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Interaction of Infant Mortality and Fertility and the Effectiveness of Health and Family Planning Programs

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Health and family planning programs can draw on each other's strengths to lower the number of births and reduce infant mortality.

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The interaction of fertility and infant mortality is well established. Lower infant mortality can lead to lower fertility by reducing the need for replacement births. Conversely, birth spacing improves the chances of child survival. To find out how these programs reinforce each other, a study done in Indonesia estimated the effects that family planning programs have on infant mortality and the effects of reduced infant mortality on fertility. The research compared the cost-effectiveness of health and family planning programs and looked at whether the interaction of infant mortality and fertility influenced estimates of the costs of both programs.

The results demonstrate a substantial spillover effect, confirming that the interaction does raise the cost-effectiveness of both programs. And the study shows that nonhospital health care is substantially more effective than hospital care at reducing infant mortality.

These findings are sufficiently consistent that policymakers should consider the mortality-fertility interaction as a regular part of the appraisal of health and population projects. Integrated programs offer lower costs and more effective promotion. They also improve efforts to assure infant survival and achieve birth prevention objectives.

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by
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Interaction of Infant Mortality and Fertility and the Effectiveness of Health and Family Planning Programs

I. Introduction

1. This paper examines the implications of the interaction of mortality and fertility for the effectiveness of health and family planning programs. Lower infant and child mortality can lead to lower fertility rates through a reduced need for replacement births to achieve a given target family size. Conversely, lower fertility rates can lead to reduced infant mortality as longer birth intervals provide improved quality births, better child care and reduced competition for household time and resources. Taken together, these two effects, that of fertility on mortality and that of mortality on fertility, interact to determine simultaneous mutually consistent levels of fertility and mortality. There are, of course, other direct determinants of mortality and fertility, including health and family planning programs controlled by government policies. But these other direct determinants will, through the interaction of mortality and fertility, also have indirect simultaneous effects that, depending on their sign, will augment or diminish the direct effects. Thus, assessment of health and family planning policies must take into account the indirect effects produced by the interaction of mortality and fertility.

2. The influence of mortality on fertility, at first debated widely, has come to be accepted, based both on micro level household studies and macro studies using aggregate data[1]. Similarly the direct influence of fertility on mortality is equally well established[2]. Recognition of the simultaneous interaction came only later but is now also accepted although statistical estimates of the simultaneous effects, using either household or aggregate data, have been few[3], and there have been no applications of the empirical analyses to policy assessment[4]. The present paper fills a gap by providing

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[1]In their survey of the determinants of fertility McGreevey and Birdsall (1974) cite studies estimating elasticities of .2 to .4 for the response of completed fertility to changes in infant mortality (1974, p41) [Co]chrane and Zachariah (1983) survey a number of studies and also reexa[mine W]orld Fertility Survey data using linear regression. They conclude, based on an average for 25 countries, that the effect of child mortality on subsequent fertility is about .5. Some other studies establishing the effect of infant or child mortality on fertility in individual countries are Zachariah and Patel (1984), Schultz (1978), and Preston (ed., 1978).

[2]Much of the literature looking at the effects of fertility on mortality is focussed on the relationship between birth spacing and child survival. In a cross country study by Pebley and Millman (1986) it is found that the risk of dying for a child born with less than a two year birth interval is approximately 60% greater in the neonatal period and 100% greater in the remainder of the infant period than for a child born after more than a two year birth interval. Also see Cleland and Sathar (1983), and Hobcraft (1984). There have also been studies looking directly at the effects of fertility on infant mortality. See, for example, Scrimshaw (1979), and Taucher (1982).

[3]The earliest estimates of the interaction of fertility and mortality rates are those by Nerlove and Schultz (1970) explaining fertility and infant mortality in Puerto Rico, and Heller (1976) in a simultaneous equations model explaining infant mortality and age specific fertility rates in Malaysia. Using cross country data, Wheeler (1980) estimated a set of simultaneous equations relating various components of a "basic needs" model, including equations explaining fertility rates and life expectancy.

[4]The potential importance of the interaction has been examined in simulation models for Nepal by Barnum and Mohtadhi (1982) and Barnum and Yaukey (1979), and in a survey paper by Gwatkin (1984). Cochrane has also noted that the policy implications of family planning programs are significantly influenced by the effects of mortality on fertility (1983).

an estimate of both the direct and simultaneous effects of mortality and fertility determinants in Indonesia and giving an example of policy applications.

3. Some of the major policy questions examined are,

(a) Do family planning programs have a substantial effect on infant mortality?

(b) Do programs to reduce infant mortality have a substantial effect on fertility?

(c) What is the relative effectiveness of hospital expenditures and non hospital expenditures on infant mortality? How does the cost effectiveness of expenditures on both of these programs compare with the effectiveness of family planning programs?

(d) Does interaction significantly affect estimates of the cost effectiveness of family planning and health programs?

4. To answer these questions the paper examines aggregate data for Indonesia. The paper is organized as follows. Section II describes the Indonesian setting. Section III sets out the analytical framework and describes the data. Section IV presents the empirical results, and Section V gives estimates of the cost effectiveness of family planning and health

programs and draws policy conclusions in answer to the questions set out above.

II. Indonesian Setting

5. Indonesia provides a good opportunity to examine the effectiveness of health and family planning policies because of the range and depth of government support for maternal and child health (MCH) programs, the strong implementation of the family planning program over the last 15 years, and the considerable variation in the key determinants of health and fertility among provinces. In contrast to many countries, where hospital expenditures take up to 80% of the total health budget, Indonesian expenditures on hospitals comprise less than 40% of total public expenditures on health, including both province and central government expenditures. The remaining 60% -- non hospital government health expenditures -- covers health center and other first level referral services, support services, and a broad range of vertical programs encompassing community disease control and maternal child health programs.

6. Although many of the non hospital services are organized as vertical programs, they are unified in the sense that they are delivered through the health center. The health center supplies the infrastructure shell -- facilities, basic staffing and local administration -- for programs such as the expanded program on immunization (EPI), oral rehydration (ORT), tuberculosis and leprosy. Health center services are provided through

outpatient visits, outreach activities to support the vertical program, and, in health centers with beds, selected inpatient services such as unencumbered obstetrics. Referrals for inpatient services are to be made from health centers to district hospitals, but in practice referrals are erratic, most entry into hospitals is made directly and the hospital system is not well integrated into the full set of health services.

7. Family planning services are partially provided through health centers, but the family planning program remains separately organized and funded outside of the Ministry of Health. The responsibility for supervising national family planning activities lies with the National Family Planning Coordinating Board (BKKBN), a government agency reporting directly to the President. BKKBN does not provide services directly but coordinates the activities of a number of interacting government and private agencies. These agencies primarily provide services through village level volunteer workers supervised by BKKBN staff. The family planning program grew rapidly in the 1970s until, by 1980 approximately 31% of total fecund couples were practicing family planning. Of these about 27% used IUDs, 64% pills or injections, 6% condoms and 3% other methods. The success of the family planning program has been attibuted to high level political support, community involvement, and adequate funding[5].

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[5]A description and evaluation of the Indonesian family planning program is given in Warwick (1986). An important point made by Warwick is that political support, community involvement and funding result in greater contraceptive use through adequate supplies, effective implementing agents (field workers, birth attendants, professional midwives) and active acceptors groups. Thus, it is not funds alone, but the translation of funding into an effective program that underlies the success of the Indonesian program in the 1970s.

8. In spite of the noted achievements with the family planning program and the governments support of health services at the lower referral level, there is great variation among provinces in fertility, health status and the level of available services. The total fertility rate (TFR), giving the average number of births per woman over her reproductive life span, ranges from 3.4 to 6.5. The infant mortality rate (IMR) ranges from a low of .062 to .187, expressed as a proportion of births. The proportion of households contracepting ranges from .08 to .56. Non hospital health expenditures range from 521 Rp. per capita to 2695 Rp. per capita. Thus, there is sufficient variation among provinces to allow the statistical examination of the possible effects of government health and family planning expenditures on health and fertility.

III. Analytical Framework

9. The purpose of this section is to set out a general framework capturing the primary determinants of mortality and fertility. The goal is to specify the framework succinctly and to focus on the major policy determinants and the significance of mortality-fertility interaction without biasing the empirical results through the omission of important determinants. Because the specification of the determinants does not, in itself, break any new ground, this section is brief with further references given to allow entry into the extensive literature in each area. We turn first to infant mortality, then to fertility and finally discuss their interaction.

Infant Mortality

10. Infant mortality is specified to be a function of fertility, literacy, sanitation, nutritional status, and health expenditures[6]. Higher rates of fertility are associated with higher levels of infant mortality and fertility derives its effects on mortality through the physiological effects of changes in birth intervals on the quality of the birth and the effect of family size on the sufficiency of care and nutrition given the newborn child. Additionally, for a given fertility level, infant mortality is generally lower with literacy, improved sanitation, and greater availability of nutrients. These latter three proximinate determinants are included in lieu of income which is, in turn, an indirect determinant of mortality. Finally, lower rates of infant mortality are posited to be inversely related to health expenditures. For policy purposes it is useful to distinguish between hospital and non hospital expenditures. The non hospital maternal and child health (MCH) programs and special vertical programs, especially those for malaria and other communicable diseases, are presumed to have a greater effect on infant mortality than are hospital services. Using the notation given in table one, the relationship of the infant mortality rate to its determinants can be written in the form of an equation as

$$IMR = F(TFR, ILLIT, TOIL, CAL, REXNP, REXHP) \qquad (1).$$

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[6] See the references in footnote 2 for studies relating infant mortality to determinants including fertility, also see Mosley and Chen (eds., 1984), especially the discussion of the proximate determinants of infant mortality in the Introduction.

Total Fertility Rate

11. Total fertility is specified to be a function of infant mortality, literacy, income, urbanization, and family planning expenditures[7]. Higher levels of fertility are caused by higher levels of mortality. Mortality derives its affects on fertility through the physiological effects of the cessation of breastfeeding in shortening post-partum ammenorea and through behavioral or replacement effects resulting from the desire to achieve desired family size. Additionally, urbanization is generally associated with sociological changes that result in lower fertility, and income, over the short run or within cross section data, is expected to be positively related to fertility[8]. Literacy, in most studies, has been associated with a lowering of fertility although this effect, distinguished from education, has not always been found to be positive. Finally, higher levels of acceptance of family planning produced by government expenditures on family planning programs lead to lowered fertility. The relationship of the total fertility rate to its determinants can be written as

$$TFR = F(IMR, ILLIT, YP, PURB, REXFPP) \qquad (2),$$

using the notation in Table 1.

[7]The determinants of fertility are surveyed in Bulatao (1984), Birdsall (1977), McGreevey and Birdsall (1974) and Cochrane (1979).

[8]Simon (1974) and Hull and Hull (1977).

Interaction of Mortality and Fertility

12. Equations (1) and (2), referred to as the structural equations, give the framework specifying the structure of the interactive system of direct determinants of IMR and TFR. These two equations each include both dependent variables (IMR and TFR) and must be solved simultaneously to obtain mutually consistent levels of TFR and IMR that satisfy the conditions in both equations. The simultaneous solution of the structural equations, referred to as the reduced form, gives the IMR and TFR rates as functions only of the exogenous variables. Figure One illustrates how the structural equations interact to determine the level of fertility and mortality. In deriving the diagram, the levels of all variables, except IMR and TFR, have been held constant. As we move outward along the IMR equation levels of infant mortality produced by increasing levels of fertility are traced out, and conversely for the TFR equation. Only at the intersection of the two

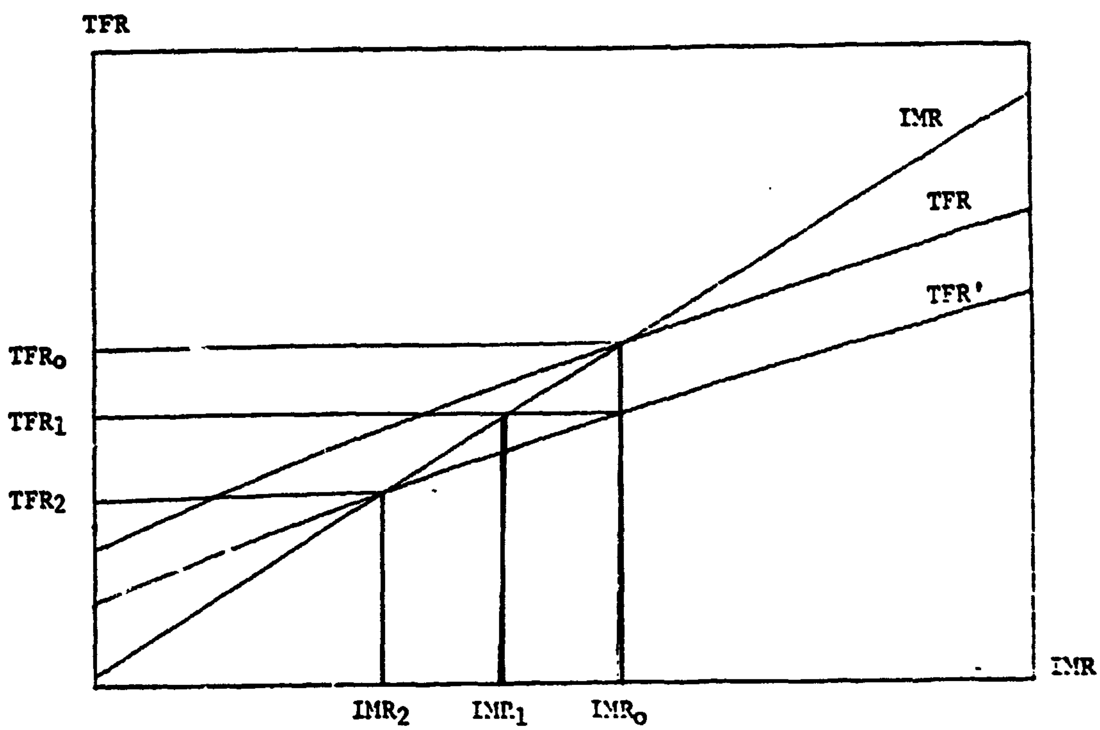

Figure One: Determination of Consistent Infant Mortality (IMR) and Fertility (TFR) Rates equations are the rates of fertility and mortality mutually consistent. Thus, the consistent or equilibrium levels of infant mortality and total fertility, for a society with the behavior encapsulated in the two equations, are IMR_0 and TFR_0.

13. The effects of a policy change that results in an increase in family planning acceptors, for example an increase in government family planning expenditures (REXFPP), can be traced out on the diagram. The exercise illustrates the difference between the direct effect of the policy change and the total effect including the interaction of mortality and fertility. An increase in REXFPP would shift the TFR equation down to TFR'. Considering only the direct fertility effects[9], the estimated fertility reduction would be $TFR_0 - TFR_1$. However, the direct effect is only part of the total effect. The fall in fertility will be accompanied by a fall in infant mortality to IMR_1 which would lead to further reductions in TFR, and so on, in the direction of the stair stepped arrow, until the process comes once again to a new equilibrium at TFR_2 and IMR_2[10]. The total change in fertility with the new level of REXFPP is, thus, TFR_0-TFR_2, which is greater than estimated from the direct effect alone. In addition, the increased family planning expenditures have had a substantial effect on the infant

[9]Approximated for example by the standard couple years of protection calculation or through application of a demographic estimation procedure such as the Population Council's TABRAP (Nortman, 1975) or TARGET (Bongaarts, 1985).

[10]The process will converge on a new equilibrium only if the IMR equation has a steeper slope than the total fertility rate. If the reverse is true, that is the IMR equation cuts the TFR equation from above, any small change from equilibrium will be destabilizing.

mortality rate, lowering infant mortality from IMR_0 to IMR_2, rather than leaving it unchanged.

14. The distinction between the direct (structural form) effect and the total (reduced form) effect is of more than theoretical interest. Differences between the two effects can be substantial and if fully understood by policy makers can make the difference between acceptance or rejection of selected health and family planning programs. The remainder of the paper elucidates the differences between these two effects for the Indonesian case.

Data

15. The data used to estimate the structural equations is derived from aggregated province level information for 26 of the 27 provinces in Indonesia. The 27^{th} province, Timor Timor, was only recently formed and does not have complete data, but it comprises less than one half of one percent of the population. The demographic and socioeconomic information, with the exception of government health expenditures and household income, is for 1980 to 1983 and was collected by the divisions of statistics in the Ministry of Health and the Department of Planning and published in a summary report by ESCAP (1984). Because detailed budget data is not available for earlier years, expenditure information is based on analysis of MOH regular and development budget data for 1984 (March 1984 to February 1985) and includes budgeted recurrent expenditures at the Central and Provincial levels. The budget headings allowed the identification of hospital expenditures. Relating 1984 government expenditures to 1980 demographic

outcomes depends on the assumption that the pattern of recurrent government expenditures among provinces has not changed greatly over time and reflects the level of services available before 1984. The assumption is supported by the fact that between 1980 and 1984 there were severe constraints on the growth of recurrent expenditures and investment was severely curtailed. The government has remained committed to the support of services in place, largely the result of the pattern of investment in the 1970s, and these did not change greatly from 1980 to 1984.

16. All data, including endogenous variables to be determined by the structural equations, policy variables, and other exogenous variables, are defined as ratios. With regard to endogenous variables, the infant mortality rate (IMR) is the proportion of children born that die within the first year (1980). The total fertility rate (TFR) is the number of children ever born per woman over her fecund years based on the estimated 1980 age specific fertility histories of women 15-45. With regard to policy variables, family planning expenditures (REXFPP) represents government expenditures per capita fon the family planning program. Non hospital recurrent expenditures per capita (REXNP) is derived as the difference between total health expenditures per capita and hospital expenditures per capita (REXHP) in each province. Similarly the remaining exogenous variables are defined either as proportions or per capita as indicated in Table 1. The advantage of the ratio specification is that it reduces the likelihood of problems with non uniform variations (heterogeneity), across provinces, in the error terms in the equations to be estimated.

Table 1

DATA USED IN INDONESIAN FERTILITY - MORTALITY MODEL

Symbol	Variable	Units	Year	Mean	STD DEV
IMR	Infant Deaths per Birth	Proportion	1980	.108	.023
TFR	Children born per Woman 15-45	Children	1980	5.228	.815
TOIL	Percent of HH with Private Waste Disposal (Toilet or Latrine)	%	1980	47.838	12.046
REXNP	Government Non Hospital Recurrent Health Expenditures per Capita	Rp 000	1984	1.272	.485
REXHP	Government Recurrent Hospital Expenditures per Capita	Rp 000	1984	.802	.687
REXFPP	Gov. Expenditures on Family Planning per Capita	Rp 000	1980	.427	.191
ILLIT	Adult Illiteracy Rate	%	1980	26.870	10.190
PURB	Percent Urban Population	%	1980	21.978	18.248
YP	Monthly Household Expenditures Per Capita	Rp 000	1983	17.609	5.318
CAL	Daily Calories per Capita	Calories	1980	1906.2	207.2

Sources: Indonesia; Department of Health, Bureau of Planning; Central Bureau of Statistics, Census; National Family Planning, Coordinating Board; SUSENAS (National Household Survey, February 1984)

IV. Empirical Results

17. Applying the conceptual framework in Figure one to cross province data for Indonesia reveals that observed pairs of IMR and TFR for individual provinces are the result of the intersection of the two simultaneous

structural equations and therefore do not, by themselves, trace out either equation. In order to identify the unbiased coefficients, additional exogenous information producing shifts in one equation but not in the other (such as the shift from TFR to TFR') is needed, and a simultaneous regression technique rather than ordinary least squares is required. Fortunately there is sufficient information in both of the specified equations to allow their identification and two stage least squares (2SLS) is used as the simultaneous equations estimator. The first subsection below gives structural equation estimates based on 2SLS. The second subsection gives the reduced form estimates of the responsiveness of TFR and IMR to changes in the independent variables.

18. Logs are taken of all variables before estimation of linear equations. Besides being appropriate[11] for the particular structural equations estimated the log linear form has the added advantage of providing coefficients that can be directly interpreted as elasticities, i.e. as the percentage change in the dependent variable with the independent variable.

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[11]The log linear form allows both equations to have a diminishing rate of increase with respect to determining variables. A diminishing rate of increase is expected because both IMR and TFR result from biological processes with natural limits. A logit form would be more appropriate for the IMR equation and was also estimated. The logit results were not substantially different from the log linear results, however, and the log linear form was retained to simplify the computations.

Structural Equation Estimates

19. Estimates for two alternative formulations of the structural equations are given in Table 2. The first alternative includes the full set of independent variables. In the second alternative REXHP is omitted.

20. The value of R^2 is about .6 in all equations, which is high for cross section regressions, and indicates that the estimated equations explain over half of the total variation in the fertility and infant mortality rates. The signs of all coefficients are as expected with the exception of the coefficient on illiteracy which is negative in the fertility equation. Similar results for illiteracy have been obtained in other studies, especially where the illiteracy variable does not distinguish between male and female literacy. For example, Heller (1976) in his analysis of Malaysian household data found a positive coefficient on male literacy and a negative coefficient on female literacy. Cochrane (1979) surveyed studies relating fertility, literacy and education and concluded that above a threshold illiteracy rate of about 40-60%, literacy and small amounts of education appear to be associated with higher fertility. This phenomenon may be operating in Indonesia although in this case the illiteracy rate is below 40%.

Table 2

ESTIMATED MORTALITY -- FERTILITY EQUATIONS a/

	Ordinary Least Squares			Two Stage Least Squares Estimates			
				Alternative #1		Alternative #2	
	Eq 1a	Eq 1b	Eq 1c	Eq 2a	Eq2b	Eq 3a	Eq 3b
	TFR	IMR	IMR	TFR	IMR	TFR	IMR
TFR		0.89	0.90		0.47		0.63
		(3.76)**	(4.74)**		(0.99)		(2.36)**
IMR	0.41			0.22		0.15	
	(3.17)**			(1.36)*		(0.76)	
Constant	2.19	-0.23	-0.21	1.65	-2.55	1.43	-1.76
	(3.85)**	(-0.09)	(-0.09)	(2.67)**	(-0.79)	(2.06)**	(-0.72)
ILLIT	-0.63	0.13	0.13	-0.34	0.98	-0.22	0.13
	(-1.00)*	(1.74)**	(2.02)**	(-0.55)	(1.32)	(-0.33)	(2.22)**
YP	0.33			0.37		0.38	
	(2.54)**			(3.00)**		(2.96)**	
PURB	-0.19			-0.22		-0.23	
	(-3.13)**			(-3.75)**		(-3.70)**	
TOIL		-0.22	-0.22		0.16		-0.22
		(-1.85)**	(-2.17)**		(-1.36)*		(-2.40)**
CAL		-0.40	-0.40		-0.19		-0.14
		(-1.23)	(-1.33)*		(-0.04)		(-0.40)
REXFPP	-0.19			-0.22		-0.23	
	(-2.59)**			(-3.15)**		(-3.13)**	
REXNP		-0.23	-0.23		-0.15		-0.22
		(-2.44)**	(-3.42)**		(-1.36)*		(-3.54)**
REXHP		-0.02			-0.05		
		(-0.04)			(-0.78)		
s.e.	.110	.123	.120	.101	.114	.106	.110
R^2	.66	.72	.72	.63	.67	.60	.69
R^{-2}	.58	.63	.65	.54	.57	.49	.61

a/ All variables are in logs. Variable definitions are given in Table 1.
n = 26. t statistics are given in parentheses below coefficients.
** = significant at 5% level, * = significant at 10% level. (one tail t test)

21. The relative magnitude of the response of infant mortality to hospital versus non hospital expenditures is of interest. In formulating the IMR equation it was expected that the non hospital expenditures, outlined in the background section above, would have greater effect than hospital expenditures in reducing infant mortality, because, among other programs, non hospital expenditures support important preventive care programs directly affecting maternal and child health. This expectation was substantiated. The infant mortality rate is found to be strongly influenced by non hospital health expenditures (REXNP) as is evidenced by the size and high level of statistical significance of the coefficient on REXNP. Conversely, because only a small percent of births take place in a hospital and because many factors other than the quality of the delivery determine infant mortality it is expected that hospital expenditures would have only a negligible effect on infant mortality. Because of the lack of statistical significance and absence of compelling justification for the inclusion of hospital expenditures, the equations omitting REXHP are used in the policy analysis below.

22. Interaction between infant mortality and fertility is confirmed by the estimated equations, although the size and statistical significance of the interaction coefficients vary across alternative estimates. In particular the size and significance of the coefficent on IMR decreases, while that on TFR increases, as the specification changes from alternative 1 to alternative 2 with the omission of hospital expenditures. The estimated coeficients are also highly dependent on the regression technique. The OLS

estimate (Table 2) of the cofficent on IMR is .41 while that on TFR is about .90. These alternative estimates illustrate that the coefficients, while confirming interaction, are dependent on specification and should be taken as indicative and not quantitatively precise. The policy conclusions are examined in Section ˜ for sensitivity to changes in the interaction coefficients. The main part of the discussion, however, centers on alternative #2 which corrects for simultaneity and omits REXHP.

23. Based on the estimate of the infant mortality equation given under alternative #2, the elasticity of the infant mortality rate to an increase in non hospital expenditures is -.22. This indicates that a doubling of nonhospital health expenditures from 1300 to 2600 Rp. per capita (a 100% increase) would reduce infant mortality by about 22% even if there were no other changes in, say, food availability, literacy, or sanitation. Similarly, the coefficient on REXFP in the fertility equation indicates that a doubling of government expenditures on family planning activities would directly decrease the fertility rate by 22%.

24. The magnitude of these responses may be affected by variable definitions and data specification. For example, REXFPP includes only government expenditures on family planning and does not include private expenditures. REXFPP also does not account for differences in effectiveness of program implementation over provinces. It is difficult to state the direction of bias these omissions give to the coefficient, but if, as may be plausible, private expenditures are positively related to motivational efforts in government programs and implementation effectiveness increases

with the per capita government expenditures, then the unbiased coefficient on REXFPP would be substantially higher then the estimated coefficient. Similarly, the expenditure on non hospital health programs includes programs that would be expected to affect infant mortality only marginally. To the extent that the proportion of MCH programs in REXNP is not uniform over provinces it would be expected that the size and significance of the response of IMR to REXNP would be diminished. In any case, even with these qualifications, the direct response is significant. The augmentation of the direct effects with the interaction of mortality and fertility adds still more to the impact of the family planning and non hospital programs.

Reduced Form Estimates

25. Solving the system of two equations for the infant mortality and fertility rates in terms of exogenous variables gives the reduced form coefficients which include interaction effects and can, therefore, be used to calculate the total effect of policy changes. Table 3 gives the reduced form coefficients, or elasticities, for alternative #2 using 2SLS. Focussing on the coefficients on REXFPP and REXNP it can be seen that, with the indirect effects included, the effect of a doubling of REXFPP is to reduce fertility by 25% rather than the 23% calculated only from the direct effects. Similarly, the total effect of a doubling of REXNP, is a reduction in the infant mortality rate of 25%, rather than the 22% estimated without the inclusion of the indirect effects.

26. In addition to the expected effects of FPHH on TFR and REXNP on IMR, the reduced form gives the extent of cross effects linking family planning with infant mortality reduction and non hospital health expenditures with reduced fertility. The reduced form coefficient of FPHH on IMR reveals that the reduction in infant mortality with a doubling in family planning is almost 16%. Correspondingly, the reduction in fertility with a doubling in non hospital health expenditures is 25%.

Table 3

MORTALITY-FERTILITY RESPONSE ELASTICITIES [a]

	TFR	IMR
ILLIT	.00	.13
LYP	.42	.26
PURB	-.26	-.16
TOIL	-.04	-.25
CAL	-.02	-.15
REXNP	-.04	-.25
REXFPP	-.25	-.16

[a]/Based on reduced form coefficients for alternative #2

V. Policy Implications of Mortality-Fertility Interaction

27. The interaction of infant mortality and fertility is usually ignored in appraising the effectiveness of family planning and MCH programs, but the illustration for Indonesia shows that this interaction can greatly affect the response of fertility and mortality and should be considered in

appraising health and population projects. This section applies the estimated results (using alternative #2) reported above to calculate the cost effectiveness of family planning program and non hospital health program expenditures (Table 4). The cost effectiveness of the programs are measured with respect to prevented births and avoided infant deaths. Cost per unit of effect are calculated for the total response, including interaction, and then compared with the unit cost derived from what might be called the "naive" model using only the direct response.

Table 4

IMPLIED COST EFFECTIVENESS OF FAMILY PLANNING AND NON HOSPITAL HEALTH PROGRAMS[a]/ (US$)

	COST PER		
	Birth Prevented	Infant Death Averted	Adjusted Infant Death Averted[b]/
Total Effects			
Family Planning Program	80	460	1200
Non Hospital Health Programs	1500	1920	2230
Direct Effects[c]/			
Family Planning Program	90	---	---
Non Hospital Health Programs	---	2500	---

[a]/ Based on reduced form elasticities from alternative #2, Table 3. The Rupee costs were converted to US$ using an exhange rate of 1US$ = 625Rp.

[b]/ The "unadjusted" infant deaths averted in the column at the left are derived from the total response elasticities. These contain two components (a) change in infant deaths due to reduced infant mortality and (b) reduced infant deaths due to fewer births. The "adjusted" deaths averted are based only on component (a).

[c]/ From the structural equations for alternative #2. This model omits interaction effects.

Cost Effectiveness of Preventing Births

28. Over the period to be considered in calculating the cost effectiveness of the program alternatives the age structure of the population can be considered constant so that the birth rate is proportional to the total fertility rate and the elasticities of the total fertility rate with respect to any determining variables (X) can be translated directly to elasticities for births (B). Under these circumstances, the change in births with a change in a determining variable is

$$\frac{\delta B}{\delta X} = \eta_{TFR,X} \cdot \frac{B}{X}$$

or, if X is given in monetary terms the change in cost per added birth prevented is

$$CE_{B,X} = X/(\eta_{TFR,X} \cdot B) \qquad (3)$$

29. This formula can be applied to calculate the cost per birth prevented by additional expenditures on family planning[12]. Considering interaction and using the reduced form elasticity of TFR with respect to REXFPP the cost per birth prevented is US$80. Ignoring the interaction and using the

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[12]For 1980 the estimated expenditure on family planning per capita was 427 Rp. With a birth rate of .03372 per capita, and a total response elasticity, derived from the reduced form coefficients, of .25, the cost per birth prevented is

$$CE_{B,REXFPP} = \frac{\Delta REXFPP}{\Delta B} = REXFPP/(\eta_{TFR,REXFPP} \cdot \frac{B}{P}) = \frac{(427 \text{ Rp})}{(.25)(.03372)} = \text{Rp. } 50600$$

or US$80, using an exchange rate of US$ 1 = 625 Rp.

elasticities provided by the direct effects only gives a cost per birth prevented of US$90. Thus, inclusion of the interaction of fertility and mortality increases the estimated cost effectiveness of the family planning program.

30. A similar calculation can be made for the cost effectiveness of the non hospital health programs in reducing births. The cost obtained[13] using the reduced form elasticity of TFR with respect to REXNP is US$1500 per birth prevented. This figure is of special interest because the prevention of births represents a bonus for the programs comprising the bulk of REXNP. Without considering the interaction of fertility and mortality such programs as malaria control or the expanded program for immunization would be estimated to affect infant deaths but to have no effect on births.

Cost Effectiveness of Preventing Infant Deaths

31. Calculation of the cost effectiveness of programs affecting infant deaths is slightly more complicated than the calculation for births because there are two components to be considered. Written in terms of elasticities

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[13] With an elasticity of .04 for the effect of REXNP on TFR and a value of 1272 Rp. for REXNP the cost per birth prevented is

$$CE_{B,REXNP} = \frac{\Delta REXNP}{\Delta B} = \frac{REXNP}{(\eta_{TFR,REXNP} \cdot \frac{B}{P})} = \frac{1272\ Rp}{(.04)(.03372)} = 943000\ Rp \text{ or US\$1500.}$$

the change in infant deaths (D) with a change in a determining variable (X) is[14]

$$\frac{\delta D}{\delta X} = \eta_{IMR,X} \cdot \frac{D}{X} + \eta_{B,X} \cdot \frac{D}{X}$$

The two components are (1) the response attributable to the reduction in risk of infant death and (2) the response attributable to a decline in births and thus, for a given IMR, a corresponding decline in total infant deaths. Inverting this expression, the cost effectiveness of programs affecting infant deaths can be calculated as

$$CE_{D,X} = X/(IMR \cdot B)(\eta_{IMR,X} + \eta_{TFR,X}) \tag{4}$$

Again using the reduced form elasticities, which incorporate the interaction of fertility and mortality, the cost per infant death averted by the non hospital health programs is US$1920 per death averted[15]. Without the interaction effect, that is, using only the direct response elasticities, the estimated cost per infant death averted would be US$2500, almost 30% more than the actual cost per death averted given the interaction of mortality and fertility. If we consider only the deaths averted through the reduction in risk, that is only the first component identified above, and

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[14]The number of infant deaths is $D = IMR \cdot B$.

[15]Expressing births and non hospital health expenditures in per capita terms,

$$CE_{D,REXNP} = \frac{REXNP}{(IMR \cdot \frac{B}{P})(\eta_{IMR,REXNP} + \eta_{TFR,REXNP})} = \frac{1272\ Rp}{(.108)(.03372)(\ .29)}$$

$$= 1200000\ Rp \text{ or US\$1920.}$$

omit deaths avoided through the reduction in the number of births, the cost per death averted through REXNP is US$2230, still slightly less than the direct effect cost.

32. As was the case with the effect of REXNP on births, there is an added bonus to family planning programs in the reduction of infant deaths. Again applying the reduced form elasticities to the basic formula for cost effectiveness gives a cost per death averted of US$460 for family planning expenditures[16]. Remarkably, this calculation reveals that because of interaction, family planning expenditures are more cost effective in reducing infant deaths than general non hospital health expenditures. Even considering only the effect of family planning programs in reducing the risk of infant death and ignoring the effect of the programs in reducing deaths through the reduced number of births, the cost per death averted, at US$1200, is less than the cost for REXNP.

33. The expenditures included in REXNP cover a broad spectrum of activities, including some that are not concerned directly with infants. Thus, the cost per infant death prevented represents an average for programs

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[16]The cost effectiveness of REXFPP in preventing infant deaths can be calculated as

$$CE_{D,REXFPP} = REXFPP/(IMR \cdot \frac{B}{P})(\eta_{IMR,REXFPP} + \eta_{TFR,REXFPP})$$

$$= \frac{(427\ Rp)}{(.108)(.03372)(-.41)} = 286000\ Rp \text{ or US } \$460$$

with varying impacts on infant mortality and the cost per unit of effect of REXNP is high compared to programs that specifically target infants. The estimated fertility response to changes in infant mortality can be applied to infant specific programs to incorporate the interaction of fertility and mortality and derive revised estimates of the cost effectiveness of programs such as the expanded program on immunization (EPI). For example, as part of a project appraisal (1978) for the expanded program on immunization in Indonesia it was estimated[17] that the cost per child death prevented by the immunization program would be US$130. However, this estimate did not include the effects of reduced child mortality on births and thus the ensuing indirect effects of improved birth intervals in further reducing mortality. Including the secondary effects of the EPI program, the cost per infant death prevented would be less than US$60 and the program would also prevent approximately one birth for every US$260 spent on immunization. The lower cost and added benefits greatly enhance an already cost effective program.

Sensitivity of Results

34. The results reported above are sensitive to the data specification and formulation of the model. The variability of the interaction coefficients was seen in a comparison of the results with and without the inclusion of the hospital expenditure variable and in a comparison of the OLS and 2SLS results. The estimates of cost effectiveness are, thus, subject to change as additional provincial level information becomes available and the

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[17] Barnum (1980)

specification of the structural equations is refined. Based on previous studies[18], the expected value of the mortality coefficient (the coefficient on IMR in the fertility equation giving the reaction of total fertility to changes in infant mortality) is between .2 and .5. The estimated coefficient in alternative #2 falls slightly below this range. Similarly, prior to conducting the analysis the expectation of the size of the fertility coefficient[19] (the coefficient on TFR in the mortality equation giving the response of infant mortality to changes in fertility) was between .4 and .8. In this case the estimated coefficient falls well within the range.

35. Sensitivity tests were conducted by varying the interaction coefficient on IMR from .2 to .5. and going through the steps described in section IV to recalculate the implied cost effectiveness of family planning and non hospital health programs. Similarly the interaction coefficient on TFR was varied from .4 to .8 and revised cost effectiveness estimates were computed. The results are highly sensitive to the variation in the mortality coefficient but much less sensitive to variation in the fertility coefficient. Over the range of values examined for the mortality coefficient the cost per death prevented by non hospital health expenditures varies by ± 30% (around the midpoint of the range given in Table 5) and the cost per birth prevented varies by 74%. Over the range examined for the fertility coefficient, the cost per infant death averted varies by 17% and the cost per birth prevented varies by 4%. The higher sensitivity to the

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[18]See the references in footnote 1.

[19]See the references in footnote 2.

magnitude of the mortality coefficient is related to it's modest size relative to the fertility coefficient. However the relative magnitude of the estimated interaction coefficients is consistent with the literature. A specific finding of the sensitivity analysis is, thus, that the size and significance of the mortality interaction coefficient is critical to the estimates of cost effectiveness and should be the subject of refinement.

36. In spite of the sensitivity of the results to the estimated mortality interaction coefficient, the range of cost effectiveness estimates generated by the sensitivity tests confirms the importance of mortality interaction. Comparing the estimates of cost effectiveness in table 4, based on the estimated coefficients, with the range of estimates in Table 5, based on the sensitivity analysis, it is seen that the estimates of cost per unit of

Table 5

SENSITIVITY OF COST EFFECTIVENESS OF FAMILY PLANNING AND NON HOSPITAL HEALTH PROGRAMS TO CHANGES IN THE INTERACTION COEFFICIENTS[a]
(US$)

	COST PER		
	Birth Prevented	Infant Death Averted	Adjusted Infant Death Averted[b]
Total Effects c/			
Family Planning Program			
Variation of:			
TFR Coef. in IMR Eq.	75-82	383-540	863-1890
IMR Coef. in TFR Eq.	62-83	359-483	959-1287
Non Hospital Health Programs			
Variation of:			
TFR Coef. in IMR Eq.	1135-1243	1752-1918	2102-2302
IMR Coef. in TFR Eq.	378-2540	1168-2138	1752-2352

a/ The table gives the range of cost effectiveness of family planning and non hospital health programs as the interaction coefficient on IMR varies from .1 to .5 and the interaction coefficent on TFR varies from .4 to .8.

b/ See Table 4 for an explanation of "unadjusted" infant deaths averted.

c/ Direct effects are not affected by changes in the interaction coefficients.

effect all lie at the higher end of the range. The comparison suggests that the estimated equations may underestimate the cross effects of family planning and non hospital health expenditures on infant deaths and fertility. A general finding of the sensitivity analysis is, thus, that the results discussed in the preceding paragraphs provide a conservative confirmation of the importance of fertility-mortality interaction.

Conclusion

37. In response to the questions raised in the Introduction, the findings demonstrate (a) the substantial effect that family planning programs can have on infant mortality, (b) the substantial effect that non hospital health interventions can have on fertility, (c) the importance of fertility-mortality interaction in raising the cost effectiveness of health and family planning programs, (d) the substantially greater cost effectiveness of non hospital health expenditures compared to hospital expenditures in reducing infant mortality. With regard to Indonesia, the findings strongly confirm the wisdom of Indonesia's current policies of retrenching in the face of declining availability of recurrent funds to support family planning programs and services delivered at the first referral level.

38. Although the quantitative results must be restricted to Indonesia, the qualitative answers to the questions raised above have implications for the cost effectiveness of health and family planning programs in general. The findings are sufficiently strong and consistent with the thrust of the

literature over the last two decades that consideration of the interaction of mortality and fertility should be a regular part of the appraisal of health and population project effectiveness. It is widely accepted that integration of family planning and health programs provides benefits in the form of lower program costs and more effective promotion. The results in this paper indicate that the programs are also mutually enhancing from the standpoint of their direct effects on infant survival and birth prevention objectives as well.

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Appendix Table 1

DATA CORRELATION MATRIX

	REXNP	REXHP	REXFPP	IMR	TFR	CAL	TOIL	YP	PURB	ILLIT
REXNP	1									
REXHP	.31	1								
REXFPP	.57	.66	1							
IMR	-.30	-.49	-.19	1						
TFR	.03	-.44	-.34	.56	1					
CAL	-.08	-.25	-.18	.17	.62	1				
TOIL	-.13	.27	-.10	-.42	-.19	-.29	1			
YP	.35	.48	.22	-.31	-.16	-.20	.27	1		
PURB	-.12	.41	-.07	-.37	-.37	-.26	.40	.73	1	
ILLIT	.18	-.20	.33	.35	-.12	-.27	-.30	-.22	-.28	1

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