Scientific Reports

NUMBER 4 • AUGUST 1979

CHARLES F. WESTOFF, JAMES MCCARTHY
NOREEN GOLDMAN and FELIX MASCARIN

Illustrative Analysis Contraceptive Sterilization and Births Averted in Panama

INTERNATIONAL STATISTICAL INSTITUTE
Permanent Office. Director: E. Lunenberg
428 Prinses Beatrixlaan, P.O. Box 950
2270 AZ Voorburg
Netherlands

WORLD FERTILITY SURVEY
Project Director:
Sir Maurice Kendall, Sc. D., F.B.A.
35-37 Grosvenor Gardens
London SW1W OBS, U.K.

The World Fertility Survey is an international research programme whose purpose is to assess the current state of human fertility throughout the world. This is being done principally through promoting and supporting nationally representative, internationally comparable, and scientifically designed and conducted sample surveys of fertility behaviour in as many countries as possible.
The WFS is being undertaken, with the collaboration of the United Nations, by the International Statistical Institute in cooperation with the International Union for the Scientific Study of Population. Financial support is provided principally by the United Nations Fund for Population Activities and the United States Agency for International Development.
This publication is part of the WFS Publications Programme which includes the WFS Basic Documentation, Occasional Papers and auxiliary publications. For further information on the WFS, write to the Information Office, International Statistical Institute, 428 Prinses Beatrixlaan, Voorburg, The Hague, Netherlands.

L'Enquête Mondiale sur la Fécondité (EMF) est un programme international de recherche dont le but est d'évaluer l'état actuel de la fécondité humaine dans le monde. Afin d'atteindre cet objectif, des enquêtes par sondage sur la fécondité sont mises en oeuvre et financées dans le plus grand nombre de pays possible, Ces études, élaborées et réalisées de façon scientifique, fournissent des données représentatives au niveau national et comparables au niveau international.
L'Institut International de Statistique avec l'appui des Nations Unies, a été chargé de la réalisation de ce projet en collaboration avec l'Union Internationale pour l'Etude Scientifique de la Population. Le financement est principalement assuré par le Fonds des Nations Unies pour les Activités en matière de Population et l'Agence pour le Développement International des Etats-Unis.
Cette publication fait partie du programme de publications de l'EMF, qui comprend la Documentation de base, les Documents Non-Périodiques et des publications auxiliaires. Pour tout renseignement complémentaire, s'adresser au Bureau d'Information, Institut International de Statistique, 428 Prinses Beatrixlaan, Voorburg, La Haye, Pays-Bas.

La Encuesta Mundial de Fecundidad (EMF) es un programa internacional de investigación cuyo propósito es determinar el estado actual de la fecundidad humana en el mundo. Para lograr este objetivo, se están promoviendo y financiando encuestas de fecundidad por muestreo en el mayor número posible de países. Estas encuestas son diseñadas y realizadas científicamente, nacionalmente representativas y comparables a nivel internacional.
El proyecto está a cargo del Instituto Internacional de Estadística en cooperación con la Unión Internacional para el Estudio Científico de la Población y con la colaboración de las Naciones Unidas. Es financiado principalmente por el Fondo de las Naciones Unidas para Actividades de Población y por la Agencia para el Desarrollo Internacional de los Estados Unidos.
Esta publicación ha sido editada por el Programa de Publicaciones de la EMF, el que incluye Documentación Básica, Publicaciones Ocasionales y publicaciones auxiliares. Puede obtenerse mayor información sobre la EMF escribiendo a la Oficina de Información, Instituto Internacional de Estadística, 428 Prinses Beatrixlaan, Voorburg-La Haya, Países Bajos.

Scientific Reports

Illustrative Analysis Contraceptive Sterilization and Births Averted in Panama

CHARLES F. WESTOFF, JAMES MCCARTHY,
AND NOREEN GOLDMAN
Office of Population Research
Princeton University

and

FELIX MASCARIN
Oficiña de Estudios de Población
Ministerio de Salud

Contents

Acknowledgments

We would like to express our deep appreciation to German Rodriguez of the WFS Staff, Michele Shedlin of the Center for Population and Family Health of Columbia University, and Hildebrando Araica A., then UN Advisor for the World Fertility Survey in Latin America, for their considerable efforts in expediting the arrangements for this analysis. We also acknowledge the methodological suggestions of Norman B. Ryder of the Office of Population Research at Princeton University, Henri Leridon of the Institut National d'Etudes Demographiques, Chai Bin Park of the East-West Population Institute, and John Bongaarts of the Population Council.

Preface

One of the main concerns of the World Fertility Survey has been the analysis of the data collected by the participating coutries. It was decided at the outset that, in order to obtain quickly some basic results on a comparable basis, each country would produce soon after the field work a 'First Country Report', consisting of a large number of cross-tabulations with a short accompanying text. Precise guidelines for the prepation of the tables were produced and made available to the participating countries.

It was also recognised, however, that at later stages many countries would wish to study in greater depth some of the topics covered in their first reports, or indeed new but related subjects, using more refined analytic techniques. In order to assist the countries at this stage a general 'Strategy for the Analysis of WFS Data' was outlined, a series of 'Technical Bulletins' was started, dealing with specific methodological issues arising in the analysis, and a list of 'Selected Topics for Further Analysis of WFS Data' was prepared, to serve as a basis for selecting research topics and assigning priorities.

It soon became evident that many of the participating countries would require assistance and more detailed guidelines for further analysis of their data. Acting upon a recommendation of its Programme Steering Committee, the WFS then launched the present series of 'Illustrative Analyses' of selected topics. The main purpose of the series is to illustrate the application of certain demographic and statistical techniques in the analysis of WFS data, thereby encouraging other researchers and other countries to undertake similar work.

In view of the potentially large number of research topics which could be undertaken, some selection was necessary. After consultation with the participating countries, 12 subjects which are believed to be of top priority and of considerable interest to the countries themselves were selected. The topics chosen for the series span the areas of fertility estimation, levels, trend and determinants, marital formation and dissolution, breastfeeding, sterilization, contraceptive use, fertility preferences, family structure, and infant and child mortality.

It was envisaged that each study would include a brief literature review summarizing important developments in the subject studied, a clear statement of the substantive and methodological approach adopted in the analysis, and a detailed illustration of the application of such an approach to the data from one of the participating countries, but with emphasis on the general applicability of the analysis. These studies have been conducted in close collaboration with the country concerned, where possible with the active participation of national staff.

It should perhaps be emphasised that the studies in the 'Illustrative Analyses' series are meant to be didactic examples rather than prescriptive models of research, and should therefore not be VIEWED as cookbook recipes to be followed indiscriminately. In many cases the investigators have had to choose a particular course of action from several possible, sometimes equally sound, approaches. In

some instances this choice has been made more difficult by the fact that demographers or statisticians disagree among themselves as to the approach most appropriate for a particular problem. In the present series we have, quite intentionally, resisted the temptation to enter the ongoing debates on all such issues. Instead, and in view of the urgency with which countries require guidelines for analysis, an attempt has been made to present what we believe to be a basically sound approach to each problem, spelling out clearly its drawbacks and limitations.

In this difficult task the WFS has been aided by an *ad hoc* advisory committee consisting of Ansley Coale (Chairman), Mercedes Concepcion, Gwendolyn Johnson-Ascádi and Henri Leridon, to whom we express our gratitude. Thanks are also due to the referees who have generously donated their time to review the manuscripts and to the consultants who have contributed to the series.

Many members of the WFS staff made valuable contributions to this project, which was co-ordinated by V.C. Chidambaram and German Rodriquez.

Sir Maurice Kendall
WFS Project Director

1. Introduction

With the growing importance of elective surgical sterilization as a method of contraception in many parts of the world, a need arises to develop procedures for measuring the probability of becoming sterilized and for evaluating the impact of sterilization on the fertility rate. The following methodological account offers a set of suggested procedures for deriving such estimates from data collected in the World Fertility Survey. Most of the estimates described require the Fertility Regulation Module which many participating countries have included; a limited few are based only on the Core Questionnaire.

Panama was selected as the country on which to illustrate these techniques for several reasons. First, there is a significant proportion of women who have been sterilized: 20.8 per cent of all ever-married women aged 20-49 reported that they had been sterilized for contraceptive reasons. Second, the Panama survey itself and first country report[1] had been completed, and a clean tape had been prepared in time to be available for this analysis.[2]

The history of sterilization in Panama began officially in 1941 with Law No. 48, which authorized the procedure. Surgical sterilization has been performed in Panama for more than 30 years without major difficulties, both in the public and private sectors. Although hospital committees of physicians must approve requests for sterilization, with health as well as social criteria evaluated, the system operates more or less to satisfy prevailing demand. As long ago as 1964, a survey in Panama City estimated that one of every five women (ever-married or in consensual union) reported having been sterilized. In the very recent past, since the WFS in 1976, a significant incidence of vasectomies has been reported, but because of its recency, only female sterilization is considered in this analysis.

Although the main purpose of this report is to suggest techniques for analyzing WFS data on sterilization and fertility, which can be used in other participating countries with any incidence of sterilization, a number of parameters of specific interest to Panama are estimated in the process.

The report begins with a discussion of the different denominators that are employed for the various estimates prepared. It then describes a range of determinants of sterilization that are evaluated in both a bivariate and multivariate approach, followed by a brief account of the timing of sterilization. Several procedures for estimating the probability of being sterilized are then presented for the total sample and selectively for subgroups. The final section develops several approaches to the measurement of births averted by sterilization.

---

1. Oficina de Estudios de Poblacion, Encuesta de Fecundidad, Informe General Panama, 1977.

2. The authors would like to express their deep appreciation to German Rodriguez of the WFS staff, in particular, for his contributions to the preparation of the final tape.

2. The Choice of a Denominator

In order to determine the probability and the demographic and social determinants of sterilization, as well as to measure its impact on fertility, we must define the population 'at risk' for sterilization. Specifically, we must define the denominators on which to calculate probabilities of sterilization and births averted. We could select from a number of such denominators, ranging from the crudest population of all ever-married women to the very refined population of currently married, fecund women who no longer want any more births. At different stages of this analysis, we have considered each of the four populations listed below:

1) all ever-married women;
2) ever-married women who want no more births;
3) currently married women who want no more births; and
4) currently married fecund women[3] who want no more births.

The arguments for preferring one denominator to another are complex. The broader populations based on ever-married women – (1) and (2) – are demographically more interesting and better suited to estimating births averted by sterilization for an entire population. Of these two, the latter is more refined, since by restricting ever-married women to those who no longer want births, we more selectively define the population at risk for sterilization.
The last two populations – currently married and currently married fecund women who no longer want births – are clearly more at risk for sterilization since they exclude those women not likely to consider sterilization. And, whereas the first two populations may be more suitable for the broader calculations of probability of sterilization and births averted in the entire population, the more restrictive populations are preferable for analyses of the determinants of sterilization since they permit a purer view of the covariation of social variables with the decision to be sterilized. Yet, the exclusion of the formerly married and the infecund presents the following problems:

- we ignore the contraceptive sterilization and the unwanted fertility of the formerly married;
- we ignore the potential future fertility of those women who remarry; and
- the measurement of non-surgical infecundity (based on the question, 'As far as you know, is it physically possible for you and your husband to have a child, supposing you wanted one?') is a subjective evaluation of uncertain validity and reliability.

In view of the competing claims of these alternative choices, a decision was reached to use different denominators for different calculations. The broader populations based on ever-maried women – (1) and (2) – are used for calculations of the probability of being sterilized, unwanted fertility rates, and births averted. The effects of different denominators on the first two measures are illustrated in Appendix III. In addition to the cruder denominators of ever-married women, the denominator of currently married, fecund women is used in the bivariate analysis of the determinants of sterilization; in the multivariate analysis, only this more refined population is employed.

3. The reason that the WFS classification of 'exposed' women is not employed for the refined denominator is that it excludes all currently pregnant women. Some of these women should be included because they may have been exposed to the risk of sterilization at an earlier time and/or have had unwanted births prior to their current pregnancy.

3. Determinants of Sterilization

The WFS questionnaire includes a considerable number of demographic, social, and economic variables whose influence on contraceptive sterilization can be explored. We have proceeded in two steps: (1) a screening of the association of these variables with the per cent contraceptively sterilized; and (2) a multivariate analysis in which the joint contributions of an number of determinants are examined. The tabulations in Table 1 show the covariation of the percentage sterilized, with a wide range of independent variables. We show three denominators for the per cent contraceptively sterilized: all ever-married women, ever-married women who want no more children, and currently married, fecund women who want no more children.

Overall, a fifth (20.8 per cent) of all ever-married women and about one-third of women who want no more children (32.8 per cent of ever-married and 38.0 per cent of currently married, fecund women) have been contraceptively sterilized in Panama.

The percentage sterilized rises sharply with age and duration of marriage, although it flattens out after age 35 and after 15-19 years of marriage. This flattening does not occur among the 'currently married, fecund, want no more' category, among whom a continuous rise is evident, and the percentage sterilized exceeds half by the oldest age or duration. This suggests that the infecund, unmarried women are causing the damping of the association in the larger population.

It should be noted, in general, that the observed connections between sterilization and these different life-cycle variables may be influenced by the recent surge in popularity of the procedure in Panama. If sterilization continues to be an attractive contraceptive alternative for the next decade and beyond, the 'steady state' relationship could be expected to show fewer irregularities, for example, at the higher ages and durations of marriage. These irregularities may simply reflect the initial impact of sterilization on women at particular stages of the life cycle.

Age at first marriage shows a complicated relationship with sterilization. For all ever-married women, the proportion sterilized declines with increasing age at marriage. A different pattern prevails when the sample is confined to women who want no more children: the percentage increases with age at marriage through age 21 and then declines at higher ages at marriage. The reversal involves the connections between age at marriage and the proportion who want no more births: the younger the age at marriage, the longer the duration of marriage, which in turn implies a higher proportion who intend no more births and thus a higher proportion sterilized among all ever-married women.

Probably because of the socio-economic selectivity and age at marriage differences, women with formal, legal marriages show a higher proportion sterilized than do women in common law marriages. Since more than half of the marriages in Panama are common law marriages which do not involve a ceremony or registration, we were concerned with the validity of the duration and age at marriage variables which require a dating of the first marriage. Two tests were made to evaluate the demographic dependability of the reported dates of marriage,[4] and the conclusion was reached that the data were usable.

Sterilization shows a tendency to rise with parity up to the fifth birth and to decline thereafter. This might have been anticipated because those women who opt for sterilization before they reach the higher parities are not at risk in the higher parities; in other words, those who eventually elect sterilization tend to be selected out before they reach the higher parities. Women at both low and at high parities may be less interested in terminating fertility at that point than are women with 3-5 births.

Although the relationship between overall parity and sterilization is non-monotonic, the number of children born in the first five years of marriage shows a sharp direct effect on the percentage sterilized. Among all ever-married women, 11.2 per cent of women with zero births in the first five years eventually become sterilized compared with 40.0 per cent of women with at least four births. Part of this strong association is due to joint correlations with age.

The age of the woman at the birth of her first child is another measure of the pace of fertility, but this variable shows only a weak association with sterilization of the same shape evident with age at marriage. At the opposite end of the reproductive cycle is the age of the woman at the birth of her last wanted child, but this variable also shows only a weak association with sterilization. The last variable of this type is one constructed to measure the length of interval between marriage and the birth of the last wanted child, a variable that is conceived of as the span of wanted childbearing. As would be expected from the non-monotonic association of the two components involved in the measure, the weak association reveals the highest proportion sterilized in the middle category.

As in the analysis of fertility and contraceptive practice in general, a cultural preference for male offspring might be expected to show some effect on the probability of seeking sterilization. The hypothesis is that women with more male children, or whose last birth was male, would be more inclined to seek sterilization. Such an expectation is confirmed in Panama, but the differences are very modest.

Since the choice of sterilization to terminate fertility is irrevocable the presumption would be that women who elect this method would have had difficulty controlling fertility, as reflected in a higher incidence of unwanted births. This hypothesis appears unsupported by the data from Panama. Although a higher proportion of women whose last birth was unwanted (27.6 per cent) choose sterilization than did those whose last birth was wanted (18.6 per cent), the opposite is true when the comparison is confined to women who want no more children. Evidently, the selection of women who, after having had a wanted last birth, decide to terminate fertility, more than offsets the contraceptive motivation arising from the experience of an unwanted birth. Another possible view of the finding is that fewer women have unwanted births *because* of sterilization.

4. One test was to substitute date of first births for date of marriage in the calculation of synthetic fertility rates (described in a later section), but the results were indistinguishable. The other was to examine the variance of the interval between the date of marriage and the date of the first birth for the two types of marriage. If women in common law marriages reconstructed their dates of marriage on the basis of the dates of their first birth, one would expect this interval to exhibit a smaller variance than that for women in formal marriages. No such difference was observed.

TABLE 1
Percentage of Women Contraceptively Sterilized, by Various Demographic and Social Characteristics

Characteristic	All Ever-Married		Ever-Married, Want No More Children		Currently Married, Fecund, Want No More Children		
	Per Cent Sterilized	Number of Women	Per Cent Sterilized	Number of Women	Per Cent Sterilized	Per Cent Using Other Efficient Methods	Number of Women
Total	20.8	3,203	32.8	2,033	38.0	21.9	1,543
Current Age							
20-24	1.1	570	4.0	149	4.6	32.4	108
25-29	12.7	699	24.3	366	26.8	33.5	310
30-34	23.6	679	33.8	474	37.8	23.1	381
35-39	30.4	506	38.1	404	43.9	21.3	310
40-44	35.2	392	41.6	332	48.4	14.0	250
45-49	33.3	357	38.6	308	53.3	5.4	184
Duration of Marriage							
<5	1.9	533	10.5	95	12.5	40.3	72
5-9	11.1	684	22.0	346	25.4	32.7	272
10-14	21.2	641	29.4	462	33.2	26.4	379
15-19	32.1	536	39.5	435	43.8	20.2	347
20-24	35.0	386	40.4	334	47.2	13.0	246
25-29	30.4	289	37.1	237	49.7	8.5	153
30+	36.6	134	39.5	124	52.7	6.8	74
Age at First Marriage							
<15	22.0	368	29.1	278	33.3	10.8	204
15-17	22.0	874	30.9	621	35.2	23.2	488
18-19	21.5	715	34.1	451	39.2	24.1	344
20-21	21.2	505	39.2	273	46.8	24.9	201
22-24	18.8	479	33.7	267	39.7	24.1	199
25+	16.1	262	29.3	143	36.4	10.6	107
Type of Most Recent Union							
Formal Marriage	24.6	1,513	38.6	964	45.6	24.5	744
Common Law	17.4	1,690	27.5	1,069	31.0	19.5	799
Children Ever Born							
0-1	2.5	553	17.3	81	33.3	24.2	33
2	9.9	547	21.6	250	28.2	38.0	163
3	23.5	520	33.9	360	42.4	29.6	257
4	26.2	393	33.1	311	35.5	29.0	245
5	36.3	339	43.3	284	45.7	17.7	243
6	34.1	252	39.6	217	42.2	16.2	173
7-8	27.3	336	31.3	294	35.0	12.5	240
9+	27.4	263	30.5	236	34.9	10.6	189
Number of Births in First Five Years of Marriage*							
0	11.2	169	21.1	90	28.3	15.1	53
1	16.2	579	28.0	336	32.8	19.6	235
2	24.5	1,051	32.7	790	39.8	21.8	588
3	31.4	741	38.1	611	41.0	21.5	498
4+	40.0	130	46.8	111	49.5	20.6	97
Age at First Birth							
<15	25.0	268	31.8	211	37.3	13.3	150
16-17	24.3	514	32.7	382	37.1	25.4	294
18-19	26.2	644	36.7	460	41.9	22.9	358
20-24	22.4	1,056	37.1	638	44.2	26.0	473
25-29	19.6	260	33.6	152	38.2	24.4	123
30+	16.9	89	27.8	54	38.5	15.4	39
Age at Last Wanted							
≤17			20.5	83	29.4	19.6	51
18-19			20.1	139	25.3	28.4	95
20-24			30.6	656	35.4	24.3	489
25-29			40.6	631	46.5	22.2	492
30-34			30.7	335	32.7	19.7	269
35+			32.1	187	39.0	13.7	146

Table 1. Cont.
Percentage of Women Contraceptively Sterilized by Various Demographic and Social Characteristics

Characteristic	All Ever-Married		Ever-Married, Want No More Children		Currently Married, Fecund, Want No More Children		
	Per Cent Sterilized	Number of Women	Per Cent Sterilized	Number of Women	Per Cent Sterilized	Per Cent Using Other Efficient Methods	Number of Women
Interval from First Marriage to Last Wanted Birth							
<5			29.1	741	36.7	27.4	529
5-9			34.4	730	38.4	23.6	571
10-14			39.3	354	42.7	13.9	281
15-19			27.9	136	32.1	11.3	106
20+			30.0	70	34.5	12.7	55
Sex Composition*							
More Males	24.1	1,252	35.9	842	42.1	19.1	655
Equal	18.6	558	27.2	383	31.6	28.6	297
More Females	21.5	1,191	33.0	776	36.8	21.5	582
Sex of Last Child*							
Male	23.4	1,543	35.0	1,032	39.9	21.5	979
Female	20.6	1,472	31.3	974	36.2	22.4	741
Wanted Status Last Child**							
Wanted	18.6	1,986	39.4	943	46.6	24.0	716
Not Wanted	27.4	1,064	27.4	1,064	30.6	20.0	823
Last Method Used (excluding Sterilization)							
No Method	24.9	1,159	38.4	753	47.6		534
Inefficient Method	21.5	624	31.9	420	35.9		312
Efficient Method	17.1	1,420	28.3	860	31.7		697
Current Residence							
Urban	22.5	1,860	37.2	1,126	43.7	28.1	807
Rural	18.4	1,343	27.2	907	31.8	15.1	736
Religion							
Catholic:							
Practising	21.6	1,405	35.4	855	40.2	23.8	652
Not Practising	20.4	1,591	30.6	1,062	36.5	20.1	800
Non-Catholic	18.4	207	32.8	116	36.3	24.2	91
Literacy							
Illiterate	14.1	304	18.9	228	20.5	11.9	185
Can Read	21.5	2,899	34.5	1,805	40.4	23.3	1,358
Education							
None	15.9	214	19.8	243	22.1	11.3	195
Elementary <4	20.4	445	32.0	244	36.3	9.8	193
Elementary 4-6	23.4	1,267	35.0	843	41.3	19.5	640
Elementary 7-8	26.5	260	41.1	168	49.2	26.6	124
High School 1-3	19.3	466	34.1	264	37.1	34.0	197
High School 4	16.5	399	32.6	172	40.0	35.2	125
College 1-3	9.6	114	26.2	42	29.0	54.8	31
College 4+	19.4	98	33.3	57	44.7	28.9	38
Pattern of Work							
Never	20.9	772	29.7	543	34.0	18.3	453
Before Marriage Only	19.3	729	32.7	431	36.8	20.9	364
After Marriage Only	21.2	217	33.1	139	37.2	24.5	94
Before and After	22.9	424	34.0	285	39.1	20.5	220
Now Only	21.9	342	32.8	229	40.7	26.2	145
Before and Now	20.3	719	36.0	406	44.6	27.3	267

* Confined to women continuously married for at least five years.
** Confined to women with at least one child.
*** Excludes 'undecided' and women with no births.

A more sophisticated analysis is required to disentangle cause and effect.[5]

On the same presumption that women with fertility control problems might be attracted to sterilization, one might hypothesize that those who had used less efficient contraceptive methods would be more likely to be sterilized. Alternatively, women who have used the more efficient methods might be drawn to sterilization because of its greater effectiveness or because they might not enjoy the prospect of a long period of using some other method, such as the pill. The results indicate, however, that there is a higher probability for women who have never used any method to be attracted to sterilization.

The remaining set of variables relates to social and economic characteristics. A higher proportion of women from urban than from rural environments elect sterilization as might be expected, given the location of medical facilities and other social characteristics that differentiate city from country dwellers.

Almost all Panamanian women are Catholic, but practising Catholics show a slightly greater propensity to elect sterilization than other Catholics, a somewhat surprising result in view of the Catholic Church's strong condemnation of the procedure.

Literacy is clearly relevant to the decision to become sterilized: the proportion sterilized among the small minority of Panamanian women who can neither read nor write is distinctly lower than that for literate women. However, the amount of formal education shows a non-monotonic relationship with sterilization, increasing through the highest grades of elementary school but decreasing at higher educational levels, except for a higher rate among those with at least a university education.

The final independent variable of interest is the pattern of the wife's employment history. We have listed the categories in a rough ordering – from those who never worked or worked before marriage only to those who worked both before marriage and are currently working as well. The proportion sterilized shows a slight but fairly regular increase with amount or recency of work experience.

The discussion to this point has been in terms of the characteristics of women who elect sterilization as a contraceptive method as compared implicitly with all other women using other methods or using no method. A more refined analysis is to distinguish between women who become sterilized and those who choose other efficient methods of contraception. The most common 'other efficient' method used in Panama is the pill, which is about equal in popularity to sterilization among all women, but is clearly second to sterilization among women who want no more births. The percentages using these other efficient methods are shown in the last column of Table 1 for currently married, fecund women who want no more births. The life-cycle differences are striking: for obvious reasons sterilization occurs at older ages, higher durations, and higher parities, while the use of other efficient methods (mainly the pill) is concentrated at the younger and the earlier durations and at the lower parities. It is important to reiterate that these life cycle differences are being observed among women who want no more births.

With only a few minor exceptions, the patterns of association that exist between sterilization and the remaining variables in Table 1 are similar to the patterns based on the use of other efficient methods. Specifically, these variables – interval from marriage to last wanted birth, sex composition, and education – show somewhat different patterns of association, but the differences are weak and irregular.

The principal conclusion is that the main factor that differentiates women who choose sterilization rather than the pill or some other efficient method is the stage in the reproductive cycle. There appear to be no obvious social, economic, or residential differences between the two groups.

3.1 MULTIVARIATIE ANALYSIS

A multiple regression analysis has been undertaken with seven of these variables which show the strongest association with sterilization to determine how much overlap there is among them and how much of variance in the proportion who become sterilized is explained by considering them jointly. The pattern of association indicated by the analysis of the percentages sterilized suggests that among currently married, fecund women who want no more children those who elect contraceptive sterilization tend to be older (in their thirties and forties), to have been married formally, to live in urban areas, to have experienced high fertility in the first five years of marriage, to have used no contraceptive method, and to have wanted the last birth. These variables plus education were entered into a multiple regression analysis[6] with sterilization status as the dependent variable.

Collectively, these variables explain only 15 per cent of the variance of the proportion sterilized. The most important variables are age, the wanted status of the last birth, the efficiency of the last method used, and the number of births in the first five years of marriage; these four alone explain 11.3 per cent of the variance.

The fact that 85 per cent of the variance is unexplained means that the major factors determining sterilization have not been elicited in the WFS interview. We can only speculate about what these might be; undoubtedly the network of communication, the peer group, the visibility of medical facilities, and other cultural factors play an important role. The WFS questionnaire was not designed, of course, to tap such dimensions.

---

5. Among women who want no more births, those whose last birth was wanted are more likely to have been formally married, to live in urban areas, and to have had fewer than three children in the first five years of marriage than women who reported their last birth as unwanted. These are all characteristics associated with sterilization.

6. The coded form of the variable as represented in Table 1 was used in the multiple regression except for age which was entered in single years and education which was included as two variables: less than 4 years and 4-8 years of schooling.

4. The Timing of Sterilization

Contraceptive sterilization is by definition a procedure elected only after couples have had all the children they want; for some, it is elected after having had children they did not want. The timing of this procedure varies in any population by age, duration of marriage, parity, and interval since the last birth. An account of the sterilization practices of any population should include a description of when during the reproductieve cycle the procedure is typically elected since, among other considerations, the timing is of obvious relevance to fertility.

A profile of such information is contained in Table 2 for ever-married women who have been contraceptively sterilized. The first column shows the year in which they were sterilized. The length of time that women in Panama have been sterilized is fairly short, a fact that limits the fertility impact. About half (48.8 per cent) reported the operation to have occurred within the past five years, another quarter (24.1 per cent) in the preceding five years, for a total of close to three-quarters who have been sterilized in the past decade.

Columns 2 and 3 of Table 2 show the distribution of sterilized women by age and duration of marriage at the time of sterilization. The most popular ages are between 25 and 34 years of age, accounting for nearly two-thirds (64.3 per cent) of all operations, and between durations 5-14, accounting for 63.3 per cent of all sterilizations.

Sterilized women are distributed across a fairly wide range of parities (column 4); there is no particular clustering between 2 and 7 children. The heaviest concentration, accounting for 52.3 per cent, is between 3 and 5 children.

The time since the last birth is tabulated in column 5. More than half of the operations are post partum and are coded 'O' months since last birth. Another quarter take place in the first year after the last birth. The remaining 21 per cent extend over a considerable range of time with 6.3 per cent after 5 years.

The time since the last *wanted* birth is, of course, more attenuated (col. 6). Compared with the 79.1 per cent who get sterilized within one year of the last birth only 53.2 per cent elect the operation within one year of their last wanted birth, while nearly a quarter delay until five or more years.

TABLE 2
The Timing of Contraceptive Sterilization in Terms of Life-Cycle Characteristics of 656 Ever-Married Sterilized Women

(1)		(2)		(3)		(4)		(5)		(6)	
Year of Operation	Per Cent	Age at Sterilization	Per Cent	Marriage Duration at Sterilization	Per Cent	Parity	Per Cent	Interval (Months) Since Last Birth	Per Cent	Interval (Months) Since Last Wanted Birth	Per Cent
1971-75	48.8	<25	15.0	< 5	12.0	< 2	10.2	0	54.7	0	44.0
						3	18.3	1-12	24.4	1-12	9.2
1966-70	24.1	25-29	34.6	5-9	32.2	4	15.5				
						5	18.5	13-24	6.0	13-24	8.8
1961-65	11.8	30-34	29.7	10-14	31.1	6	12.9	25-36	3.2	25-36	5.7
						7	9.2				
1956-60	10.3	35-39	14.5	15-19	15.0	8	4.7	37-48	3.7	37-48	4.9
						9	3.8	49-60	1.7	49-60	3.3
Before 1956	5.0	40+	6.3	≥20	9.7	10+	7.0				
								61+	6.3	61+	23.9
Total	100.0	Total	100.0	Total	100.0	Total	100.0	Total	100.0	Total	100.0

5. The Measurement of the Probability of Sterilization

We have approached the measurement of the probability of sterilization by considering both simple proportions ever sterilized and synthetic proportions sterilized based on recent sterilization rates. Specifically, we calculate the proportions of women sterilized by successive durations in the two following ways:

1) simple proportions of women ever-sterilized by current duration – i.e. the proportion of women in *d* years duration who have been sterilized at any time prior to the survey date (end of 1975);

2) synthetic proportions of women sterilized by *d* years duration, under the assumption that the women experienced the most recent duration-specific sterilization rates (1971-75) throughout their lifetimes.

For each of these two measures, we define 'duration' in two ways:*

1) duration since first marriage, for all ever-married women;

2) duration since last wanted birth, for ever-married women who want no more births.

The first measure, the simple proportions ever-sterilized, allows us to assess the impact of sterilization rates as they have occurred in the past. The synthetic measure, on the other hand, considers the long-term implications of the sterilization rates in effect during the most recent five-year period (1971-75). Since the popularity of sterilization had increased considerably in recent years in Panama (48.8 per cent of all sterilizations have occurred since 1971), we expect the synthetic measures to be substantially higher than the simple proportions. It is possible that the synthetic measures may be inflated as a result of the recent popularity of sterilization in Panama, and that recent (1971-75) rates will taper off in the future.

When we define these sterilization measures in terms of marriage duration, the population at risk for sterilization is assumed to be all ever-married women. A more refined population at risk consists only of ever-married women who no longer want any births. Since a woman considers sterilization only when she no longer wants any more children, the time of last wanted birth is an appropriate starting point from which to measure proportions sterilized. A disadvantage of such a procedure, however, is that we need to identify the last wanted birth. In countries where the Fertility Regulation Module has not been incorporated in the questionnaire, identification of the last wanted birth is not feasible, unless one is willing to rely entirely upon the difference between desired and actual number of living children (see Appendix I for procedures). The Fertility Regulation Module is also essential for any measure involving dates of sterilization.

The calculations involved in determining the simple proportions sterilized are straightforward: for a specified current duration (since marriage or since last wanted birth), we look at the ratio of the number of women sterilized to the total number of women in the duration. All ever-sterilized women are included in the number of women in the duration. All ever-sterilized women are included in the numerator, without regard to whether their sterilizations occurred in the most recent five-year period, and women are classified according to their duration during the most recent five-year period. Thus, we consider the proportion of women at each duration – since marriage or since last wanted birth – as of the period 1971-75 who were sterilized at any time prior to the end of 1975.[7]

The calculations for the synthetic measure are somewhat more complicated. We obtain duration specific sterilization probabilities for 1971-75 by calculating the ratio of the number of women sterilized at a given duration to the number of non-sterilized women at the beginning of the duration *only* for those sterilizations which occurred during 1971-75.[8] Again, women are classified by their duration as of the period 1971-75. We then cumulate these probabilities to obtain the proportions of women who would be sterilized by duration *d* had they experienced the sterilization rates at all durations less than *d*. In effect, we are constructing a life table for sterilization: that is, we view recent sterilization rates as we would view the proportions dying in a given period (${}_nq_x$) and calculate proportions sterilized as we would proportions dead ($1 - \ell_x$). Since we are, in effect, constructing a cumulative probability function, the synthetic proportions sterilized must increase (or, strictly speaking, they cannot decrease) with increasing duration. This need not be true for the simple proportions sterilized, although by and large these also increase with increasing duration. The detailed procedures for constructing both measures of sterilization are presented in Appendix II.

Distributions of proportions sterilized from the Panama WFS are presented in Table 3 and in Figures 1 and 2. Proportions sterilized by marriage duration for both measures are shown in Figure 1. As we expect, the synthetic measure is approximately equal to or higher than the simple measure, at every duration.

Whereas 55 per cent of women would be sterilized after 30 years of marriage had they experienced recent sterilization rates, only 36 per cent of women at this duration are actually sterilized. The differences between the two measures are smaller at lower durations of marriage: i.e. 34 per cent of women would be sterilized after 15 years of marriage had they experienced 1971-75 rates, whereas 26 per cent were actually sterilized after 15 years of

* In Appendix D we also calculate these two measures by *ages*, for all women regardless of marital status.

7. Since our ultimate interest is to determine births averted by sterilization, we calculate our measures for the five-year period 1971-75: estimates of the birth rates and proportions sterilized for the period 1971-75 are considerably more stable than the corresponding estimate for the single year 1975. For each of the five years in the period, we need to classify women (and their sterilizations) by their marital duration (or duration since last wanted birth) in that year. The simple proportion sterilized is actually *person-years* ever-sterilized during 1971-75 for a specified duration. A more complete discussion of these measures is presented in Appendix B.

8. The exposure time of women who were sterilized for non-contraceptive reasons during the five years is included up to the time of the operation, but is then excluded from all subsequent calculations.

TABLE 3
Four Measures of Proportions Sterilized, by Specified Durations.

Marriage Duration	Proportions Sterilized: Simple Porportions Sterilized (1)	Proportions Sterilized: Synthetic Proportions Sterilized (Based on 1971-75 rates) (2)	Duration Since Last Wanted Birth	Proportions Sterilized: Simple Proportions Sterilized (3)	Proportions Sterilized: Synthetic Proportions Sterilized (Based on 1971-75 rates) (4)
1	.002	.002	1	.179	.179
5	.037	.037	2	.227	.219
10	.150	.172	3	.261	.253
15	.255	.341	4	.268	.289
20	.322	.451	5	.300	.324
25	.308	.513	10	.309	.446
30	.355	.552	15	.390	.524
			20	.434	.582
			25	.417	.598

FIGURE 1
Proportions Sterilized, by Marriage Duration

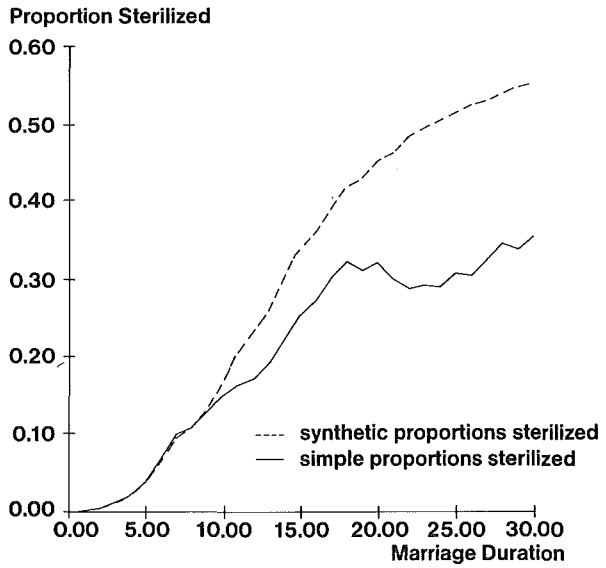
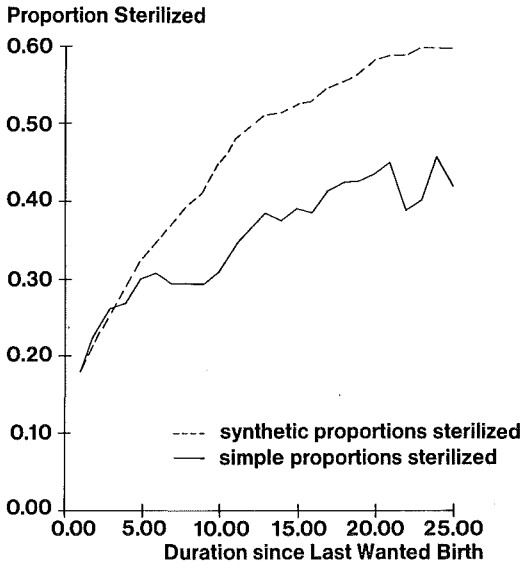


FIGURE 2
Proportions Sterilized, by Duration Since Last Wanted Birth



marriage. We expect the two measures to diverge more with increasing marriage duration since the longer the duration, the more the simple proportion depends on sterilization rates prior to 1971, rates which are considerably lower than recent rates.

Proportions sterilized by duration since last wanted birth for both measures are shown in Figure 2. Again, the synthetic proportions are consistently higher than the cohort proportions. By 25 years since the last wanted birth, 60 per cent of women would be sterilized had they experienced recent rates, whereas 42 per cent are actually sterilized.

The synthetic proportions sterilized by duration since last wanted birth have been calculated for various subpopulations in the sample (Table 4). The generalizations about group differences in the probability of being sterilized are similar to those already discussed on the basis of the tabulation of percentages sterilized (Table 1). The cumulative probability of being sterilized is higher for women in formal marriages for whom 62 per cent would be sterilized in 15 years than for women in common law marriages (43 per cent in 15 years).

The probabilities increase with parity through 5-6 children, but decline at 7 or more children. A similar, though irregular, direct association exists between sterilization and the number of births in the first five years of marriage. There is a consistently higher probability of sterilization in urban than in rural areas, and there is a direct association with amount of education. However, the analysis basically shows a difference only between illiterate or women with less than 4 years of schooling and those with more education. The

TABLE 4
Cumulative Probability of Contraceptive Sterilization, by Various Social Characteristics, for Ever-Married Women Who Want No More Children

Characteristic	Years since Last Wanted Birth						
	1	2	3	4	5	10	15
Total	.179	.219	.253	.289	.324	.446	.524
Type of Most Recent Union							
Formal Marriage	.242	.293	.329	.364	.400	.545	.621
Common Law	.135	.166	.199	.236	.239	.354	.429
Children Ever Born							
0-2	.116	.132	.132	.156	.156	.254	.308
3-4	.188	.227	.267	.311	.340	.463	.496
5-6	.222	.292	.341	.364	.416	.551	.604
7+	.182	.207	.239	.283	.321	.429	.554
Births in First 5 Years							
<2	.172	.202	.246	.317	.334	.465	.492
2	.188	.246	.291	.316	.347	.433	.499
3+	.210	.242	.265	.298	.347	.485	.608
Place of Residence							
Urban	.229	.265	.303	.335	.371	.513	.589
Rural	.129	.171	.203	.242	.276	.360	.437
Literacy – Education							
Illiterate or <4 yrs.	.074	.103	.147	.203	.226	.275	.326
4-8 yrs.	.199	.237	.270	.310	.347	.499	.595
More than 8 yrs.	.220	.271	.301	.313	.355	.473	.534

differences between those with 4-8 years and those with more education are so small as to be insignificant. The more conservative conclusion, therefore, is that education makes a difference mainly in the distribution between those with little or no education and those with some schooling.

The statistics on sterilization presented here include only contraceptive sterilizations.[9] A sterilization is considered contraceptive if the respondent answered 'yes' to the question: "Was the purpose of the operation to prevent you from having (more) children?" Although our interest here is to learn the determinants and demographic consequences of a contraceptive procedure which should not be confused with general surgical-medical procedures for the treatment of pathologies, there is a serious question about the reliability and validity of the information collected on motivation. In some situations, there may be cultural pressures to rationalize contraceptive intent as a medical procedure resulting in an underestimate of the incidence of contraceptive sterilization. In addition, one can imagine genuine ambiguities in the interpretation of motivation, such as a woman who is advised to have a hysterectomy because having another pregnancy would be dangerous to her health. Such a reason could or could not be regarded as being contraceptive in intent.

Despite the measurement difficulties involved in determining intent of sterilization and the fact that non-contraceptive sterilizing surgery has the same effect as contraceptive sterilization on the probability of conception, the policy interest in this subject is confined primarily to the effects of contraceptive sterilization. Consequently, we

TABLE 5

Comparison of the Cumulative Probability of Contraceptive Sterilization and All Types of Sterilization, Based on 1971-75 Sterilization Rates

Years Since Last Wanted Birth	Cumulative Probability	
	Contraceptive	All Surgical
1	.179	.215
2	.219	.256
3	.253	.290
4	.289	.326
5	.324	.364
10	.446	.509
15	.524	.596

9. In addition, male sterilizations have been omitted from the analysis. In the Panama sample, only 10 men were reported to have been contraceptively sterilized.

have restricted analyses to contraceptive sterilizations which comprise 82 per cent of all sterilization reported in the survey.[10] In Table 5 we compare synthetic proportions sterilized by duration since last wanted birth, for all sterilizations and for only contraceptive sterilization. By 10 to 15 years after the last wanted birth, the probability of sterilization would be approximately 6-7 per cent higher had we included non-contraceptive sterilization in the analysis.

10. Women who are surgically sterilized for non-contraceptive reasons are not subsequently considered to be at risk of contraceptive sterilization.

6. Measurement of Births Averted by Sterilization

One of the primary objectives of this analysis is to suggest methods for estimating the number of births averted by contraceptive sterilization. There are several ways to approach the question, none of which is the only 'right' way. We will illustrate these approaches, describe the assumptions involved, and compare the estimates.

A bibliography of the research literature on contraceptive sterilzation has been painstakingly compiled in *Population Reports*, which contains some 444 citations, and in the 52-page bibliography in *Behavioral-Social Aspects of Contraceptive Sterilization*. Most of these references, however, are to health or clinical studies; moreover, that part of the literature in the social sciences on births averted relates mainly to the evaluation of the demographic impact of sterilization programs, for example, in India. There are only two studies that have come to our attention which are directly relevant to the estimation of births averted by sterilization from data collected in cross-sectional sample surveys, such as the WFS. One of these is simply an application of the same procedures developed here to survey data collected in the United States. The other study is Harriet Presser's earlier work in Puerto Rico. Presser used several approaches which we have followed here in Tables 6 and 7 which compare the fertility of sterilized and non-sterilized women. The procedures we develop here, however, go beyond this type of comparison and are based in large part on data on unwanted fertility which were not available in the Puerto Rico study. Several other references are listed in the bibliography, which contain some theoretical ideas relevant to this general methodology.

We begin by comparing the cumulative fertility of sterilized women with that of non-sterilized women. This entire analysis is confined to ever-married women. Since most women do not elect sterilization until they are at least 25 years of age or married at least five years, the comparison should be age or duration specific. The comparisons in Table 6 show that differences in fertility are greatest at the earlier ages and durations. This indicates that women with disproportionately higher fertility at younger ages elect sterilization. The fertility of the sterilized woman is by definition completed fertility, while the non-sterilized women, especially the younger ones, can expect additional births. A less distorted comparison occurs at the ages of completed fertility: in the 40's or above 15-19 years marriage duration, there is little difference in the 'completed' fertility of the two groups. This is quite different from the situation in Puerto Rico in 1965 where sterilized women in their 40's reported two fewer births than non-sterilized women of the same age. The lack of such a difference in Panama may reflect differences in the duration of time since sterilization; as we have seen, the practice is newer in Panama and women have elected it at older ages (in Puerto Rico, 41.6 per cent were sterilized before age 25, while in Panama only 15.0 per cent opted for such early sterilization).

The conclusion from the comparisons in Table 6 appears to be that for women at the current age of completed fertility, sterilization has not seemed to have exerted much effect on their fertility as compared with those non-sterilized women at comparable older ages. It would be erroneous, however, to reach the conclusion that no births are being averted by sterilization, for two reasons: (1) the older sterilized women could have experienced higher fertility than the non-sterilized older women if they had not elected the surgery: (2) the younger sterilized women already showed higher fertility than their contemporaries, suggesting that their ultimate fertility would be much higher without sterilization.

TABLE 6
Mean Number of Children Ever Born for Ever-Married Women Contraceptively Sterilized, By Current Age and By Duration of Marriage.

	Sterilized		Not Sterilized	
Age and Duration	Mean	Number of Women	Mean	Number of Women
Current Age				
25-29	3.78	89	2.83	610
30-34	4.64	160	3.87	519
35-39	5.43	154	5.09	352
40-44	5.75	138	5.83	254
45-49	6.21	119	5.74	238
Years since First Marriage				
5-9	3.36	76	2.58	608
10-14	4.10	136	3.77	505
15-19	5.17	172	5.01	364
20-24	5.92	135	5.93	251
25-29	6.50	88	6.63	201
30+	7.55	49	7.12	85

The age and duration measures in Table 6 are as of the interview date and do not control for the amount of time since the operation, or to put it differently, do not equate the exposure to the risk of childbearing of the two populations. A tabulation has been prepared which equates the years of risk to childbearing of women sterilized and not sterilized, for women who want no more births. For sterilized women, the tabulation shows fertility by duration of marriage to the time of the operation (Table 7); this is compared with the number of children ever born to non-sterilized women (who want no more births) by simple duration of marriage to the time of interview. It is clear from this comparison that sterilized women are selected for high fertility; the average number of children ever born ranges from 0.35 greater in the 'less than 5 years duration' category to 2.54 greater in the '20 or more years' category. These differences, however, are slightly exaggerated because approximately half of the sterilizations occurred immediately after a birth (see Table 2). Since the exposure period, defined as the number of years married at the time of the operation, terminates with a birth for women with a post partum sterilization, the numbers of children ever born at each duration for sterilized women are somewhat inflated. Nevertheless, the differences in Table 6 are large enough to warrant the conclusion that the sterilized women have been selected for high fertility. This selectivity suggests that a measure of births averted by sterilization which assumes that their fertility would have been the same as that of non-sterilized women if they had not elected the procedure might be a very conservative estimate.

TABLE 7
Children Ever Born, by Years of Exposure to the Risk of Childbearing,[1] for Contraceptively Sterilized And Non-Sterilized Ever-Married Women Who Want No Births.

Years of Exposure	Children Ever Born			Number of Women	
	Sterilized	Not Sterilized	Difference	Sterilized	Not Sterilized
< 5	2.71	2.36	0.35	78	85
5-9	4.12	3.23	0.89	210	270
10-14	5.49	4.40	1.09	203	326
15-19	6.53	5.36	1.17	98	263
20+	9.33	6.79	2.54	63	423

1 For sterilized women, exposure is defined as years married at the time of the operation; for nonsterilized women, exposure is simply number of years married.

More refined estimates of births averted by sterilization require assumptions about:
(1) the distribution of proportions sterilized by duration;
(2) the duration specific birth rates the sterilized women would have had in the absence of sterilization.

Although, alternatively, age could be used, marriage duration is preferred because the sample is defined as ever-married women of reproductive age. This means that young women, by definition, would be married at a young age, and any characteristics associated with youthful age at marriage would be reflected in the fertility rate for that age group. With marriage duration that bias is avoided because women married only a few years could theroretically be married at any age up to 49. In addition, the use of marriage duration obviates the need for estimates of proportions married by age, which would be required to calculate the conventional Total Fertility Rate.*

As described in Section V on the measurement of the probability of sterilization, we have been considering four different distributions of proportions sterilized by duration. Specifically, we use both a simple measure of proportions sterilized by duration as it exists in the population in 1975 and a synthetic measure of the steady-state distribution of proportions sterilized implied by the 1971-75 duration specific sterilization rates. For each of these two approaches, we consider two measures of duration: marriage duration for all ever-married women and duration since last wanted birth for those women who want no more births. These measures define two different populations at risk for sterilization: all ever-married and those who no longer want births. On the basis of these two populations at risk, we can make two assumptions about the births rate the sterilize would have had in the absence of sterilization (Table 8):

1) the sterilized would have had the marriage duration-specific birth rates for all (non-sterilized) ever-married women;

2) the sterilized would have had the same birth rates by duration since last wanted birth as the non-sterilized women who want no more births.

As before, the former assumption is less refined in the sense

TABLE 8
Duration Specific Birth Rates Assumed in the Absence of Sterilization.

Marriage Duration	Birth Rate of Non-Sterilized Women	Duration since Last Wanted Birth	Birth Rate of Non-Sterilized Women Who Want No More Births
0-4	.372	0-4	.120
5-9	.248	5-9	.083
10-14	.160	10-14	.059
15-19	.126	15-19	.053
20-24	.080	20-24	.036
25-29	.029		

Note:
The birth rates given above are expressed in five-year intervals for illustrative purposes. However, all measures of births averted are based on birth rates for single-year durations.

that the population at risk – all non-sterilized ever-married women – is crude. To assume that the sterilized would have had all the births of the non-sterilized is to include wanted as well as unwanted births (to the sterilized women) in the measure of births averted by sterilization. For example, in a population in which couples practice perfect fertility control after they experience their last wanted birth, the birth rate of the non-sterilized women would equal zero. Hence, a measure of births averted by sterilization would (and theoretically should) be equal to zero. Assumption 1, however, would specify wanted fertility in the absence of sterilization and, if sterilization rates are high, would lead to a high estimate of births averted. Thus, in a population with a high degree of fertility control, Assumption 1 would result in an overestimate of births averted by sterilization. On the other hand, we have seen already that the sterilized are actually more fertile than the non-sterilized (to the time of sterilization), so that Assumption 1 may not be unreasonable. The second assumption is more refined since it restricts the analysis to those women who no longer want any births – i.e. women who are likely to have a fertility experience similar to that which sterilized women would have had in the absence of sterilization. With this assumption, the estimate of births averted may actually

* In Appendix, however, we illustrate the calculation of births averted by *ages*, for the case where a sample of all women regardless of marital status is available.

be too conservative since the sterilized women, in the absence of the operation, would probably have higher fertility than women not sterilized who want no more births. Of course, one could plausibly speculate that the high level of motivation that leads women to elect sterilization might have induced them alternatively to use other efficient methods. Thus, if their fertility in the absence of sterilization were more like that of women using the pill or the IUD, the measures of births averted would be overestimates.

In this analysis, we base both assumptions on birth rates for the most recent five-year period, 1971-75: total birth rates by marriage duration and unwanted birth rates by duration since last wanted birth are calculated by determining women's durations in 1971-75 and attributing to them the births which occurred during the five years. Those sterilized during the period 1971-75 are included until the time of sterilization, while those sterilized before 1971 are excluded.[11]

By combining the simple and synthetic measures of proportions sterilized with these two assumptions about birth rates in the absence of sterilization, we obtain four measures of births averted by sterilization. The four measures are shown schematically:

Measures of Births Averted by Sterilization

Birth Rates 1971-75 in the Absence of Sterilization (r_i)	Proportions Sterilized by Duration (p_i)	
	Simple Proportions Ever Sterilized as of 1975	Synthetic Proportions Sterilized Implied by 1971-75 Sterilization Rates
Birth Rates of All Non-Sterilized Women, by Marital Duration	1	2
Birth Rates of Non-Sterilized Women Who Want No More Births, by Duration Since Last Wanted Birth.	3	4

We define the birth rate in duration i as r_i and the proportion sterilized by duration i as p_i, as shown in the table above. Then, in all four cases, we can determine births averted by the end duration d using the general formula:

$$\text{Births averted by duration } d = \sum_{i=1}^{d} p_i r_i \text{ , } d = 1,2, \ldots D$$

We specifically consider eventual births averted by duration D, either 30 years of marriage or 25 years since last wanted births.

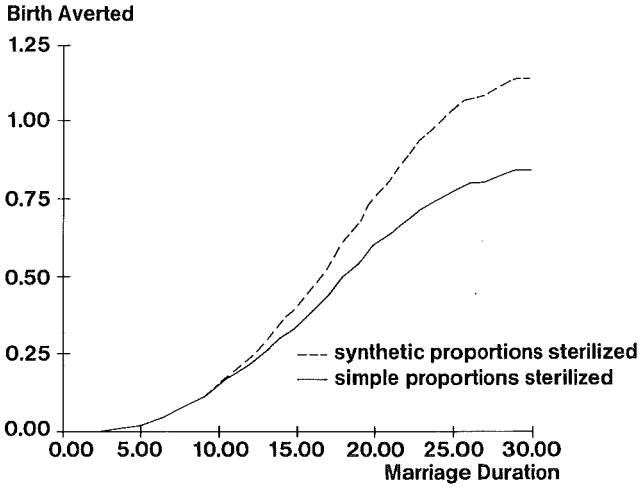
We noted previously that the values of r_i are always based on 1971-75 birth rates. In addition, the values of p_i are always cumulated proportions sterilized – cumulated either implicitly by using an actual schedule of past experience or cumulated synthetically. Thus, all four measures of births averted by D years are births averted by the end of a reproductive career, assuming fertility rates of the most recent five-year period throughout.

Details of the calculations involved in obtaining these four measures are described in Appendix II. In the following pages, we consider the interpretation of these measures, as well as the resulting estimates for Panama.

Measure 1 estimates births averted by sterilization prior to 1975 under the assumption that the sterilized would have continued to experience births at the 1971-75 rate for all non-sterilized women. As shown in Appendix II, we can view this measure as the amount by which the Total Marital Fertility Rate[12] (TMFR) for the period 1971-75 would have been higher had no sterilizations ever occurred in the past. The actual TMFR in Panama for 1971-75 equals 5.07. Had no sterilizations occurred, the TMFR would have equalled 5.91. The difference of 0.84 births is one measure of births averted by sterilization.

Measure 2 estimates births averted by sterilization for a synthetic cohort that would have experienced both the sterilization rates of 1971-75 and the birth rates of 1971-75 for all non-sterilization women. By the end of her reproductive career (i.e. 30 years of marriage) the average women would have averted 1.14 births. As we would expect, this

FIGURE 3
Births Averted By Marriage Duration



11. Since all measures of births averted use the fertility experience of the sterilized until the time of sterilization, all of the measures require the date of sterilization. This information is available only from the Fertility Regulation Module. A somewhat cruder version of Measure 1 could be used if the Fertility Regulation Module is not available. Specifically, we could assume that, in the absence of sterilization, the sterilized would have had the marriage duration specific birth rates of women who have *never* been sterilized rather than basing the calculation on *all* non-sterilized exposure time. Measures 2, 3, and 4 of births averted could not be revised in the absence of the Fertility Regulation Module: Measures 3 and 4 require data on the wanted status of the last birth, contained only in the Module, while Measures 2 and 4 require the identification of sterilizations occurring in the last five years (which depends on the date of sterilization).

12. We define the Total Marital Fertility Rate (TMFR) as the sum of marriage duration specific fertility rates, for ever-married women. The TMFR is similar to the frequently used Total Fertility Rate (TFR), but is based on marriage duration rather than on age. It can be interpreted as the number of births a hypothetical cohort of married women would have if the duration specific rates of the recent period applied through N years of marriage.

TABLE 9
Four Measures[1] of Births Averted per Women, by Specified Durations.

Marriage Duration	Cumulative Births Averted: Simple Proportions Sterilized (Measure[1]) (1)	Synthetic Proportions Sterilized (Measure[2]) (2)	Duration Since Last Wanted Birth	Simple Proportions Sterilized (Measure[3]) (3)	Synthetic Proportions Sterilized (Measure[4]) (4)
1	0.00	0.00	1	0.00	0.00
			2	0.05	0.05
5	0.02	0.02	3	0.10	0.10
			4	0.15	0.15
10	0.15	0.16	5	0.20	0.20
15	0.34	0.40	10	0.38	0.42
20	0.61	0.76	15	0.56	0.65
25	0.78	1.03	20	0.73	0.89
30	0.84	1.14	25	0.84	1.05

1 See text for complete descriptions of the four measures.

estimate is higher than the estimate of 0.84 births from Measure 1. Since both measures assume the same birth rates in the absence of sterilization, the difference of 0.30 births is due to the difference in proportions sterilized: 0.30 more births are averted based on 1971-75 sterilization rates than on the overall record of sterilization rates in the past.

Figure 3 shows numbers of births averted by successive marriage durations up to 30 years for Measures 1 and 2; selected values are shown in Table 9. As we noted earlier, there is little difference between the simple and synthetic measures of sterilization for early marriage durations. Thus, there is little difference between numbers of births averted for Measures 1 and 2 at early durations. The two measures diverge with increasing marriage duration, reaching a difference of 0.30 births by 30 years of marriage. Few sterilizations occur at early durations of marriage: thus, for example, only 0.15 or 0.16 (using Measures 1 and 2, respectively) births are averted by 10 years of marriage, whereas 0.84 and 1.14, respectively, are averted by 30 years of marriage.

Measures 3 and 4 of births averted by sterilization are anologus to measures 1 and 2, respectively, with the unwanted birth rate by duration since last wanted birth replacing the total birth rate by marriage duration. Measure 3 can be interpreted as the amount by which the Total Unwanted Fertility Rate[13] for 1971-75 would have been higher had no sterilizations occurred in the past. The actual Total Unwanted Fertility Rate for 1971-75 equalled 1.73; in the absence of sterilization it would have equalled 2.57, a difference of 0.84 unwanted births averted by sterilization. Measure 4 can be interpreted as unwanted births averted by sterilization for a synthetic cohort subject to both the sterilization rates and the unwanted birth rates of 1971-75. By 25 years after her last wanted birth, the average woman in this synthetic cohort would have averted 1.05 unwanted births. The difference of 0.21 births between Measures 3 and 4 is due once more to the higher recent sterilization rates.

FIGURE 4

Births Averted, by Duration Since Last Wanted Birth

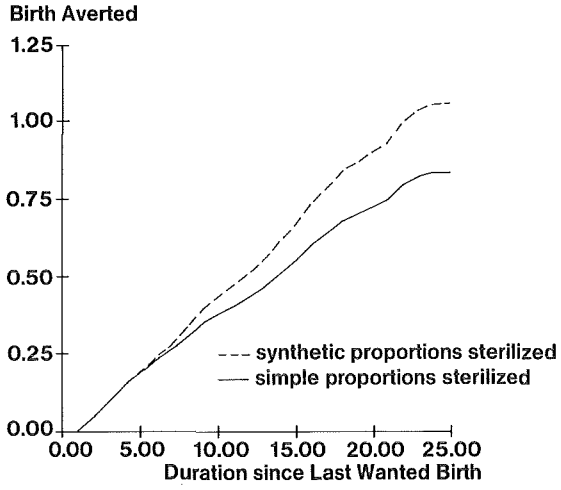


Figure 4 shows numbers of births averted by duration since last wanted birth up to 25 years for Measures 3 and 4 (see Table 9). From the estimates in Table 9, we note that eventual births averted (i.e. by either 25 years duration since last wanted birth or 30 years of marriage) are very nearly equal for Measures 1 and 3 and for Measures 2 and 4. Although such close agreement is to some extent coincidental, it increases confidence in the general magnitude of our estimates of births averted by sterilization. For early durations, however, Measures 3 and 4 are higher than Measures 1 and 2, respectively. In other words, for low values of d, more births are averted by d years since last wanted birth than by the same d years of marriage. This is as one would expect: for the average woman, sterilization rates are naturally higher in the early years after a woman no longer wants births than in the early years of marriage. To summarize, we show eventual births averted (by either 25 years since last wanted birth or 30 years of marriage) for

the four measures in the diagram that follows:

Measures of Births Averted by Sterilization by Final Duration

Birth Rates 1971-75 in the Absence of Sterilization (r_i)	Proportions Sterilized by Duration (p_i)	
	Simple Proportions Ever-Sterilized as of 1975	Synthetic Proportions Sterilized Implied by 1971-75 Sterilization Rates
Birth Rates of All Non-Sterilized Women by Marital Duration.	1 0.84	2 1.14
Birth Rates of Non-Sterilized Women Who Want No More Births, by Duration Since Last Wanted Birth	3 0.84	4 1.05

As an extension of Measures 4, we can estimate the additional unwanted births which could be averted per woman if all women who became sterilized did so immediately after their last wanted birth. We note that whereas 59.8 per cent of women who want no more births eventually would be sterilized (by 25 years after last wanted birth, based on 1971-75 sterilization rates), only 17.9 per cent would be sterilized by the first year after last wanted birth. Based on the actual 1971-75 sterilization rates, 1.05 unwanted births are averted by 25 years since last wanted birth; an additional 0.48 unwanted births, for a total of 1.53 births per woman, could eventually be averted if all sterilizations were to occur immediately after last wanted birth. More unwanted births could only be averted if women who had hitherto never elected sterilization were to change their behavior.

In addition to the four measures above, all of which estimate births averted in terms of a woman's reproductive career, we can determine the actual number of births averted per woman in the five-year period 1971-75. During this period 2,886 births occurred to an average of 2,923 ever-married women, yielding 0.99 births per woman over the five years. With no sterilization, these women would have had an additional 397 births, or an additional 0.14 births per woman, assuming (as in Measure 1) that the sterilized would have had the marriage duration specific births rates of the non-sterilized ever-married women. Similarly, we note that over the same five-year period, 721 unwanted births occured to an average of 1,695 women who no longer want births, yielding 0.43 unwanted births per woman. With no sterilization, these women would have had an additional 294 unwanted births, or an additional 0.17 births per woman, assuming (as in Measure 3) that the sterilized would have had the duration specific unwanted birth rates of those who want no more births.

13. We define the Total Unwanted Fertility Rate (TUFR) as the sum of the duration specific unwanted fertility rates, summed over durations since last wanted birth.

7. Summary

The growing popularity of sterilization throughout the world and its potential demographic significance increase the importance of developing a set of standard techniques for measuring its incidence and its impact on fertility. The main objective of this report is to describe a set of procedures for estimating various parameters of contraceptive sterilization from WFS data which are of demographic interest: (1) the probability of sterilization; (2) the social and demographic determinants of sterilization; and (3) the births averted by sterilization. The WFS data from Panama were selected for this illustration because of the significant incidence of sterilization in that country and because the survey was completed earlier in Panama than in some other countries which might also have been appropriate models.
A total of 20.8 per cent of ever-married women 20-49 in Panama had been contraceptively sterilized by the end of 1975. Among ever-married women who want no more births (the subset eligible for contraceptive sterilization) the figure reaches almost a third – 32.8 per cent. The percentage sterilized is higher with increasing age and duration of marriage, with a greater number of births in the first five years of marriage, among women who had never used any contraceptive before, and for those whose last births was wanted. The incidence of sterilization is also higher among couples who were formally married rather than in common law marriages, who live in urban rather than in rural areas, and among women who are literate. The combined effect of these variables, however, explains only 15 per cent of the variance of whether or not women elect sterilization; it is quite clear that the main determinants of sterilization were not included in the WFS.
A comparison of the characteristics of women electing contraceptive sterilization with those of women electing other efficient methods of contraception reveals that the principal difference is the stage of the reproductive life: women using other efficient methods are younger, married fewer years, and have had fewer births in the early years of marriage.
The most popular time for sterilization in Panama is between the 5th and 14th years of marriage, between ages 25 and 34. Sterilization occurs across a wide range of parities with some concentration between 3-5 children. More than half of the operations take place shortly after childbirth, with another quarter within one year from a birth.
Two basic types of measurement of the probability of becoming sterilized are proposed: a simple proportion ever-sterilized by 1975 by duration and a synthetic proportion sterilized by duration based on 1971-75 experience. Duration is defined in two ways: years since first marriage for all ever-married women and years since the last wanted birth for women who want no more births. The date of the last wanted birth is estimated for each woman from a combination of information on the wanted status of the last birth contained in the Fertility Regulation Module and from the data in the core questionnaire on desired and actual number of children. The combination of the two proportions and the two durations yields four estimates which are shown for different intervals up to 30 years of marriage duration and 25 years since the birth of the last wanted child. The cumulative probability of being sterilized by 30 years of marriage is .35 for the simple measure and .55 for the synthetic measure; by 25 years after the birth of the last wanted child, the probabilities of sterilization are .42 for the simple measure and .60 for the synthetic measure. The synthetic measures, reflecting 1971-75 experience, are understandably higher than the simple measures because they reflect a higher period rate of sterilization (half of all sterilizations in Panama occurred during the five years preceding the survey).
The synthetic measure by years since last wanted birth is also estimated for various categories of the population by type of marriage, parity, births in first five years, urban-rural residence, and literacy-education. The highest probabilities after 15 years since the last wanted birth are for women in formal marriages (.62) and those with three or more children in the first five years of marriage (.61); the lowest probabilities are for women with fewer than three children ever born (.31) and for women who are illiterate or who had less than four years of schooling (.33).
The magnitude of births averted by sterilization depends on three components: the proportions sterilized, the timing (duration or age) of the procedure during the reproductive span (which in turn depends in part on the number of children desired), and an assumption about the fertility women would have experienced if they had not been sterilized. It is clear that the women who elect sterilization have higher fertility per year of exposure to risk than other women; this leads to the hypothesis that those women sterilized might have had higher fertility in the absence of sterilization than other women of comparable duration. The assumption actually implied in the calculation of births averted may therefore be conservative since it assumes that their fertility would have been the same as for all non-sterilized women or as for non-sterilized women who want no more children. Just how conservative this assumption is depends on the fertility control practices that would have been adopted if they had not in fact elected sterilization: had most of them elected other highly efficient methods of contraception, the assumption used in our procedure would lead to an overestimate of births averted by sterilization.
The birth rates assumed are all based on 1971-75 experience and are calculated as either marriage duration specific rates or rates specific for duration since the birth of the last wanted child. The combination of these birth rates with the simple or the synthetic distributions of proportions sterilized yields four measures of births averted. The values of these estimates range from about 0.8 births per woman for the simple proportions ever-sterilized to about 1.1 births for the synthetic proportions. This latter estimate could have been as high as 1.5 had all observed sterilizations occurred immediately following the birth of the last wanted child. Had no sterilizations at all occurred in Panama, the Total Marital Fertility Rate for 1971-75 would have been 17 per cent higher than it was (5.9 rather than the observed 5.1); the Total Unwanted Fertility Rate would have been about 50 per cent greater than it was (2.6 vs. 1.7). These differences would have been even greater under more recent sterilization rates.
It is appropriate to conclude with a note of caution: any estimate of births averted by sterilization rests on a non-verifiable assumption about the fertility of these women had they not been sterilized. These assumptions have been made explicit here, and although they seem reasonable, they may in fact be off in either direction; there is no way of knowing.

Bibliography

Agarwala, S.N. and K. Venkatacharya, 'A Method for Estimating Annual Births Saved by Use of Various Family Planning Methods', in A. Bose, P.B. Desai and S.P. Jain, Eds., *Studies in Demography*, University of North Carolina Press, 1970, pp. 240–261.

Araica, H., 'Breves Notas Sobre Esterilizacion Feminina en Panama', unpublished manuscript.

Haynes, M.A., G.E. Immerwahr, A. George and P.S.J. Nayar, 'A Study of the Effectiveness of Sterilizations in Reducing the Birth Rate', *Demography*, Vol. 6, No. 1, February 1969, pp. 1–11.

Keyfitz, Nathan, 'Migration as a Means of Population Control', *Population Studies*, Vol. 25, No. 1, March 1971, pp. 63–72.

'M/F Sterilization', *Population Reports*, No. 2, March 1978, pp. 37–72. See especially the 444-item bibliography.

Newman, S.J. and Z.E. Klein Eds., *Behavioral-Social Aspects of Contraceptive Sterilization*. Lexington Books, D.C. Heath and Co., Toronto, 1978.

Presser, H.B., *Sterilization and Fertility Decline in Puerto Rico*. Population Monograph Series No. 13, University of California, Berkeley, 1973, 211 pp.

Presser, H.B. and L.L. Bumpass, 'Demographic and Social Aspects of Contraceptive Sterilization in the United States: 1965–70', in C.F. Westoff and R. Parke, Jr., Eds., *Demographic and Social Aspects of Population Growth*, Vol. I of the Research Reports of the Commission on Population Growth and the American Future, Government Printing Office, Washington, D.C., 1972, pp. 506–568.

Rele, J.R. and T. Patankar, 'Differential Fertility of Contraceptors and Non-contraceptors', *International Population Conference*, Vol. I, International Union for the Scientific Study of Population, London, 1969, pp. 448–455.

Srinivasan, K. and P.M. Kulkarni, 'An Assessment of the Demographic Implications of a Programme of Compulsory Sterilization', *Studies on Sterilization*, Series No. 1, Population Centre Bangalore, 1976, pp. 1–26.

Venkatacharya, K., 'A Model to Estimate Births Averted Due to IUCD's and Sterilization', *Demography*, Vol. 8, No. 4, November 1971, pp. 491–505.

Westoff, C.F. and J. McCarthy, 'Sterilization in the United States', *Family Planning Perspectives*, Vol. 11, No. 3, May-June, 1979.

Appendix I Identification of the Last Wanted Birth

For several of the measures of proportions sterilized and of births averted, which have been described here, it is necessary to identify the last birth wanted by the woman. This measurement is based on three questions in the WFS interview, two from the Core Questionnaire and one from the Fertility Regulation Module.

1. 'Do you want to have another child sometime?'

2. If the answer to that question was No or Undecided, the following question from the Fertility Regulation Module was asked: 'Thinking back to the time before you became pregnant with your last child, had you wanted to have any more children?'

From these two questions, only the wanted status of the last birth can be determined. In order to identify the last wanted birth which could of course be an earlier birth, we have relied on the additional 'desired number of children' question from the Core Questionnaire:

3. 'If you could choose exactly the number of children to have in your whole life, how many children would that be?'

Examining responses to this question in the light of the actual number of living children provides a basis for identifying the wanted status of births prior to the last. This last step could be implemented alone without the use of Question 2 (available only in countries that included that Fertility Regulation Module) on the wanted status of the last birth. However, the 'last wanted' question offers a more robust estimate of at least part (the most recent part) of the unwanted fertility record. This opinion is based in part on the consideration that the 'last wanted' question (Question 2) appears to denote a more specific reference both in time and in the woman's fertility history than does the more hypothetical question about choosing the exact number they would have (Question 3). The latter question appears to invite the respondent to think in terms of a personal ideal situation. It also focuses the respondent's attention on the total number of children over a lifetime rather than on the latest child in the sequence. The impression that these questions are not measuring the same variable is confirmed by the much lower percentage of ever-married women with at least one birth who would be classified as having had an unwanted birth by the 'desired number' question (22.6 percent) than by the more direct 'last wanted' question (34.6 percent). Nevertheless, the two estimates converge with increasing parity (see Table A-1). Even among women who want no more births, 30.9 per cent of those whose desired number of children *exceeds* their actual number, reported the last birth as not wanted. The use of this 'desired number' variable, therefore, underestimates the amount of unwanted fertility that probably would have been reported had the question on the wanted status of the last birth been asked about every birth in the woman's history.

The actual procedure followed in identifying the last wanted birth involved:

1) Identifying from the question (Question 1) asked of currently married women: 'Do you want to have another child sometime?' those women who want no more children. Women who were sterilized contraceptively were not asked this question but are here imputed to want no more children. Infecund women, who were not asked Question 1, are also assigned to the 'want no more' category even though the majority (61.1 per cent) expressed a wish for more children than they actually had. The rationale is that they would presumably have no more births regardless of their preferences and that this is the paramount consideration since one objective of the exercise is to estimate births averted by sterilization.

The 45 women who replied 'Undecided' to this question are imputed to want more or no more on the basis of the classification on the wanted status of the last birth (Question 2) – those who replied 'Unwanted' are classified as 'want no more'. Those in this category who replied 'Wanted' are assigned on the basis of the relation between their response to the 'desired number' question (Question 3) and their actual number of living children.

2) Assigning formerly married women (who are not asked the 'want more' question – Question 1) to one or another category following the same procedure as that followed for the Undecided respondents. Those who replied that their last birth was unwanted in Question 2 are classified as 'want more' if their desired number exceeded their actual number of children; the remaining combinations are classified as 'want no more'.

Some women in the survey (23 in Panama) are in both categories of formerly married and infecund; these women are assigned to the 'want no more' category. The logic of confining the analysis to women who currently want no more children is that this is the category which would have a last wanted birth.

These procedures resulted in a total of 2,111 ever-married women who say they want no more or are imputed to want no more children. This is the base population from which contraceptive sterilizations are drawn.

3) Selecting from these 2,111 women who want no more births, the subset who replied that before they became pregnant with their last child, they had wanted more children, that is, their last birth was wanted (Yes, to Question 2). Women who reported that their last child was wanted (1,021 of the 2,111) were assigned that order of birth as the last wanted. The remaining 1,064 women (26 women had no births) had reported their last birth as unwanted.

4) Routing these 1,064 women who had reported their last birth as unwanted through the 'desired number of children' question (Question 3). If the desired number equalled or exceeded the actual number of living children, their last wanted birth was identified as the birth preceding the total number of living children (giving precedence to the 'last wanted' question). If the desired number agreed with the 'last unwanted', the penultimate birth was identified as the last wanted birth. Finally, if the desired number was less than the order of the last unwanted, that lower order was designated as the last wanted birth.

A measure of unwanted fertility is required not only to identify the last wanted birth, but also to estimate the magnitude of fertility that would occur in the absence of sterilization in order to provide estimates of births averted by sterilization. The procedure described above is used to establish the last wanted birth, and consequently the want-

ed status of each birth for those women who want no more births. When the last wanted birth is identified, the procedure followed identifies all subsequent births as unwanted and all prior births as wanted. These data have been adapted to a life table format to yield the cumulative probability of having an unwanted birth as a function of the duration of time since the last wanted birth (Table A-2), for the period 1971-75.

The desired statistic, however, is a rate that would reflect all of the unwanted births experienced by women during their exposure to such risk, that is, during the period after their last wanted birth. An Unwanted Fertility Rate (reflecting 1971-75 experience) is then calculated as the cumulative number of unwanted births per woman-year of exposure to risk. The difference in the calculation of this rate and the probability of having at least one unwanted birth is that in the latter measure women continue to be exposed after one unwanted birth and all such births are counted. The Unwanted Fertility Rate by duration since last wanted birth is also shown in Table A-2. Women in Panama are estimated to have had a mean of 1.73 unwanted births in 25 years after the birth of the last wanted child. Since the probability of having had at least one unwanted birth in 25 years of risk is .55, the implication is that 55 per cent of the women are having an average of 3.2 unwanted births over this duration and, as we have observed earlier, the WFS measures available for estimating unwanted fertility no doubt err on the conservative side.

As the foregoing account suggests, the identification of unwanted births from WFS data is not a straightforward matter, and there may be room for improvement. A further investigation of the subject is now being planned, which conceivably could result in some modification of the procedure. Even if modifications do occur, however, they would probably have only a minor effect on estimates of births averted by sterilization, since the procedures independent of the measurement of unwanted fertility yield very similar results.

TABLE A-1

Estimates of the Percentage with at Least One Unwanted Birth From Two Measures: (1) The Percentage Whose Desired Number is Less Than The Actual Number of Living Children; (2) The Percentage Who Reported Their Last Child as Not Wanted. Base Confined to Currently Married, Fecund Women, Including Currently Pregnant Women, Who Want No More Children.

Number of Living Children	Desired Less Than Actual (a)	Last Child Unwanted (b)	Ratio a/b (c)
Total	32.9	50.4	.653
1	0.0	13.2	.000
2	1.6	19.1	.084
3	12.1	41.6	.291
4	22.1	44.9	.492
5	40.2	56.9	.707
6	45.4	61.3	.741
7	64.7	77.4	.836
8	72.6	73.8	.984
9+	74.2	74.2	1.000

TABLE A-2

Probability of Having at Least One Unwanted Birth and Unwanted Fertility Rate, by Duration Since Last Wanted Births.

Years since Last Wanted Birth	Probability of Having At Least One Unwanted Birth	Unwanted Fertility Rate
1	.02	0.02
2	.18	0.19
3	.33	0.36
4	.42	0.50
5	.47	0.61
10	.55	1.02
15	.55	1.32
20	.55	1.57
25	.55	1.73

[1] Based on 1971-75 unwanted fertility rates.

Appendix II Calculation of Births Averted by Sterilization

As described in Section VI, all of the measures of the births averted by sterilization require assumptions about:
1) the distribution of proportions sterilized by duration (since marriage or since data of last wanted birth);
2) the duration specific birth rates the sterilized would have had in the absence of sterilization.
In an attempt to assess the impact of sterilization on recent fertility in various ways, we have considered both simple proportions of women ever sterilized and cumulative proportions sterilized implied by recent sterilization rates. In addition, we have based our 1971-75 birth rate calculations on two alternative base populations, both restricted to ever-married women: (1) non-sterilized women and (2) non-sterilized women who want no more births. As a result, we have developed four measures of births averted per women by sterilization, shown schematically below (see also page 16):

Measures of Births Averted by Sterilization

Birth Rates 1971-75 in the Absence of Sterilization (r_i)	Proportions Sterilized by Duration (p_i)	
	Simple Proportions Ever Sterilized as of 1975	Synthetic Proportions Sterilized Implied by 1971-75 Sterilization Rates
Birth Rates of All Non-Sterilized Women, by Marital Duration	1	2
Birth Rates of Non-Sterilized Women Who Want No More Births, by Duration since Last Wanted Birth.	3	4

For each of the four measures, our input data consist of the proportions of women sterilized by duration *i* (p_i) and the birth rate the sterilized would have had in the absence of sterilization (r_i). (Note that throughout this discussion duration *i* refers to the interval (i-1, i).) The data can be arranged as in the table below:

Duration	Proportion Sterilized	Birth Rate in the Absence of Sterilization
0-1	P_1	r_1
1-2	P_2	r_2
2-3	P_3	r_3
.	.	.
.	.	.
.	.	.
(D-1)-D	P_D	r_D

For each duration *d* (duration since marriage or since last wanted birth), d = 1, 2, . . .D, births averted by duration *d* (specifically, by the end of the d^{th} duration) can be expressed as

$$\text{Births Averted by Duration } d = \sum_{i=1}^{d} p_i r_i \qquad (1)$$

In this analysis, the final duration D is taken to be 30 years for marriage and 25 years for last wanted birth (i.e. practically no births or sterilizations occur after these durations). For final durations D, each measure denotes births averted per women by the end of her reproductive career. We define the four measures in more detail as follows:
For Measures 1 and 3, both based upon simple proportions ever-sterilized, we use the following notation:
s_i = number of person-years sterilized in duration *i*, 1971-75[1], i = 1, 2, . . . D.
n_i = number of person-years not sterilized in duration *i*, 1971-1975, i = 1, 2, . . . D.
t_i = total number of person-years in duration *i*, 1971-75 ($t_i = s_i + n_i$), i = 1, 2, . . . D.
b_i = number of births to women in duration *i*, 1971-75, i = 1, 2, . . . D.
In Measure 1 person-years of exposure and numbers of births are based upon the experience of all women, by duration since marriage. In Measure 3, on the other hand, person-years of exposure and numbers of births are based upon the experience of only those women who no longer want births, by duration since last wanted birth.
The simple proportion ever-sterilized by duration *i* equals $\frac{s_i}{t_i}$; with a slight modification[2] this simple ratio is used to calculate the values to proportions sterilized in Table 3 (columns 1 and 3). The birth rate for duration *i* is assumed to equal $\frac{b_i}{n_i}$ in the absence of sterilization. (Values of $\frac{b_i}{n_i}$ for five year intervals by marriage duration and duration since last wanted birth are given in Table 8.) Substituting $\frac{s_i}{t_i}$ for p_i and $\frac{b_i}{n_i}$ for r_i in equation (1), we have

$$\text{Births Averted by Duration } d \text{ (Measures 1 and 3)} = \sum_{i=1}^{d} \left[\frac{s_i}{t_i} \cdot \frac{b_i}{n_i}\right] \qquad (2)$$

Equation (2) is used to calculate births averted by the end of any specified duration for Measures 1 and 3 (columns 1 and 3 of Table 9 and Figures 3 and 4).
We can rewrite equation (2) using the following steps. Noting that total person-years t_i equals $n_i + s_i$, we have

$$\text{Births Averted by Duration } d \text{ (Measures 1 and 3)} = \sum_{i=1}^{d} \left[\frac{s_i}{n_i + s_i} \cdot \frac{b_i}{n_i}\right]$$

Adding and subtracting $b_i n_i$ to the numerator and rearranging terms, we have

$$= \sum_{i=1}^{d} \left[\frac{s_i b_i + b_i n_i - b_i n_i}{(n_i + s_i) n_i}\right]$$

$$= \sum_{i=1}^{d} \left[\frac{b_i(n_i + s_i) - b_i n_i}{(n_i + s_i)n_i} \right]$$

$$= \sum_{i=1}^{d} \left[\frac{b_i}{n_i} \right] - \sum_{i=1}^{d} \left[\frac{b_i}{n_i + s_i} \right]$$

Births averted by duration d (Measures 1 and 3)

$$= \left[\sum_{i=1}^{d} \frac{b_i}{n_i} \right] - \left[\sum_{i=1}^{d} \frac{b_i}{t_i} \right] \qquad (3)$$

The second term on the right-hand side of (3) is simply a sum of duration-specific birth rates. If we let d equal the final duration D (30 years of marriage or 25 years since last wanted birth), this quantity is what we define to be a variant of the Total Fertility Rate: for Measure 1, it is the Total Marital Fertility Rate (TMFR) whereas for Measure 3 it is the Total Unwanted Fertility Rate (TUFR). The first term is the sum of duration specific birth rates in the absence of sterilization, under the assumption that the sterilized would have had the same fertility experience as the non-sterilized. Thus, this expression describes what the TMFR or the TUFR (for Measure 1 and 3 respectively) would have equalled in the absence of sterilization. The difference is a measure of births averted by the end of duration D. (See the discussion of actual values for Panama on page 16).

Using the same assumptions as in Measure 1 and 3, the *total number* of births averted during the period 1971-75 equals

Total Births Averted 1971-75

$$= \sum_{i=1}^{D} \left[s_i \cdot \frac{b_i}{n_i} \right] ,$$

whereas the number of births that actually occurred during the period equals

Number of Births 1971-75

$$= \sum_{i=1}^{D} b_i \quad .$$

Actual values of these expressions for Panama are given on page 18.

Calculations for Measure 2 and 4 are somewhat more complicated, since these measures require the construction of synthetic cumulative distributions of proportions sterilized based upon recent sterilization rates. We use the following notation for Measures 2 and 4:

s_i^* = number of women sterilized within duration i, for *only* those women sterilized during 1971-75, i = 1, 2, . . . D.

n_i^* = number of non-sterilized women at the start of duration i, 1971-75, i = 1, 2, . . . D.

n_i = number of person-years not sterilized in duration i, 1971-75, i = 1, 2, . . . D.

b_i = number of births to women in duration i, 1971-75, i = 1, 2, . . . D.

The latter two terms are identical to those used for Measures 1 and 3 (see page 29). The first two terms, however, have been redefined in order to determine probabilities of sterilization for the period 1971-75. As before, numbers of women and births for Measure 2 are based on all women by duration since marriage, while the corresponding values for Measure 4 are based on only those women who want no more births, by duration since last wanted birth. The exposure time of women who were sterilized for non-contraceptive reasons during the five years is included up to the time of the operation, but is then excluded from all subsequent calculations, and the event of their non-contraceptive sterilization is not included in s_i^*.

We can determine duration specific probabilities of sterilization, for the period 1971-75, by forming the ratios $q_i = \frac{s_i^*}{n_i^*}$, i = 1, 2, . . .D; q_i denotes the probability of being sterilized at the end of duration i for those not sterilized at the beginning of duration i. The cumulative probability of being sterilized by the end of duration d (i.e. at exactly D years) implied by 1971-75 sterilization rates, z_d, equals one minus the product (π) of the probability of not being sterilized during any duration less than and including d:

$$z_d = 1 - \prod_{i=1}^{d} (1 - q_i) \qquad (4)$$

Equation (4) is used to calculate the values of proportions sterilized given in Table 3 (columns 2 and 4) and in Figure 1 and 2.

In order to calculate births averted, we need to convert these cumulative proportions sterilized by the *end* of duration d (z_d) into cumulative proportions sterilized *within* duration d. We have done this by a simple interpolation scheme. For all durations greater than the first, we have taken simple averages. That is, we have calculated the cumulative proportions sterilized within duration D, z_d, as $(z_{d-1} + z_d)/2$, d = 2,3, . . .D. Since about 70 percent of those sterilizations which occur during the first year since last wanted birth do so within the first month (see Table 2), we have assumed that z_1' equals $0.85z_1$.

As with Measures 1 and 3, the birth rate for duration i is assumed to equal $\frac{b_i}{n_i}$ in the absence of sterilization. Substituting these birth rates together with the synthetic proportions sterilized in duration i, z_i', into equation (1), we have

Births Averted by Duration d (Measures 2 and 4)

$$= \sum_{i=1}^{d} \left[z_i' \cdot \frac{b_i}{n_i} \right] . \qquad (5)$$

Equation (5) is used to calculate births averted by the end of any specified duration for Measures 2 and 4 (columns 2 and 4 of Table 9 and Figures 3 and 4),

As an extension of Measure 4, we can estimate the additional births which could be averted per women if all women who elected sterilization did so immediately after their last wanted birth. Noting that z_D' is the eventual proportion sterilized (by 25 years since last wanted birth) implied by recent sterilization rates, we have

Additional Births Averted per Women

$$= \sum_{i=1}^{D} (z_D' - z_i') \frac{b_i}{n_i} \quad .$$

---

1. Measures 1 and 3 consider all sterilizations: i.e. those prior to and after 1971. Thus, for example, a woman sterilized at the beginning of duration 8 in 1970 would contribute person-years sterilized to durations 9, 10, 11, 12, and 13 in the period 1971-75. On the other hand, a woman sterilized at the beginning of duration 8 in 1973 would contribute person-years not sterilized to durations 6 and 7 and person-years sterilized to durations 8, 9, and 10, for the period 1971-75.

2. The values of proportions ever sterilized, which we have given in Section V (columns 1 and 3 of Table 3; Figures 1 and 2), are estimates of proportions of women ever sterilized by the *end* of duration d. Average proportions sterilized *within* the duration are required for calculations of births averted. However, in order to precisely compare proportions ever sterilized with cumulative proportions sterilized based on 1971-75 sterilization rates (see equation (4) in this appendix), we have averaged successive values of $\frac{s_i}{t_i}$.. Thus for example, the simple proportion of women ever sterilized by the end of duration 1 is estimated by $\left(\frac{s_1}{t_1} + \frac{s_2}{t_2} \right)/2$.

Appendix III Effects of Different Denominators

TABLE C-1.

Comparison of Three Denominators Among Women Who Want No More Births (Ever-Married, EM; Currently Married, CM; Fecund, Fec) for Calculations of Cumulative Proportions Sterilized and Unwanted Fertility Rates.[1]

Years Since Last Wanted Birth	Cumulative Proportions Sterilized			Unwanted Fertility Rate		
	EM	CM	FEC	EM	CM	FEC
1	.179	.187	.198	.02	.02	.02
2	.219	.233	.245	.19	.17	.18
3	.253	.270	.282	.36	.35	.37
4	.289	.308	.321	.50	.49	.52
5	.324	.342	.356	.61	.59	.63
10	.446	.461	.484	1.02	1.03	1.11
15	.524	.541	.570	1.32	1.33	1.47
20	.582	.605	.646	1.57	1.63	1.81
25	.598	.625	.668	1.73	1.81	2.05

[1] Based on 1971-75 sterilizations and unwanted fertility rates.

Appendix IV Estimate by Age

The probability of contraceptive sterilization and births averted by sterilization has been measured in two temporal dimensions: the duration of marriage, which is appropriate for a sample of ever-married women, and the interval since the last wanted birth, which is appropriate for women who want no more children. A third alternative, where a sample of all women regardless of marital status is available, is age. In Panama, such a sample is in fact available since single women were interviewed as well, although no women below the age of 20 were included. The calculation is directly analogous to that for duration of marriage. Specifically, the variable *i* previously used to denote durations 1, 2, . . .D, can be used to denote the single-year intervals of age 20, 21, . . .49.

The simple and synthetic probabilities of contraceptive sterilization by age and by marriage duration (from Table 3 for purposes of comparison) are shown in Table D-1. The age and marriage duration comparisons for each of the two rates show very similar patterns (age and duration are roughly aligned in the table) and, as would be expected, the synthetic rates by age, reflecting the more recent experience, are higher than the simple proportions sterilized, as was observed earlier for the marriage duration calculations.

The analogous measures of births averted are shown in Table D-2, again reproducing the calculations by marriage duration (from Table 9) for comparative purposes. The simple measure of births averted (analogous to Measure 1) estimates how much higher the Total Fertility Rate (the sum of age specific fertility rates for the period 1971-75) would have been in the absence of sterilization. Similarly, the synthetic measure (analogous to Measure 2) estimates the number of births averted by each age for a synthetic cohort that experiences both the age specific sterilization rates and the age specific birth rates of the 1971-75 period for all non-sterilized women. Thus by the end of the reproductive age, all women would have averted 0.57 births at the rates of sterilization actually experienced over the past in Panama, or 0.78 births at the rates of sterilization experienced in the past five years.

These values are appreciably lower than the 0.84 and 1.14 estimates for the simple and synthetic measures by marriage duration because the latter are based on the sterilization and fertility of married women only. When the estimated births averted are expressed as a percentage of the Total Fertility Rate that theoretically would have occurred in the absence of sterilization, the simple measure yields an estimate of 12 per cent and the synthetic measure 15 per cent. The corresponding estimates for the marriage duration and marital fertility rates are 14 and 19 per cent.

TABLE D-1
Comparisons of Age and Marriage duration for estimates of the Probability of Contraceptive Sterilization and of Births Averted by Sterilization

Years of		Simple Proportions Sterilized		Synthetic Cumulative Proportions Sterilized (Based on 1971-75 rates)	
Age (All Women)	Mariage Duration (Ever-Married Women)	Age	Mariage Duration	Age	Marriage Duration
20	1	.002	.002	.001	.002
25	5	.034	.037	.022	.037
30	10	.129	.150	.161	.172
35	15	.219	.255	.330	.341
40	20	.297	.322	.441	.451
45	25	.328	.308	.493	.513
50	30	.409*	.355	.495	.552

* Calculated for ages 48-49 combined because of small frequencies.

TABLE D-2
Comparisons of Births Averted by Contraceptive Sterilizations, by Age and by Marriage Duration

Years of		Simple Measure (Measure 1)		Synthetic Measure (Measure 2)	
Age (All Women)	Mariage Duration (Ever-Married Women)	Age	Marriage Duration	Age	Marriage Duration
20	1	0.00	0.00	0.00	0.00
25	5	0.01	0.02	0.01	0.02
30	10	0.11	0.15	0.11	0.16
35	15	0.29	0.34	0.34	0.40
40	20	0.48	0.61	0.63	0.76
45	25	0.55	0.78	0.75	1.03
50	30	0.57	0.84	0.78	1.14