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On the Time Trend of Averted Births due to Various Methods of Family Planning

THE distribution of averted births over time has great relevance to policy and planning of population programmes for, among other things, it affects the projected population figures. A number of aspects of human fertility have bearing on this time distribution of averted births. The present work is in a way a sequel to the author's earlier work (Venkatacharya, 1971).

The Problem

A method of family planning prevents the occurrence of a conception which would otherwise have taken place. Methods such as salpingectomy and vasectomy are almost 100% effective and permanent. Such methods as IUCD and conventional contraceptives are not so effective; they differ in their effectiveness to prevent conception (Chandrasekaran *et al.,* 1971). A conception can result in a live birth or a pregnancy wastage, but we will be interested in the prevention of live births, which we term as 'averted births'.

Different family planning methods are initiated at various biological statuses such as menstruating state, gestation state, and postpartum amennorhea state of a married fecund woman. For example, most of the lUCDs are inserted when the woman is susceptible to conception i.e., when, within the reproductive span, she is subject to her menstruation cycle. A small percentage of lUCDs are, however, inserted towards the end of postpartum period, that is, when the woman is in non-susceptible state. The estimates of averted births by time are shown to be affected by the *initial* susceptible status of women accepting contraception (Venkatacharya, 1971).

The estimation of averted births by time explicitly and with sufficient accuracy needs sophisticated techniques including those that use high speed computers. These techniques cannot be recommended as a routine method in family planning evaluation, for such a method should be simple and computationally easy. Though less accurate but simple, techniques for estimating births averted by time exist.

In one such method, the absolute number of averted births unadjusted for time are computed first by applying the age specific (marital) fertility rates—abbreviated as *AS (M)FR*— to family planning users in a year, say *N.* However, the problem arises as to the time to which these averted births are to be related. Taking into consideration the implications of initial susceptibility status of family planning adopters (Venkatacharya, 1971), we can approximately attribute these unadjusted births averted to the year $T + K$, where K (years) is a shift parameter.

Assuming that we can obtain values of K for a particular situation we are in, the above method—hereafter termed as Short-cut Procedure One—is suitable for routine analysis in many family planning programmes, especially in the third world. The above method with Staking a value of one (year) for all methods of family planning, age distribution etc. becomes identical with the methods used by Lee-Isbister (1956) and Stolnitz (1968).

Thus before recommending this procedure, we need to know how sensitive K is with respect to the method of family planning, the age distribution of acceptors, the various biological variables of the group of woman under question, and so on. The effect of age distribution of acceptors, monthly chance of conception of family planners, and initial susceptible status of family planners on *Kis* known to some extent (Venkatacharya, 1971). However the impact of the tempo of family planning acceptance on K is not known which is the main interest of the present paper. (By tempo of family planning acceptance we refer to the time series of family planning adopters).

After examining the difficulties in the application of *K,* it has been found more expedient to use a variant of the above mentioned Short-cut Procedure One. According to this, the estimated number of averted births are first obtained in the same way as in that procedure by applying ASMFR to current family planning users in a year *T.* Then these unadjusted estimates of births averted are cumulated by time. In order to take care of the timing of births averted, the unadjusted cumulated births averted are attributed to the year $T + K^*$, where K^* (year) is a shift parameter. Later by successive subtraction or by other mathematical procedures, the estimates of averted births by time are derived. For purposes of cross reference we name this as Short-cut Procedure Two.

The most crucial factor in the applicability of the short-cut procedure is the easy availability of a set of *K* or K^* for a particular specific population. Towards this end, in the present paper an examination of the sensitiveness of *K* or K^* with reference to certain demographic variables including the tempo of family planning is made.

Methodology

A model based on expected values developed by the author earlier yields the probability of occurrence of live births by age at acceptance of family planning method and current age. These matrices are specific to the initial susceptibility status of woman accepting a method of family planning. The model takes into account a number of demographic and biological variables such as monthly chance of conception (MCC); probability of a given conception terminating in a live birth or pregnancy wastage; probability of gestation associated with live birth and pregnancy wastage; and the probability of past-partum amenorrhea (PPA) associated with a live birth and pregnancy wastage.

In a given population probability of the averting births through IUCD insertions in the first year are small, but it remains high in the second year or third years and then gradually decreases in the subsequent years, (Venkatacharya, 1971). In the case of salpingectomy, the number of averted births will be almost zero in the first year, reaches a maximum in the second and third years and thereafter decreases (Table 1). Similar considerations arise in the case of vasectomy.

TABLE 1 -THE PROBABILITY OF OCCURRENCE OF LIVE BIRTHS (ϕ-MATRIX) AND THEIR CUMULATIVE VALUES FOR WOMEN ACCEPTING SALPINGECTOMY, ASSUMING THAT THEY HAVE NOT DONE SO, FOR LOW LEVEL OF MCC : AND THE CORRESPONDING *AS(M)FR* BY AGE GROUP OF ACCEPTANCE AND YEARS SINCE ACCEPTANCE

Years since acceptance (v)	Age *group at the time of acceptance (i)*					
	1	*2*	*3*	*4*	*5*	*6*
			ϕ-Matrix			
1	.002	.002	.002	.001	.001	.000
2	.098	.126	.113	.069	.035	.016
3	.266	.314	.272	.173	.089	.043
4	.289	.309	.257	.168	.088	.048
5	.291	.296	.233	.148	.074	.046
6	.299	.290	.216	.131	.063	—
7	.305	.280	.198	.116	.057	—
8	.307	.267	.180	.101	.051	—
9	.307	.251	.163	.086	.048	_
10*	.303	.233	.146	.073	.045	—
			A-Matrix or ASMFR			
1	.183	.295	.293	.217	.131	.062
2	.234	.301	.282	.199	.115	.056
3	.257	.304	.269	.181	.100	.051
4	.275	.304	.253	.164	.086	.047
5	.286	.300	.236	.147	.073	.044
6	.295	.293	.217	.131	.062	-
7	.301	.282	.199	.115	.056	—
8	.304	.269	.181	.100	.051	-
9	.304	.253	.164	.086	.047	—
10*	.300	.236	.147	.073	.044	—

Table 1 *(contd.)*

Cumulated values				ϕ_s-Matrix		
1	.002	.002	.002	.001	.001	.000
2	.100	.128	.115	.070	.036	.016
3	.366	.442	.387	.243	.125	.059
4	.655	.751	.644	.411	.213	.107
5	.946	1.047	.877	.559	.287	.153
6	1.245	1.337	1.093	.690	.350	—
7	1.550	1.617	1.291	.806	.407	—
S	1.857	1.884	1.471	.907	.458	—
9	2.164	2.135	1.634	.993	.506	_
10*	2.467	2.368	1.780	1.066	.551	—
		Cumulated values *A* -Matrix				
1	.183	.295	.293	.217	.131	.062
2	.417	.596	.575	.416	.246	.118
3	.674	.900	.844	.597	.346	.169
4	.949	1.204	1.097	.761	.432	.216
5	1.235	1.504	1.333	.908	.505	.260
6	1.530	1.797	1.550	1.039	.567	-
7	1.831	2.079	1.749	1.154	.623	—
8	2.135	2.348	1.930	1.254	.674	-
9	2.439	2.601	2.094	1.340	.721	—
10*	2.739	2.837	2.241	1.413	.765	—

*** Values exist upto v=30 which are not shown in the table.**

Making use of these matrices (described below) the estimates of averted births can be obtained for various combinations of variables including some patterns of family planning performance. These annual estimates of averted births give the true time distribution. By relating these estimates with those derived through the use of ASMFR under the same combination of variables, we can obtain values *K* and *K**. The details of obtaining *K* and *K** are given below.

Assumptions. (1) The potential fertility of family planning acceptors is assumed to be the same as that of the general population of women. Thus ASMFR can be used to estimate averted births without any inflation. However, the same procedure indicated in this paper can be extended if the potential fertility is found to be more than ASMFR by inflating the ^-matrices (defined below) by appropriate factor. (2) The age distribution (Table *2)* of acceptors as well as the demographic and biological variables implied in the derivation of $ are assumed to remain constant between 1956-90. (3) In the absence of family planning methods the women are not assumed to use another method of contraception i.e., no substitution. However the present method can be extended to the case when substitution exists with some modifications. (The various assumptions made in deriving ^-matrices and A-matrix (defined below) are those mentioned in the author's earlier article.)

TABLE 2—AGE DISTRIBUTIONS OF SALPINGECTOMIZED FEMALES, WIVES OF VASECTOMIZED MALES AND WOMEN USING IUCD FOR TWO LEVLS-
L AND H

Age group	*Salpingectomy*		*Vasectomy*		*IUCD*	
	L	*H*	*L*	*H*	*L*	*H*
15-19	-	—	—	—	—	—
20-24	.092	.070	.102	.020	.240	.080
25-29	.364	:200	.423	.130	.340	.227
30-34	.321	.120	.320	.300	.250	.303
35-39	.186	.190	.151	.290	.130	.270
40-44	.037	.420	.004	.260	.040	.113
Mean age (years)	31.1	36.0	30.2	35.7	29.5	32.9

SOURCE : Based on Indian data. For details see author's earlier article.

Input values. In the present study for each method of family planning two levels of MCC (with two corresponding levels of PPA) are used. Further two age distributions of acceptors are assumed (Table 2). Mortality of the population has been assumed to be of three levels corresponding to high, medium and low e^0_0—expectation of life at birth. These values are shown in Table 3.

TABLE 3-EXPECTATION OF LIFE AT BIRTH FOR MALES AND FEMALES UNDER THREE LEVELS CORRESPONDING TO THE PERIOD BEGINNING 1956-60 to 1986-90

HIGH e^0_0			*MEDIUM* e^0_0		*LOW* e^0_0	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*
1956-60	40.7	40.4	36.3	35.8	32.1	31.4
61-65	45.0	45.1	40.7	40.4	36.3	35.8
66-70	50.3	51.0	45.0	45.1	40.7	40.4
71-75	52.1	53.0	50.3	51.0	45.0	45.1
76-80	55.3	56.5	52.1	53.0	50.3	51.0
81-85	58.4	60.1	55.3	56.5	52.1	53.0
86-90	61.4	63.6	58.4	60.1	55.3	56.5

SOURCE : Based on the paper by Immerwahr and Sinha (1970).

The tempo of family planning performance is an important factor considered here. The study is concerned with the period 1956-90. For the period 1956-70 the actual family planning performance in India has been used. These are shown in Table 4. For the period beyond 1970 four levels for each method of family planning have been chosen. These are not expected to be either most probable or exhaustive levels of future family planning performance but only a set of possibilities. Without much difficulty these levels can be multiplied to cover other possible patterns. The various patterns of family planning performance for the period 1971-90 are also shown in Table 4.

Definitions

ϕ $(j \bullet j + v)$—the probability of a family planning acceptor adopting a method at age *j,* giving a birth after v years, at age $(j + v)$, *subject to the condition that the couple had not actually used the method of family planning;* where j = 1,2,3,..., 30 and v = 0, 1, 2,.. .,30, — *j;* and the values of j correspond to ages 15,16,17, . . .,44. ϕ $(j, j + v)$ is equivalent to the age specific fertility rate at age $j + v$, based on those women who have been in a specific susceptibility status at age *j,* which in turn depends on the initial susceptibility status of family planning acceptors, assuming that they have not actually gone for the method of family planning. In order to reduce the computational labour, the ϕ's are expressed in five year age groups.

TABLE 4-THE NUMBER OF COUPLES (IN THOUSANDS) ADOPTING SALPINGECTOMY, VASECTOMY AND IUCD IN EACH YEAR IN INDIA UNDER FOUR PATTERNS

Year	Vasectomy				Salpingectomy				IUCD			
	V_1	V_2	V_3	V_4	S_1	S_2	S_3	S_4	I_1	I_2	I_3	I_4
(1)	(2)	(3}	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11}	(12)	(13)
1956*	2				5							
57	4				10							
58	9				16							
59	18				25							
60	38				27							
61	64				41							
62	112				46							
63	115				56							
64	201				68							
65	402				75				730			
66	655				164				832			
67	1236				309				728			
68	1444				361				526			
69	1097				349				464			
70	891				409				458			
71	793	851	1003	1003	480	480	453	453	458	428	485	477
72	706	811	1128	1147	562	550	501	497	458	401	512	495
73	628	770	1270	1227	659	620	555	540	458	374	540	515
74	559	730	1430	1338	772	691	614	584	458	350	567	536
75	498	690	1610	1450	905	761	680	628	458	327	594	557
76	443	650	1812	1562	1060	831	753	672	458	306	621	579
77	394	610	2040	1674	1243	902	834	716	458	286	648	602
78	351	569	2296	1786	1456	972	923	759	458	267	675	626
79	312	529	2584	1897	1707	1042	1021	803	458	250	702	651
80	278	489	2908	2009	2001	1113	1131	847	458	234	729	677
81	247	449	3273	2121	2345	1183	1252	891	458	218	756	704
82	220	409	3684	2233	2748	1254	1386	934	458	204	783	732
83	196	368	4147	2345	3221	1324	1534	978	458	191	810	761

Table 4 *(contd.)*

(1)	(?)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
84	175	328	4667	2457	3774	1394	1698	1022	458	178	837	791
85	156	288	5253	2548	4424	1465	1880	1066	458	167	865	822
86	138	248	5912	2680	5201	1535	2081	1110	458	156	892	855
87	123	208	6654	2792	6095	1605	2303	1153	458	146	919	889
88	109	167	7490	2904	7144	1676	2550	1197	458	136	946	924
89	97	127	8430	3016	8372	1746	2823	1241	458	127	973	961
90	87	87	9487	3175	9812	1817	3125	1285	458	119	1000	1000

NOTES : VI Decreases between 1970-90 in *a* geometric progression at the rate of. 11 per year which is half of the average rate of performance of vasectomies during 1968-70.

V_2 Decreases between 1970-90 in arithmetic progression at the rate of .11 per year.

V_3 Increases between 1970-90 in geometric progression at the rate of .1255 per year which is one half of the average rate performance of vasectomies for 1965-70.

V_4 Increases between 1970-90 in arithmetic progession at the rate of .1255 per year.

S_1 Increases in a geometric progression at the rate of .172 which is the rate of increase for 1960-70.

5_2 Increases in arithmetic progression at the rate of .172 per year.

S_3 Increases in geometric progression at the rate of. 107 which is the average rate of 1967-70.

S_4 Increases in arithmetic progression at the rate of .107 per year.

I_1 Constant beyond 1970.

I_2 Decreases in a geometric progression at the rate of .0652 per year which is the average rate for 1969-70.

I_3 Increases in arithmetric progression to a million in 1990.

I_4 Increases in geometic progression to million in 1990.

2.* Patterns for V_2, V_3, V_4 ; S_2, S_a, 5_4 ; I_2 I_3 I_4 for the years 1956-70 are the same as those of V_{ls} $S_{1;}$ and I_1 respectively.

ϕ (i, i + v)—the probability of a family planning acceptor, adopting the method of family planning in the age group *i,* giving a birth after v years in the age group *i* + v, *assuming that she had not actually used the method of family planning,* where *i* = *1,2, ... ,6* and v = 0, 1, 2, . . . , 29 — 5 (*i* — *1*). Here *i* corresponds to the five year age groups 15-19, 20-24, . . . , 40-44. *i* + *v* means age group *i* advanced over v years. For the age group 15-19, i.e. *i* = 1; *i* + 1 will correspond to the age group 16-20, *i*+2 to 17-21 etc. The operator + should be interpreted in this sense.

The values of $\bar{\phi}$ are obtained by averaging ϕ's as shown below;

$$\bar{\phi}(i, i+v) = \frac{1}{n} \sum_{j=1+5(i-1)}^{1+5(i-1)+n} \phi(j, j+v),$$

where

$$i = 1, 2, \ldots, 6$$
$$v = 0, 1, 2, \ldots, 29 - 5(i-1)$$
$$n = 5 \text{ for all } v \leqslant 29 - 5i,$$

and

$$n = 29 - 5(i-1) - v \quad \text{for } 29 - 5i < v \leqslant 29 - 5(i-1)$$

$A(i, i+v)$—the values of age specific marital fertility rate corresponding to the age group $i+v$ of acceptors of family planning at age group i, on the assumption that the couple had not gone for family planning. It is obtained from the age specific marital fertility schedule (single year age) f_x. The ASMFR for the age j is obtained as

$$f_j = \sum_{s=1}^{j} M_s \phi_l (s, j - s + 1),$$

where M_s is the probability of consummated marriage at age $s + 14$ years. j takes values 1, 2, . . . corresponding to 15, 16, . . . 35 years. Marriages are assumed to take place between ages 15 to 35 years. The input of M_s are based on Indian experience (Venkatacharya, 1971). It is assumed that the women are in the susceptible state at the time of marriage (same as IUCD acceptors).

Further, we have

$$A(i, i+v) = \frac{1}{n} \sum_{j=1+5(i-1)}^{1+5(i-1)+n} f_j,$$

where

$$i = 1, 2, \ldots, 6$$
$$v = 0, 1, 2, \ldots, 29 - 5(i-1)$$
$$n = 5 \text{ for all } v \leqslant 29 - 5i$$
$$n = 29 - 5(i-1) - v \quad \text{for } 29 - 5i < v \leqslant 29 - 5(i-1)$$

$B\bar{\phi}(y)$—estimated number of averted births using $\bar{\phi}$

$BA(y)$—estimated number of averted births using A.

Since initial susceptibility status of women adopting salpingectomy, vasectomy and IUCD are different the ϕ's will be different and they are denoted by ϕ_S, ϕ_V and ϕ_I respectively. On the other hand A will be the same. While the susceptibility status of women adopting IUCD and salpingectomy are known, the susceptibility status of women whose husbands go for vasectomy is not known. Therefore, in the present work ϕ_V is approximated as $\frac{1}{2}(\phi_I + \phi_S)$. The corresponding values of $\bar{\phi}$ are denoted as $\bar{\phi}_S$, $\bar{\phi}_V$ and $\bar{\phi}_I$.

$S(i, y, t)$—the joint survival ratios (survival of wife and husband) for women in the i-th age group in the y-th year for t future years. These survival ratios are obtained from the U.N. West Model Life Tables (United Nations, 1967) corresponding to e_0^0, shown in Table 2.

P^y—number of family planning adopters in y-th year of either of vasectomy or salpingectomy or IUCD.

a_i^V, a_i^S and a_i^I—proportion of women accepting a method of family planning at i-th age group where

$$\Sigma a_i^V = \Sigma a_i^S = \Sigma a_i^I = 1.$$

Estimates of Averted Births—Vasectomy and Salpingectomy

The number of births that would occur in the year $T + t$ on the assumption that either the woman or her husband does not get sterilized can be given as :

$$\sum_{y=T}^{T+t} \sum_{i=1}^{6} (P^y \cdot a_i) \cdot S(i, y, T + t - y) \cdot \bar{\phi}(i, i + T + t - y) \quad (1)$$

for $$t = 0, 1, 2, \ldots, 34.$$

T is the year of initiation of sterilization or IUCD program. In the case of vasectomy and salpingectomy $T = 1956$; for IUCD, $T = 1965$ and maximum $T + t = 1990$.

By using $\bar{\phi}_V$ and $\bar{\phi}_S$ with corresponding a_i^V and a_i^S we obtain the number of births that would have occurred in the absence of sterilization and

$B\bar{\phi}(y)$—estimated number of averted births using $\bar{\phi}$

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The number of births that would occur in the year $T + t$ on the assumption that either the woman or her husband does not get sterilized can be given as :

$$\sum_{y=T}^{T+t} \sum_{i=1}^{6} (P^y \cdot a_i) \cdot S(i, y, T + t - y) \cdot \bar{\phi}(i, i + T + t - y) \quad (1)$$

for $$t = 0, 1, 2, \ldots, 34.$$

T is the year of initiation of sterilization or IUCD program. In the case of vasectomy and salpingectomy $T = 1956$; for IUCD, $T = 1965$ and maximum $T + t = 1990$.

By using $\bar{\phi}_V$ and $\bar{\phi}_S$ with corresponding a_i^V and a_i^S we obtain the number of births that would have occurred in the absence of sterilization and since sterilization is 100% effective these numbers give the estimates of averted births (which are automatically adjusted for time distribution). If we use $A(i, i + v)$ instead of $\overline{\phi}$ in the Eq. (1) we obtain estimates of averted births, unadjusted for time distribution, through the application of ASMFR.

Table 1 presents numerical values of the elements $\overline{\phi}_S$ and A for salpingectomy under one set of variable combination. Similar tables can be derived for $\overline{\phi}_V$ and $\overline{\phi}_I$. From this rable it is evident that the values of $\overline{\phi}$ $(i, i + v)$ for $v = 0$ and $v = 1$ are much smaller than the corresponding $A(i, i + v)$ for all i. This is because of the initial non-susceptible status of women who would adopt salpingectomy. Also for $\overline{\phi}_I$ and $\overline{\phi}_V$ such a pattern will hold, though less pronounced. However $\overline{\phi}_s$ $(i, i + v)$ for $v = 2$ and $v = 3$ (for $v = 2$ only in the first three age groups) are slightly more than the corresponding $A(i, i + v)$. For values of v greater than 3, the values of $\overline{\phi}_S$ and A are quite close.

From Eq. (1) we can infer that the estimates of averted births obtained through the use of $\overline{\phi}$ will be less than those obtained through A under identical conditions, in the light of the preceding paragraph.

In the same Table 1 cumulated values of $\overline{\phi}$ and A are given, towards the end, for each age group. From this it is evident that for a single cohort of family planning users *in the long run*, the cumulated estimates of averted births obtained by using $\overline{\phi}$ will be lower than the corresponding cumulated estimates using A, other things remaining the same. This is due to the fact that the matrix A is based on ASMFR, which are equivalent to steady state rates, whereas $\overline{\phi}$ is based on the experience of initial time period of the reproductive process starting in a specific susceptible status. This will be less pronounced in the case of vasectomy and much less in the case of IUCD.

Under certain conditions it is possible to derive the estimates of averted births making use of A, and redistribute them in some way over time such that it corresponds to the true pattern of averted births that could have been obtained by using $\overline{\phi}$ values. For this we assume that the performance of family planning increases with time in a gradual manner. Then from Eq. (1), $B\overline{\phi}_S(y)$ and $BA(y)$ will be increasing functions of time. In Fig. 1 the estimates of averted births obtained for pattern S_3, low MCC and low-age distribution are shown (using $\overline{\phi}$ and A).

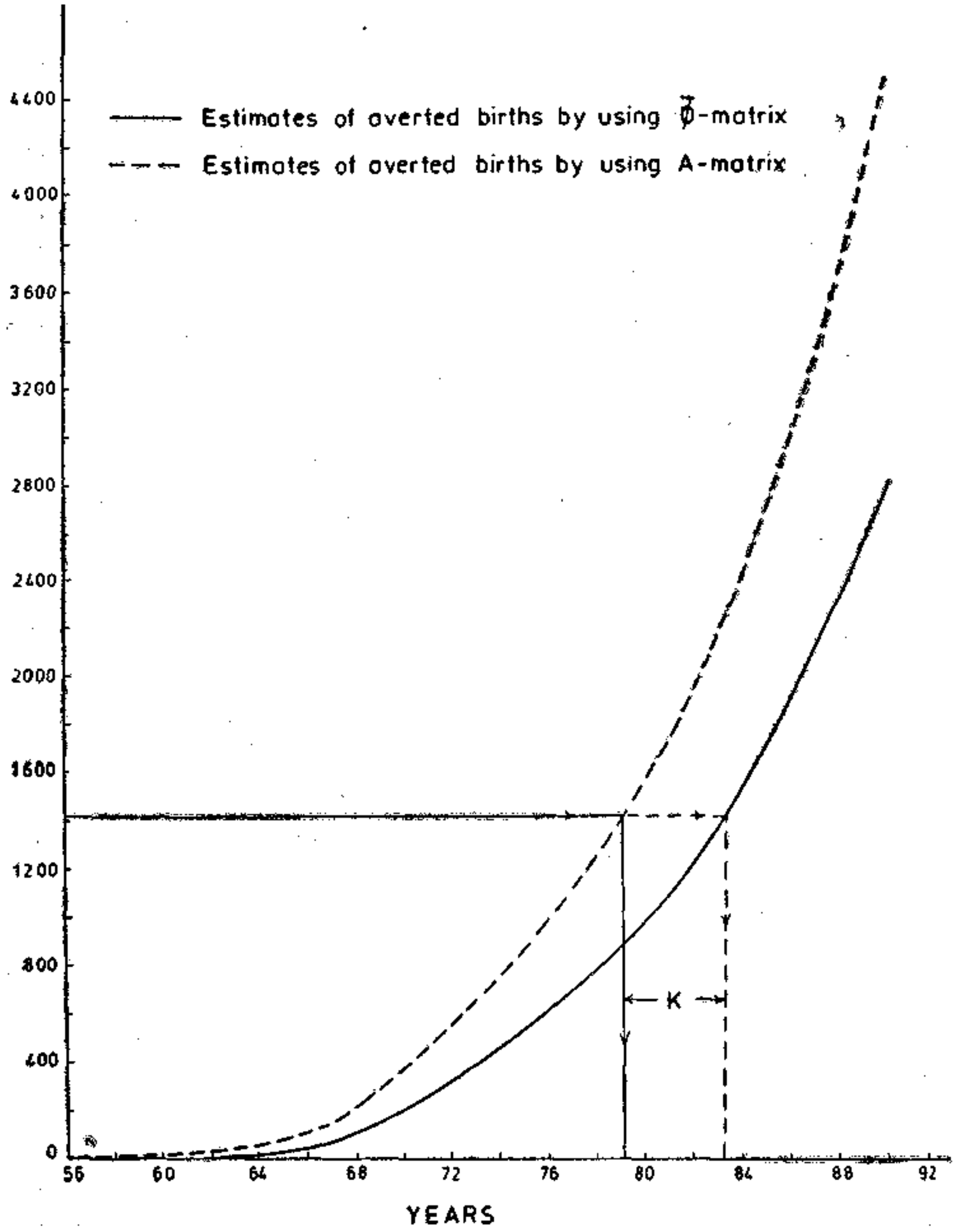

Fig. 1. Estimates of averted births for salpingectomy (S_3 pattern, L-age distribution and low MCC) using $\overline{\phi}$ and A matrices.

As $B\bar{\phi}$ values are always lower than the values of BA for a given year N^1, we can always find a value K such that

$$BA(N^1) = B\bar{\phi}(N^1 + K).$$

K can be estimated—as we know both $B\bar{\phi}$ and BA for different years—as ;

$$K = (Z - N) + \frac{B\bar{\phi}(Z+1) - BA(y)}{B\bar{\phi}(Z+1) - B\bar{\phi}(z)}, \qquad (2)$$

where Z is such that $B\bar{\phi}(Z) \leqslant BA(y) \leqslant B\bar{\phi}(Z+1)$. The second term in the above equation gives the fraction of a year and $(Z - N)$ gives the integral number of years.

The estimated annual averted births for a given year can be assumed to be centred around the mid-year. Taking years and estimates of annual averted births as the two coordinates, we can draw curves of averted births. The meaning of the above equation is that by starting with points $[y, BA(y)]$, $y = T, T+1, \ldots, T+t$ lyingon the curve of unadjusted estimates of averted births, we can derive the curve of adjusted births corresponding to points

$$[y + K, BA(y) = B\bar{\phi}(y + K)], \quad y = T, \; T+1, \ldots, T+t.$$

Instead of using $B\bar{\phi}(y)$ and $BA(y)$ in Eq. (2) if we use the corresponding cumulated values $B\bar{\phi}^*(y)$ and $BA^*(y)$ we obtain the value of K^* corresponding to K, where

$$B\bar{\phi}^*(y) = \sum_{s=1}^{y} B\bar{\phi}(s) \quad \text{and} \quad BA^*(y) = \sum_{s=1}^{y} BA(s).$$

This method can be used even when family planning performance does not steadily increase with time. This is due to the fact that the cumulated estimates of births averted always increase with time whatever may be the pattern of family planning performance. It is to be noted that, both K and K^* are functions of time. The values of K alone are shown in Tables 5 and 6.

IUCD. For IUCD we need to take into account the effectiveness- of IUCD in reducing fertility and the retention rates of IUCD. It is necessary to obtain

TABLE 5—VALUES OF *K*, FOR VASECTOMY UNDER TWO LEVELS OF MCC, TWO AGE DISTRIBUTIONS AND DIFFERENT PATTERNS OF PERFORMANCE

	Level of MCC															
	Low								High							
	Level of age distribution								Level of age distribution							
	L				H				L				H			
	Patterns of performance															
	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
(1)	(2)	(3}	(4}	(5)	(6)	(7)	(8)	(9)	(10)	(11}	(12)	(13)	(14)	(15)	(16)	(17)
56	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	.2	1.2	1.2	1.3	1.3	1.3	1.3
57	1.1	1.1	1.1	1.1	1.3	1-3	1.3	1.3	1.2	.2	1.2	1.2	1.4	1.4	1.4	1.4
58	1.1	1.1	1.1	1.1	1.4	1.4	1.4	1.4	1.3	.3	1.3	1.3	1.4	1.4	1.4	1.4
59	1.2	1.2	1.2	1.2	1.4	1.4	1.4	1.4	1.3	.3	1.3	13	1.5	1.5	1.5	1.5
60	1.2	.2	1.2	1.2	1.5	1.5	1.5	1.5	1.3	.3	1.3	1.3	1.6	1.6	1.6	1.6
61	1.3	.3	1.3	1.3	1.6	1.6	1.6	1.6	1.4	.4	1.4	1.4	1.6	1.6	1.6	1.6
62	1.5	.5	1.5	1.5	2.0	2.0	2.0	2.0	1.7	1.7	1.7	1.7	2.0	2.0	2.0	2.0
63	1.4	.4	1.4	1.4	1.8	1.8	1.8	1.8	1.5	1.5	1.5	1.5	1.8	1.8	1.8	1.8
64	1.3	.3	1.3	1.3	1.6	1.6	1.6	1.6	1.4	1.4	1.4	1.4	1.7	1.7	1.7	1.7
65	1.3	.3	1.3	1.3	1.6	1.6	1.6	1,7	1.4	1.4	1.4	1.4	1.7	1.7	1.7	1.7
66	1.3	.3	1.3	1.3	1.6	1.6	1.6	1.6	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
67	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	1.6	1.6	1.6	1.6	2.0	2.0	2.0	2.0
68	2.0	2.0	2.0	2.0	4.2	3.9	3.6	3.6	2.4	2.4	2.3	2.3	4.8	4.2	3.8	4.2
69	3.3	3.1	2.8	2.8	—	—	4.6	4.6	4.5	3.7	3.2	3.2	—	—	4.7	—
70	—	—	2.9	2.9	—	—	4.6	4.7	—	—	3.3	3.3	—	—	4.7	—
71	—	—	3.0	3.1	—	—	4.5	4.8	—	—	3.3	3.4	—	—	4.6	—
72	—	—	3.1	3.3	—	—	4.4	5.0	—	_	3.4	3.6	—	—	4.5	—
73	—	—	3.1	3.5	=	—	4.4	5.2	—	—	3.4	3.8	—	—	4.4	—
74	—	—	3.2	3.7	—	—	4.3	5.4	—	—	3.4	4.0	—	—	4.4	—
75	—	—	3.2	3.9	—	—	4.3	5.6	—	—	3.4	4.2	—	—	4.3	—
76	—	—	3.2	4.1	—	—	4.2	5.8	—	—	3.4	4.4	—	—	4.3	_.
77	—	—	3.1	4.2	—	—	4.1	6.1	—	—	3.4	4.6	—	—	4.2	—
78	—	—	3.1	4.4	—	—	4.1	6.3	—	—	3.3	4.8	—	—	4.1	—
79	—	—	3.1	4.6	—	—	4.1	6.6	—	—	3.3	5.0	—	—	4.1	—
80	—	—	3.1	4.8	—	—	4.1	6.9	—	—	3.3	5.2	-	—	4.1	—
81	—	—	3.1	5.1	—	—	4.0	7.2	—	—	3.3	5.5	—	—	4.1	—
82	—	—	3.0	5.3	—	—	4.0	7.5	—	—	3.3	5.7	—	—	4.0	—
83	—	—	3.0	5.5	—	—	4.0	—	—	—	3.3	5.9	—	—	4.0	—
84	—	—	3.0	5.8	—	—	4.0	—	—	—	3.2	—	—	—	4.0	—
85	—	—	3.0	—	—	—	4.0	—	—	—	3.2	—	—	—	4.0	—
86	—	—	3.0	—	—	—	3.9	—	—	_,	3.2	—	—	—	—	—
87 } 90																

TABLE 6—VALUES OF *K*, FOR SALPINGECTOMY UNDER TWO LEVELS OF MCC, TWO AGE DISTRIBUTIONS AND PATTERNS OF PERFORMANCE

	Level of MCC															
Year	LOW								HIGH							
Level	of age distribution								Level of age distribution							
	L				H				L				H			
Patterns of performance	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
(1}	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16}	(17)
56	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
57	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3
58	1.9	1.9	1.9	1.9	2.1	2.1	2.1	2.1	2.3	2.3	2.3	2.3	2.5	2.5	2.5	2,5
59	2.2	2.2	2.2	2.2	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.8	2.8	2.8	2.8
60	2.2	2.2	2.2	2.2	2.4	2.4	2.4	2.4	2.6	2.6	2.6	2.6	2-8	2.8	2.8	2.8
61	2.5	2.5	2.5	2.5	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8	3.1	3.1	3.1	3.1
62	2.6	2.6	2.6	2.6	2.8	2.8	2.8	2.8	2.9	2.9	2.9	2.9	3.3	3.3	3.3	3.3
63	2.7	2.7	2.7	2.7	3.0	3.0	3.0	3.0	3.1	3.1	3.1	3.1	3.4	3.4	34	3.4
64	2.6	2.6	2.6	2.6	2.8	2.8	2.8	2.8	3.1	3.1	3.1	3.1	3.3	3,3	3.3	3.3
65	2.2	2.2	2.2	2.2	2.3	2.3	2,3	2.3	2.6	2.6	26	2.6	2.8	2.8	2.8	2.8
66	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.4	2.4	2.4	2.4	2.6	2.6	2.6	2.6
67	2.3	2.3	2.3	2.3	2.5	2.5	2.5	2.4	2.6	2.6	2.6	2.6	2.8	2.8	2.8	2.8
68	2.7	2.7	2.7	2.7	2.9	2.9	2.9	2.9	3.0	3.0	3.0	3.0	3.4	3.4	3.4	3.3
69	2.8	2.8	2.9	2.9	3.1	3.1	3.2	3.1	3.2	3.2	3.2	3.2	3.6	3.6	3.6	3,6
70	3.0	3.0	3.1	3.1	3.2	3.3	3.5	3.5	3.3	3.3	3.4	3.4	3.7	3.8	4.0	4.0
71	3.0	3.1	3.3	3.4	3.3	3.4	3.7	3.8	3.4	3.5	3.7	3.7	3.8	3.9	4.2	4.3
72	3.1	3.3	3.5	3.6	3.4	3.6	3.9	4.1	3.5	3.7	3.9	4.0	3.9	4.1	4.4	4.6
73	3.2	3.5	3.7	4.0	3.4	3.8	4.1	4.4	3.6	3.9	4.1	4.4	4.0	4.4	4.7	5.0
74	3.2	3.7	3.9	4.3	3.5	4.1	4.2	4.8	3.6	4.1	43	4.7	4.0	4.1	4.8	5.4
75	3.3	4.0	4.0	4.6	3.5	4.5	4.4	5.1	3.7	4.4	4.4	5.1	4.1	5.0	5.0	5.8
76	3.3	42	4.1	5.0	3.5	4.7	4.5	5.5	3.7	4.7	4.6	5.5	4.1	5.3	5.1	6.2
77	3.3	4.5	4.2	5.3	3.5	5.0	4.6	5.9	3.7	5.0	4,7	5.8	4.1	5.6	5.2	6.6
78	3.3	4.8	4.3	5.7	3.6	5.3	4.6	6.2	3.7	5.3	4.8	6.2	4.1	6.0	5.3	7.1
79	3.3	5.1	4.4	6.0	3.6	5.6	4.7	6.6	3.7	5.6	4,8	6.6	4.1	6.3	5.3	7.5
80	3.3	5.4	4.4	6.4	3.6	5.9	4.7	7.0	3.7	5.9	4.9	7.1	4.1	6.7	5.3	8.0
81	3.3	5.7	4.4	6.8	3.6	6.3	4.7	7.4	3.7	6.3	4.9	7.5	4.1	7.1	5.4	8.4
82	3.3	6.0	4.4	8.2	3.6	6.6	4.8	7.8	3.7	6.6	4.9	7.9	4.1	7.5	5.4	—
83	3.3	6.4	4.5	—	3.6	7.0	4.8		3.7	7.0	5.0	—	4.1	—	5.4	—
84	3.3	—	4.5	—	3.6	—	4.8	—	3.7	-	5.0	—	4.1	—	5.4	—
85	3.3	—	4.5	—	3.6	—	4.8	–	3.7	—	5.0	—	4.1	—	—	—
86	3.3	—	—	—	3.6	—	—	–	3.7	—	—	—	i—	—	—	—
87 } 90 }																

the births that would have occurred in the absence of the use of IUCD, specific to the year under question and duration since the insertion of IUCD, because retention rates change with duration. Let $C\overline{\phi}_I(T+t, x)$ denote the number of births that would have occurred in the year $T+t$ due to women who would have got IUCDs inserted in the year $(T+t-x)$ but are assumed not to have done so. Then

$$C\overline{\phi}_I\ (T+t, x) = \sum_{i=1}^{6} (P^y \cdot a_i^t) \cdot S(i, T+t-x, x) \cdot \overline{\phi}_I\ (i, i+x). \quad (3)$$

The number of births averted due to IUCDs in year $T+t$ is given as

$$B\overline{\phi}_I\ (T+t) = \sum_{x=1}^{L} C\overline{\phi}_I\ (T+t, x) \cdot R(x) \cdot E(x), \quad (4)$$

where $L \leqslant 5$ (the maximum number of years for the retention of IUCD is assumed to be equal to 5 years)

$L = 5$ if $T+t \geqslant 1970$

$= t$ if $T+t < 1970$

$R(x)$: proportion of the x-th women year for which IUCD is retained

$E(x)$: reduction in fertility due to the use of IUCD in the x-th year.

The numerical valuse of $R(x)$ and $E(x)$ used in this paper are;

X	R(x)	E(x)
1	.8586	.932
2	.6440	.920
3	.4829	.916
4	.3623	.916
5	.1000	.916

By substituting $A(i, x)$ for $\overline{\phi}_I(i, i+x)$ in Equation (3) and then in Equation (4) we obtain the averted births, BA_I, by using ASMFR. Proceeding on the same lines, indicated for vasectomy and salpingectomy (i.e., using Equation 2) we can obtain values of K. The values of K for two patterns of IUCD performance are shown in Table 7.

Assuming that the values of *K,* for IUCD, for a particular population of women are known, the estimates of unadjusted averted births obtained through the use of ASMFR can be adjusted as was done in the case of vasectomy or salpingectomy.

Results and Discussion

Vasectomy. Table 5 presents the values of *K* for vasectomies for two levels of MCC, two levels of age distributions and four patterns of vasectomy performance. This table reveals the following points :

(a) As the performance increases over years (especially after 1971) the values of *K* also generally increase except for a few years (1962, 1963 etc.).

(b) But when the number of vasectomies over years start decreasing after 1970 (refer patterns V_1 and V_2) the values of *K cannot* be obtained. The reason for this lies in the differences in values of ϕ and *A,* for v = 0 to 5. However, if we use cumulated averted births and obtain K^* we will be able to derive K^* for a larger number of years. For instance values of *K* in Column 2, stops by the year 1969 but the corresponding values of K^* could be derived upto 1980. But as the family planning performance decreases the values of K^* increase very rapidly.

Thus it is useful to use K^* values when the performance of family planning decreases. However, use of K^* has one disadvantage also. As its values are derived from cumulated averted births, K^* may be unduly affected by changes or fluctuations in the past performance of vasectomies. The values of *K* are also influenced by the past performance but to a lesser extent.

(c) The increase from a low (L) age at acceptance to higher *(H)* age at acceptance, has increased the value of *K* (refer Columns 2 and 6 ; Columns 3 and 7 etc.). This is due to the fact that differences in ϕ $(i, i + v)$ and A $(i, i + v)$ are more pronounced in the middle age groups (i.e., i = *2,* 3 or 4) and by increasing mean age at acceptance we tend to decrease the gap between $B\phi(T)$ and BA (T).

(d) The values of .AT for the case when the number of vasectomies increases in a geometric progression are smaller than the values of *K* when the number

of vasectomies increases in an arithmetic progression (Columns 2 and 3 etc.).

(e) Table 5 and also subsequent Tables 6 and 7 are based on medium level of expectation of life. Similar exercises for other levels of mortality reveal that variations between levels of mortality did not affect *K* significantly.

Table 5 also suggests a decrease in the values of *K* for pattern V_3 towards the end of 1975-90. This is due to rapid increase in the performance by the end of 1975-90. Further, though the number of vasectomies are the same for the years 1956-70 for V_1; V_2 V_3 and V_4 the values of *K* do not remain constant for any combination of MCC and age distribution. The values of *K* remain constant only for 1956-67. The changes in the number of vasectomies from and after 1971 affects on the curve of averted births which changes the values of *K* beginning with a couple of years preceding 1971.

From Fig. 1 we notice that the values of *K* cannot be found after 1985. The horizontal line, say, passing through 2,900 for 1985 (for A-matrix) does not interseet the curve of estimated births averted by ϕ- matrix. This is the reason why values of *K* in Table 5 and in Tables 6 and 7, stop short of 1990.

Salpingectomy. Table 6 presents the values of *K* for salpingectomy under various combinations. General observations made on vasectomy are valid here also, but the values of *K* are larger than those for vasectomy. This is due to the initial non-susceptibility status of salpingectomies which gives lower initial values (Table 1).

IUCD. Table 7 presents values of *K* under various combinations. Pattern I_1 shows a decreasing trend till 1970 and thereafter is assumed to remain constant (Table 4). Pattern I_2 is assumed to steadily decrease during 1965-90. In both these cases values of K cannot be obtained for reasons explained earlier. Therefore patterns I_1 and I_2 are not given in Table 7.

The values of IUCD insertions increase during 1965-66 and steadily decrease during 1966-70. Values of *K* are less than a year for all combinations. For 1966 the values for high MCC range between one to two years. For low MCC no *K* can be found. For the years 1967-73, *K* cannot be found even for patterns I_3 and I_4 because during these years lUCDs decreased.

TABLE 7-VALUES OF *K* FOR IUCD, UNDER TWO LEVELS OF MCC.
TWO AGE DISTRIBUTIONS AND TWO PATTERNS OF PERFORMANCE

Year	*Level of MCC*							
	LOW				*HIGH*			
	Level of age distribution				*Level of age distribution*			
	L		*H*		*L*		*H*	
	I_3	I_4	I_3	I_4	I_3	I_4	I_3	I_4
1965	0.20	0.20	0.20	0.20	0.78	0.78	0.45	0.45
66	—	—	—	—	1.00	1.00	1.80	1.80
1967t								
73								
1974	10.0	9.4	10.8	10.3	7.2	6.4	8.0	7.3
75	10.0	9.8	10.8	10.7	7.3	6.7	8.0	7.7
76	10.0	10.3	10.9	11.3	7.2	7.0	8.0	8.0
77	10.0	10.8	10.9	11.7	7.2	7.3	8.0	8.3
78	10.0	11.1	10.8	*	7.2	7.7	8.0	8.8
79	10.0	*	10.8	*	7.2	7.9	8.0	9.0
80	*	*	*	*	7.3	8.2	8.0	9.3
81	*	*	*	*	7.3	8.6	8.0	*
1982	*	*	*	*	*	*	*	*
90								

NOTES : fFor this period as the number of IUCD insertions steadily decreased values of *K* cannot be obtained.
*For these years the estimated births averted by /4-Matrix or. ASMFR exceed those obtained by ^-matrix for all years and hence no values of *K* can be obtained.

As mentioned earlier, the values of K^* can be derived even if the tempo of family planning performance decreased over time. For the purpose of illustration the values of K^* for IUCD under patterns I_2 and I_3 are shown in the Table 8. The values of K^* for IUCD present a better illustration of its efficiency because in one pattern of IUCD (i.e., I_2) the tempo of IUCD inser-

TABLE 8-VALUES OF ESTIMATED CUMULATIVE AVERTED BIRTHS (C.A.B) THROUGH 0/ AND *A* MATRICES ; AND THE VALUES OF K* FOR IUCD FOR TWO LEVELS OF MCC, TSVO AGE DISTRIBUTIONS AND TWO PATTERNS OF IUCD INSERTIONS

			Level of MCC							
			HIGH				LOW			
			Age distribution				Age distribution			
			H		L		H		L	
			Patterns of IUCD insertions							
			I_2	I_3	I_2	I_3	I_2	I_3	I_2	I_3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	C.A.B.-ϕ_I	C.A.B.-A								
1965	17	130	.8	.8	.7	.7	1.1	1.1	1.2	1.2
66	165	368	.9	.9	.8	.8	1.3	1.3	1.2	1.2
67	393	662	1.1	1.1	1.0	1.0	2.0	1.7	1.6	16
68	634	958	1.6	1.6	1.4	1.4	2.5	2.4	2.2	2.2
69	844	1226	2.3	2.3	2.0	2.0	3.4	3.3	3.6	3.0
70	1022	1464	2.9	2.7	2.5	2.4	4.3	3.8	3.9	3.5
71	1184	1677	3.6	3.0	3.1	2.7	5.3	4.2	4.8	3.9
72	1334	1874	4.3	3.3	3.2	2.9	6.4	4.5	5.8	4.2
73	1475	2059	5.1	3.5	4.4	3.1	7.7	4.8	6.9	4.4
74	1607	2233	60	3.6	5.1	3.2	9.2	5.5	8.3	4.7
75	1730	2395	7.0	3.8	6.0	3.4	11.5	5.4	9.8	4.9
76	1845	2547	8.2	4.0	7.0	3.6	13.3	5.5	11.6	5.1
77	1953	2689	9.6	4.2	8.1	3.7	_	5.7	-	5.3
78	2054	2822	11.3	4.2	9.4	3.9	—	6.0	—	5.5
79	2148	2946	—	4.5	11.0	4.0	—	6.2	-	5.7
80	2236	3062	—	4.6	—	4.1	-	6.3	-	5.9
81	2318	3170	-	4.8	-	4.2	-	6.5	—	6.1
82	2395	3271		4.9	—	4.4	-	6.7	—	6.2
83	2467	3366	-	5.3	—	4.5	—	6.9	-	6.4
84	2534	3454	—	5.2	—	4.6	—	-	—	—
85	2597	3537	—	•—	—	4.7	-	___	—	—
86	2656	3614	—	—	—	—	-	—	-	—
87	2711	3686	—	—	—	—	—	—	—	—
88	2762	3753	-	, "_	—	—	—	-	-	-
89	2810	3816	—	—	—	—	—	—	-	—
90	2855	3875	-	-	-	—	_.	-	—	-

tions decreased from the very second year (unlike in vasectomy or salpingec-tomy where the performance was increasing upto 1968).

From Table 8 we note that the values of K^* increase as the level of MCC decreased or as the age at acceptance of IUCD increased. The values of K^* are less than those of the corresponding *K's* (Table 7) wherever they existed. It may be added that comparisons of K and K^* for vasectomy and salpingec-tomy also showed a similar pattern but the gap between the values of K and K^* is smaller in magnitude for any one combination of variables except when vasectomies or salpingectomies decreased over time.)n the latter case the K^* values increase rapidly.

The values of K *in* Table 7 increased enormously in the period 1974-82. Part of this is due to the past decreasing trend in lUCDs. But a look at Table 8 shows that the values of K^* are smooth and always increase with time whatever may be the trend of lUCDs. This is one of the strong points in favour of using K^* for adjusting averted births over time. A similar trend is observe d in the case of vasectomy and salpingectomy, for which K^* are not shown in the paper.

The values of K are found to be greater than those obtained for vasectomy or salpingectomy. The same observation is made in the case of K^*. In this connection it is not notable that while the number of sterilizations steadily increased in the first 14 or 15 years (Table 4), the values of IUCD insertions steadily decreased almost since inception and while the effect of performing a sterilization lasts for the entire residual reproductive life, the effect of IUCD could atmost persist for five years, the normal period for which they are retained in India.

Conclusion

It is clear that the values of K depend very much on the time pattern or tempo of family planning acceptance. K also depends on the monthly chance of conception, (i.e. on the level of fertility of women under no contraception) and on the age distribution of acceptors, but this dependence is weaker than on, the tempo of family planning performance. In other words, even if we ignore other factors, in determination of K (or K^*) the tempo of family planning performance should be taken into consideration. Thus to make a blanket assumption of $K = 1$ without regard to tempo of family planning or method of family planning (Lee-Isbister, 1956; Stolnitz, 1968) leads to errors in the estimates of births averted by time, especially in case population projections are attempted.

Among the two short-cut procedures discussed in the paper, the second procedure involving cumulated births averted and K^* is better as it works under all patterns (including decreasing trend) of the tempo of family planning performance. However, values of K are more useful to study directly the time distribution of estimates of averted births, than K^* values.

Theoretically, it is possible to obtain a family of *K's* or *K*'s* to envelope the many variable-combinations that approximate to experience of developing countries, but it is relatively difficult to specify sets of *K's* or *K*'&* for different patterns of family planning performance. However, it is possible to develop techniques through which one can determine the relevant parameters concerning fertility, acceptance of family planning methods, tempo of family planning acceptance and by using them, pick out a set of K or K^* from pre-worked-out tables appropriate for the population under question. Thus the feasibility of the short-cut procedures depends on the availability of set of K or K^* for a particular population.

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