interaction between fertility and infant mortality thus the reduced form coefficients are expected to reflect the total effects of the exogenous variables on the endogenous variables in the system.

The reduced form coefficients based on simultaneous solution of two endogenous variables viz. total fertility rate (TFR) and infant mortality rate (MR); in terms of exogenous variables viz. urbanization (URB), female literacy (FLIT), female employment in organised sector (PWEOI), per capita expenditures on health (PCEH) and per capita expenditure on family welfare (PCEFW); are provided in the following Table 2.

TABLE 2 : REDUCED FORM ESTIMATES*

Exogenous Variables	*Endogenous*	*Variables*
	LTFR	*LIMR*
LURB	-.116	-.153
LFLIT	-.018	-.064
LPWEOI	-.324	-.381
LPCEH	-.080	-.296
LPCEFW	-.305	-.259

* All the variables in the system have Logarithmic transformation which ensures the interpretation of reduced form co-efficients as total response elasticities.

A perusal of the total response elasticities reveals that total effects of all the policy variables on fertility and mortality are in expected directions. As per general expectations we find that all the coefficients being negative depict that extent of urbanization (LURB), extent of female literacy (LFLIT), and female employment in organised industry (LPWEOI),

have negative effect on fertility as well as infant mortality. Also the total effects are found to be much more intense compared to direct effects such as all the reduced form coefficients are substantially higher that the corresponding structural coefficients, depicting direct effects. Interestingly, we find that per capita expenditure on family welfare (PCEFW) depict it's total effect (-.305) to be almost one and a half times more compared to it's direct effect (-.208) on fertility. Similarly, per capita health expenditures (PCEH) depicts its total effect (-.296) to be almost 46 percent higher than it's direct effect (-.202), on infant mortality. The total effects are significantly higher than the direct effects, which is basically on account of the significant interaction between fertility and infant mortality.

Interestingly, we find that doubling of per capita expenditure on health will reduce infant mortality by around 30 percent, whereas it will also reduce fertility by 8 percent. Similarly doubling of per capita expenditure on family welfare will reduce fertility by around 31 percent and infant mortality by around 26 percent. The cross effects between the two is basically because of the interaction between fertility and infant mortality highlighted earlier. Interestingly, we find that family welfare expenditures effecting infant mortality reduction and health expenditures effecting fertility reduction turn out to be quite substantial. Obviously the interaction between fertility and infant mortality has important policy implications in the sense that while evaluating the cost effectiveness of health and family planning programs one need not ignore these externalities in terms of reduction in fertility and mortality. These response elasticities can be utilised in eliciting cost effectiveness of the relevant programs.

The Cost Effectiveness of Health and Family Welfare Programs

The cost effectiveness, cost per unit of effect, of health as well as family welfare program can be measured with respect to preventing infant deaths and averting births, respectively. The cost per unit of effect[7] is calculated using the structural coefficients, which depict only the direct effect, as well as reduced form estimates, which also account for the interaction between the two, to highlight the comparative cost effectiveness. The basic difference between the two costs reflect the improvement in the cost effectiveness because of the interaction between fertility and mortality. The estimated costs per birth averted and death prevented through health and family welfare programs are presented in the following Table 3.

Cost of Averting Births

Under the presumption of constancy of age structure the elasticities of TFR can simply be translated to elasticities of Births or Crude Birth Rate (CBR), as birth rate becomes proportional to total fertility rate. Under such presumption the change in births with a change in any determining variable (X), would be as follows:

[7] Possibly, detailed information on program specific expenditures, proportions of the manpower and material resources spent on recurring and non-recurring components of Health and Family Welfare Programs would have helped in eliciting the exact estimates of cost per unit of program specific outputs. Since primary objective of the study is not the estimation of the cost per unit of output but to highlight the impact of the interaction effect on the overall cost effectiveness of the programs.

TABLE 3 : COST EFFECTIVENESS OF HEALTH AND FAMILY WELFARE PROGRAMS

	Cost per		
	Birth Averted	*Death Prevented*	*Overall Death Prevented@*
Direct Effects*			
By Family Welfare Program	292	—	—
By Health Program	—	9425	—
Total Effects**			
By Family Welfare Program	199	—	—
By Health Program	8845	6432	5064

* Based on direct response elasticities provided by the structural coefficients in the system.
* * Based on total response elasticities provided by the reduced form estimates.
@ The cost per overall death prevented accounts for two components (i) deaths prevented because of reduced infant mortality, and (ii) deaths prevented because of fewer births which would have resulted into deaths.

$$dB / dX = \eta_{TFR,X}^{*} (B/X)$$

and, if X is given in monetary terms the change in cost per birth averted or cost effectiveness of family welfare program (i.e. presuming $dB = 1$ and dX provides estimate of the cost per unit of effect i.e. CE, in terms of elasticities as follows:

$$CE_{B,X} = X/(\eta_{TFR,X}^{*} B)$$

This formula[8] can be applied to calculate the cost per birth averted in terms of per capita additional expenditures through family welfare program. Using total response elasticities, for eliciting the cost per unit of effect, will account for the fertility-mortality interaction. Using total response elasticities TFR with respect to PCEFW from Table 1, in the above formula, the cost per birth averted turns out to be Rs.199[9] Whereas, the use of direct response elasticities, provided in Table 2, in the above formula provides the cost per birth averted to be Rs. 292. Thus, the substantial reduction in the additional cost from Rs. 292 to Rs. 199 per additional birth averted is basically because of the interaction effect between fertility and mortality, which makes the family welfare program to be much more cost effective when we account for its externalities in terms of reduction in infant mortality too.

The additional benefit of the health program in terms of births averted can also be calculated by using reduced form elasticity of TFR with respect to per capita expenditures on health (PCEH). The cost of averting a birth through additional health expenditures, using

[8] For detailed formulation see Barnum (1988).
[9] For 1981, per capita family welfare expenditure being Rs. 2.06, birth rate per capita being .0339, and total response elasticity of TFR with respect to PCEFW being .305, the cost per birth averted through family welfare program works out as follows: $CE_{B,\,PCEFW} = 2.06/(.305 * .0339) = Rs. 199$

reduced form elasticity of TFR with respect to PCEH from Table 1, turns out to be Rs 8845[10]. This figure is of special interest because the aversion of births through per capita expenditures on health represents a bonus for the health program. Thus, the cost effectiveness of health program would also turn out to be much higher or alternatively the cost per unit of effect would be much less, than stipulated in terms of prevention of deaths only, without accounting for the interaction between fertility and mortality.

Cost of Preventing Deaths

Changes is cost effectiveness of programs affecting deaths can be worked out by utilising direct response elasticities as well as total response elasticities of infant mortality rate with respect to any determining variable *(X)*. Thus, in elasticity terms the change in deaths (D) corresponding to a change in determining variable *(X)* would be as follows:

$$dD / dX = \eta_{IMR.X} * (D / X)$$

Similarly, the formula can be utilised to calculate the cost per additional death prevented as follows:

$$CE_{D.X} = dX / dD = X / \eta_{IMR.X} * D$$

Using reduced form elasticity of infant mortality rate (IMR) corresponding to per capita health expenditures (PCEH) from Table 1, to account for the interaction between fertility and mortality, the additional cost per additional death prevented turns out to be Rs. 6432", which turns out to be almost 32 percent less than Rs. 9425, which was the cost per additional death prevented using direct response elasticities from Table 2. Thus, accounting for the interaction between fertility and mortality we find that the increase in the cost effectiveness or alternatively the reduction in the cost per unit of effect, of the health program turns out to be substantial i.e. of the order of 32 percent.

Cost of preventing overall or adjusted deaths. It may be further argued that cost per death prevented, should also account for an additional component comprising mortality response attributable to decline in births. Alternatively, the infant deaths which would have occurred to the additional births, which have been prevented, may also be accounted for while estimating the cost effectiveness of the program expenditures. Thus, for a given CDR, a corresponding decline in total deaths would be still larger because of fewer births.

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[10] **For 1981, per capita expenditure on health being Rs.23.99, crude birth rate per capita being .0339, and reduced form total response elasticity estimate of TFR with respect to health expenditures being .080, the cost of averting birth through health program works out as follows:**

$CE_{B.PCEH}$ = 23.99/(.0339 * .080) = Rs. 8845

[11] **For 1981, per capita expenditure on health being Rs.23.99, crude death rate per capita being .0126, and reduced form total response elasticity of IMR with respect to PCEH being .296, the cost per death prevented through health expenditures works out as follows:**

$CE_{D.PCEH}$ = 23.99 / (.0126 * .296) = Rs. 6432

In elasticities terms the change in number of overall or adjusted deaths *(AD)* corresponding to a change in determining variable *(X)* should be as follows:

$$dAD/dX = \eta_{IMR,X}^{*} (D/X) + \eta_{TFR,X}^{*} (D/X)$$

The second component depicts mortality response attributable to the decline in fertility. Inverting this expression, the cost effectiveness of program expenditures affecting deaths can be calculated as follows:

$$CE_{AD,X} = X / (D * (\eta_{IMR,X} + \eta_{TFR,X}))$$

The additional component in the denominator, corresponding to TFR, comprises mortality response attributable to the decline in fertility. Thus, using total response elasticities from Table 1 the cost per additional adjusted death prevented *(AD)* through health program turns out to be still lower at Rs. 5064[12]. Thus, we find that accounting for the additional component of reduction in mortality which would have occurred because of reduction in fertility further brings down the cost per death averted from Rs. 6432 to Rs. 5064 depicting a further decline of 21 percent cost in averting an additional death through the health program expenditures.

An impressive improvement hi the cost effectiveness or the reduction in the cost per additional death prevented through health program expenditures gets depicted in the earlier discussion, However, the overall decline from Rs. 9425 to Rs. 5064 in the cost per additional death prevented depicting almost 46 percent decline, through health program expenditures, if we account for the interaction between fertility and mortality.

Concluding Observations

The empirical findings demonstrate significant interaction between fertility and infant mortality. Thus, accounting for the interaction between the two we find that the cost effectiveness of health and family welfare programs improves substantially. Alternatively, the cost per unit of effect of health and family welfare programs in terms of prevention of additional death or additional birth, respectively, reduces significantly.

Revised and exact estimates for cost per unit of program-specific output can be elicited subject to the availability of detailed information about program specific expenditures in terms of proportions on manpower and material resources and furthermore on recurring as well as non-recurring components of health and family welfare programs. Nevertheless, the basic argument would still hold that accounting for the interaction between fertility and mortality would substantially enhance the cost effectiveness of the programs. Thus, for any realistic appraisal of the health and family welfare programs the interaction effect between the two should always be accounted for.

Since the health and family welfare programs are found to reinforce the basic objectives of each other, the integration of the two provides benefits in terms of better coordination,

[12] For 1981, per capita expenditures on health being Rs 23.99, crude death rate per capita being .0126, total response elasticity of IMR w.r.t. PCEH being .296, and total response elasticity of TFR w.r.t. PCEH being .080, the cost of preventing an additional death through the health program expenditures works out as follows:

$CE_{AD,PCEH}$ = 23.99 / (.0126 * (.296 + .080)) = Rs. 5064

effective monitoring, and lower program costs for promotion of the twin objectives of fertility and mortality reduction and thus accelerating the population stabilisation process in the Indian context.

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Appendix

TABLE 1 : LIST OF VARIABLES

No.	*Abbreviated Name*	*Variable*
1.	CBR	Crude Birth Rate, 1981
2.	CDR	Crude Death Rate, 1981
3.	TFR	Total Fertility Rate, 1981
4.	EMR	Infant Mortality Rate, 1981
5.	URB	Urban Population as per cent of total population, 1981
6.	FLU	Females literate as per cent of total female population, 1981
7.	PWEOI	Per cent female workers employed in organised sector, 1981
8.	PCEH	Per capita expenditure on health, 1981
9.	PCEFW	Per capita expenditure on family-welfare, 1981

TABLE 2: SUMMARY STATISTICS FOR THE SELECTED VARIABLES

No.	*Variable*	*Mean*	*S.D.*	*C.V.*	*Skewness*	*Min.*	*Max.*
		(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
1.	CBR	32.89	4.09	12.42	0.05	25.64	39.60
2.	CDR	11.69	2.63	22.49	0.19	6.60	16.60
3.	TFR	4.32	0.82	12.42	0.24	2.80	5.80
4.	IMR	97.23	29.32	30.15	0.51	37.00	150.00
5.	URB	21.66	8.11	37.44	-0.10	7.61	35.03
6.	FLIT	31.29	14.71	47.15	1.47	13.99	75.65
7.	PWEOI	12.96	7.90	60.96	1.86	7.00	35.00
8.	PCEH	31.35	20.62	65.77	1.96	14.00	84.00
9.	PCEFW	2.01	0.79	39.31	1.75	1.04	4.44