Levels and Recent Trends in Fertility and Mortality in Colombia (1982)

Pages
237

Size
5 x 9

ISBN
0309328330

Zlotnik, Hania; Committee on Population and Demography; Commission on Behavioral and Social Sciences and Education; National Research Council

COMMITTEE ON
POPULATION AND DEMOGRAPHY

Report No. 12

Levels and Recent Trends in Fertility and Mortality in Colombia

Hania Zlotnik

Committee on Population and Demography
Commission on Behavioral and Social Sciences and Education
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1982

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Available from

NATIONAL ACADEMY PRESS Publication on demand
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Printed in the United States of America

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PREFACE

The Committee on Population and Demography was established in April 1977 by the National Research Council, in response to a request by the Agency for International Development (AID) of the U.S. Department of State. It was widely felt by those concerned that the time was ripe for a detailed review of levels and trends of fertility and mortality in the developing world. Although most people in the demographic community agree that mortality has declined in almost all developing countries during the last 30 years, there is uncertainty about more recent changes in mortality in some countries, about current levels of fertility, about the existence and extent of recent changes in fertility, and about the factors determining reductions in fertility.

In 1963, a Panel on Population Problems of the Committee on Science and Public Policy of the National Academy of Sciences published a report entitled The Growth of World Population. The appointment of that panel and the publication of its report were expressions of the concern then felt by scientists, as well as by other informed persons in many countries, about the implications of population trends. At that time, the most consequential trend was the pronounced and long-continued acceleration in the rate of increase of the population of the world, and especially of the population of the poorer countries. It was estimated in 1963 that the annual rate of increase of the global population had reached 2 percent, a rate that, if continued, would cause the total to double every 35 years. The disproportionate contribution of low-income areas to that acceleration was caused by rapid declines in mortality combined with high fertility that remained almost unchanged: the birth rate was nearly fixed or declined more modestly than the death rate.

Since the earlier report, however, the peak rate of growth in the world's population has apparently been passed. A dramatic decline in the birth rate in almost all the more developed countries has lowered their aggregate annual rate of increase to well below 1 percent, and the peak rate of increase has also apparently been passed in the less-developed parts of the world as a whole. A sharp decline in fertility in many low-income areas has more than offset the generally continued reduction in the death rate, although the rate of population increase remains high in almost all less-developed countries.

The causes of the reductions in fertility--whether they are the effect primarily of such general changes as lowered infant mortality, increasing education, urban rather than rural residence, and improving status of women or of such particular changes as spreading knowledge of and access to efficient methods of contraception or abortion--are strongly debated. There are also divergent views of the appropriate national and international policies on population in the face of these changing trends. The differences in opinion extend to different beliefs and assertions about what the population trends really are in many of the less-developed countries. Because births and deaths are recorded very incompletely in much of Africa, Asia, and Latin America, levels and trends of fertility and mortality must be estimated, and disagreement has arisen in some instances about the most reliable estimates of those levels and trends.

It was to examine these questions that the Committee on Population and Demography was established within the Commission on Behavioral and Social Sciences and Education of the National Research Council. It was funded for a period of five and one-half years by AID under Contract No. AID/pha-C-1161 and Grant No. AID/DSPE-G-0061. The committee has undertaken three major tasks:

1. To evaluate available evidence and prepare estimates of levels and trends of fertility and mortality in selected developing nations;
2. To improve the technologies for estimating fertility and mortality when only incomplete or inadequate data exist (including techniques of data collection);

3. To evaluate the factors determining the changes in birth rates in less-developed nations.

Given the magnitude of these tasks, the committee decided to concentrate its initial efforts on the first two tasks; it initiated work on the third task in 1979.

The committee approaches the first task through careful assessment, by internal and external comparison, and through analysis, by application of the most reliable methods known, of all the data sources available. Each of the country studies therefore consists of the application of a range of methods to a number of data sets. Best estimates of levels and recent trends are then developed on the grounds of their consistency and plausibility and the robustness of the individual methods from which they were derived.

The committee's second task, refinement of methodology, is seen as a by-product of achieving the first. The application of particular methods to many different data sets from different countries and referring to different time periods will inevitably provide valuable information about the practical functioning of the methods themselves. Particular data sets might also require the development of new methodology or the refinement of existing techniques.

The committee set three criteria for identifying countries to study in detail: that the country have a population large enough to be important in a world view; that there be some uncertainty about levels and recent trends of fertility or mortality; and that sufficient demographic data be available to warrant a detailed study. After a country has been selected for detailed study, the usual procedure is to set up a panel or working group of experts, both nationals of the country and others knowledgeable about the demography and demographic statistics of the country. The role of these panels and working groups, which generally include at least one committee member, is to carry out the comparisons and analyses required. A small staff assists the committee, panels, and working groups in their work. In a few cases, including the Colombia study, a staff member has undertaken primary responsibility for analyzing available data and preparing the report.

As of early 1982, 168 population specialists, including 94 from developing countries, have been involved in the work of the committee as members of panels or working groups. The committee, the commission, and the

National Research Council are grateful for the unpaid time and effort these experts have been willing to give.

Each country being studied has a different mix of data sources and different problems with data errors. Therefore, there is no standard pattern for all the reports. However, each report includes a summary of the main findings regarding estimates of fertility and mortality, a description of the data sources available, and a presentation of the analyses that were carried out, classified by type of data analyzed; detailed methodological descriptions are included where necessary in appendixes.

In some of the reports the estimates of fertility and mortality are presented as ranges. The use of a range is deliberate. It indicates that the panel and the committee are confident that the range includes the true value, but have concluded that the evidence does not warrant selecting a single figure as best. The range conveys an important aspect (uncertainty) of the estimation. Ideally, in constructing an average for several populations in each of which estimation is presented as a range, an aggregate range would be calculated (as the population-weighted average of the constituents). The user who selects a single figure from the middle of the range does so at the risk of misleading simplification.

This report, on levels and recent trends of fertility and mortality in Colombia, is No. 12 in a series of reports issued by the Committee on Population and Demography. In 1980 a first draft of the report was prepared by Hania Zlotnik using published materials. Jane Menken contributed a section on the analysis of child mortality differentials as inferred from the maternity history data gathered by the 1976 Colombian Fertility Survey. The committee is grateful to the World Fertility Survey and to the Corporacion Centro Regional de Poblacion for making possible the use of the fertility survey data.

A workshop to discuss the preliminary report was held in Bogota in September 1980. It was attended by some 35 experts and officials concerned with demographic measurement in Colombia. Special thanks are due to the Facultad de Estudios Interdisciplinarios of the Pontifica Universidad Javeriana for hosting the workshop in Bogota, to its director, Hector Maldonado, for helping in organizing the workshop, and to the workshop participants for their contributions and guidance in improving the report. The many ideas and suggestions they offered during the workshop served as a basis for revision of the manuscript. In particular, the support of the Departamento Administrativo Nacional de Estadistica (DANE) in making available the National Household Survey data and the expertise of the DANE staff greatly contributed in strengthening its conclusions. Following the workshop, Dr. Zlotnik prepared a revised draft. The Committee extends warm thanks to her for taking primary responsibility for the preparation of this report. Many hours of painstaking calculations and analysis were required to bring this project to completion.

The committee also wishes to thank Katherine Miller who edited the manuscript and Lois Hemphill, Benita Anderson, and Solveig Padilla for typing the manuscript. Brenda Buchbinder, administrative assistant on the committee staff while this report was being produced, helped with workshop arrangements and many other tasks, and other members of the committee staff provided advice and encouragement. Elaine McGarraugh carried out the final proofreading and other production editing tasks. The committee also notes with appreciation the Assembly reviewers of this report.

ANSLEY J. COALE, Chair
Committee on Population and Demography

SUMMARY

In 1978 the population of Colombia was the fourth largest in Latin America. At 26 million, its population was comparable to that of third-place Argentina, approximately one-third that of Mexico, and slightly greater than one-fifth that of the giant Brazil. Therefore, in regional terms, its demographic import is substantial. Furthermore, with the exception of countries like Argentina and Chile, Colombia was the first large Latin American country to experience a well-documented decline in fertility. Indications of such a decline were evident by the early 1970s, but they have become more profuse and convincing in recent years. Not suprisingly, the extent and nature of this decline have been the subject of much research. In fact, the desire to better understand its dynamics has been the most important motive propelling most of the recent surveys. For this reason, at least during the 1970s, there is no lack of data that can be used to estimate fertility.

The same cannot be said about mortality. Like many other Latin American countries, Colombia has had an operational vital registration system for a fairly long time; however, its output has never been adequate. In addition, although the country has had a fairly long history of census taking (some type of population enumeration was carried out as early as 1780), the consistency and regularity of its censuses leave much to be desired. The last three took place in 1951, 1964, and 1973, and of the three the most recent one is most deficient in terms of completeness of coverage (it understates the Colombian population by at least 8 percent). Disregarding migration and assuming as a somewhat arbitrary standard of comparison that the female population in 1964 was correctly enumerated, the final estimates of completeness of coverage of these three censuses are 93, 98, and 89 percent, respectively.

Prior to 1964, the only sources of demographic information at the national level were the censuses and vital registration, the latter carried out mostly by the Catholic Church. Given the deficiencies inherent in these data, estimates for the 1950-64 period can be derived only by making simplifying assumptions about the characteristics of the population. In spite of this limitation, the mortality estimates for this period meet most of the consistency checks possible and are probably a good approximation to overall trends, which suggest substantial declines in mortality. During this period the detailed estimation of fertility is not possible due to the paucity of adequate data; the evidence indicates only an approximately constant level.

The National Morbidity Survey of 1965 marked the beginning of the "sample survey era" in Colombia. Although the purpose of this survey was not strictly demographic, it did explore some demographic topics and pioneered the development of the Master Sample, which has served as a basis for most of the subsequent demographic surveys. The first in this series was the 1969 National Fertility Survey, in which the main objectives were the estimation of levels, trends, and differentials in fertility. Its results were the first to indicate that fertility was decreasing, a trend that was confirmed later by the 1973 census. Soon after, the desire to monitor ongoing demographic changes closely led to more frequent use of surveys as a measurement tool. In 1976, the Colombian Fertility Survey (part of the World Fertility Survey program) was undertaken, followed in 1978 by the National Household Survey and the Contraceptive Prevalence Surveys. Although each of these surveys had a slightly different purpose, they all gathered information relevant to estimating fertility and child mortality. In addition, the 1978 National Household Survey collected data on maternal orphanhood and widowhood (death of the first spouse), which allow average adult mortality levels to be estimated for an imprecisely defined period preceding the survey. Therefore, there are fairly solid grounds on which to construct estimates of fertility and mortality of children, at least during the 1964-78 period. Among both sets of estimates, however, those corresponding to the most recent years are the least reliable, since they are based on the smallest amount of evidence.

Because substantial statistical evidence exists for the estimation of levels and trends of fertility and mortality in Colombia (especially fertility and child mortality), and since much of that evidence has previously been studied and reported, the following chapters contain an unusually long and complicated analysis. In this summary it is possible to present only the essence of major approaches and principal findings; readers who want to follow the demographic detective work and review the strengths and weaknesses of available evidence on demographic trends in Colombia are encouraged to turn to the body of the report.

This report evaluates the evidence available for estimating fertility and child and adult mortality in Colombia during the past three decades. Three main demographic indicators are treated separately: child mortality, adult mortality, and fertility.

Child Mortality

Most of the data available for estimating child mortality were gathered during the 1970s; therefore the majority of the estimates obtained refer to the 1965-76 period. Estimates for earlier periods are derived from relatively weak data (extrapolation to childhood of the mortality estimates derived via stable and quasi-stable analysis of the census age distributions), and estimates for 1977 and 1978 must be constructed without the benefit of multiple data sources that would permit consistency checks. In Chapter 2, Section 2.3.8, a final series of yearly child mortality estimates for the 1950-78 period is derived.

Table 1 and Figure 1 present the values of two parameters in this series: infant mortality (${}_1q_0$) and the probability of dying by exact age 5 (${}_5q_0$), which, for simplicity, will be referred to from here on as child mortality.

According to these estimates, infant mortality (${}_1q_0$) in Colombia declined by approximately 40 percent between 1950 and 1964, from a level of 150 deaths per thousand births to 85 per thousand for both sexes combined. Infant and child mortality continued to decline after 1964--by about 28 percent between 1964 and 1978--so that by 1978 infant mortality was about 64 deaths per thousand births, lower than similar rates in many developing nations. Overall, during the 1950-78 period there has been substantial improvement in the

TABLE 1 Selected Final Child Mortality Estimates by Sex, 1950-78: Colombia

Year	Female		Male	
	Infant Mortality ($_1q_0$)	Probability of Dying by Exact Age 5 ($_5q_0$)	Infant Mortality ($_1q_0$)	Probability of Dying by Exact Age 5 ($_5q_0$)
1950	.1375	.2107	.1619	.2337
1951	.1347	.2072	.1587	.2300
1952	.1294	.2004	.1524	.2227
1953	.1242	.1938	.1464	.2157
1954	.1193	.1874	.1405	.2087
1955	.1145	.1811	.1349	.2020
1956	.1098	.1750	.1294	.1954
1957	.1053	.1690	.1242	.1889
1958	.1010	.1633	.1191	.1827
1959	.0969	.1576	.1142	.1766
1960	.0924	.1522	.1095	.1706
1961	.0884	.1468	.1049	.1648
1962	.0852	.1417	.1006	.1592
1963	.0829	.1367	.0973	.1489
1964	.0813	.1318	.0942	.1442
1965	.0796	.1295	.0920	.1408
1966	.0777	.1268	.0901	.1375
1967	.0758	.1215	.0875	.1329
1968	.0739	.1165	.0849	.1284
1969	.0717	.1124	.0822	.1242
1970	.0691	.1090	.0793	.1201
1971	.0666	.1063	.0765	.1162
1972	.0642	.1038	.0738	.1124
1973	.0619	.1010	.0712	.1087
1974	.0606	.0995	.0693	.1059
1975	.0603	.0993	.0690	.1056
1976	.0600	.0991	.0687	.1053
1977	.0597	.0990	.0684	.1050
1978	.0594	.0988	.0681	.1047

chances of survival of young children: child mortality ($_5q_0$) declined by more than half (about 54 percent for both sexes combined), and in the case of infant mortality the reduction amounted to 57 percent. Nevertheless, despite this improvement, in 1978 the

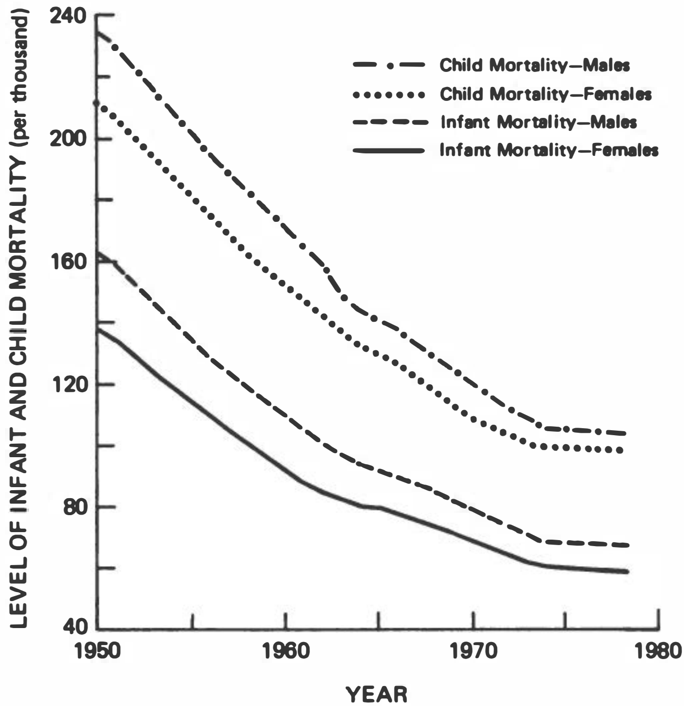


FIGURE 1 Final Estimates of Infant ($_1q_0$) and Child ($_5q_0$) Mortality by Sex, 1950-78: Colombia

Note: Infant mortality is $_1q_0$ x 1,000; child mortality is $_5q_0$ x 1,000.

Source: Table 1.

probability of a child dying before reaching a fifth birthday was close to one in 10. In addition, greater reductions appear to have taken place before rather than since 1964 (infant mortality falling from 150 to 85 per thousand from 1950 to 1964, and from 85 to 64 in the next 14 years).

Adult Mortality

Adult mortality, estimated in terms of the expectation of life at birth (e_0) and at age 5 (e_5), also declined.

During the 1950-64 period the expectation of life at age 5 increased by approximately 10 and 11 percent for males and females, respectively. The estimated values of the expectation of life at birth in 1950 and in 1964 are, respectively, 43.7 and 53.1 years for males and 46.7 and 56.4 years for females.

The estimates of adult mortality for 1964-78 are based mainly on a life table fitted to adjusted age-specific mortality rates obtained from the 1973 census and registered deaths. Since the quality of these data is fairly weak, the accuracy of the estimates presented is also uncertain. Unfortunately, the set of reliable indirect estimates of adult mortality that can be derived from the 1978 National Household Survey data does not refer to the 1970s. Therefore, no external consistency check is possible. Hence, adult mortality estimates for the last decade should be interpreted with caution. They imply that the expectation of life at age 5 increased by 5 and 6 percent among males and females respectively and that the expectation of life at birth in 1973 was 58.1 years for males and 61.7 years for females. The final yearly estimates of adult mortality for the 1950-78 period are presented in Table 2 and Figure 2.

The reasons for the uncertainty surrounding the estimated levels of adult mortality prevalent during the most recent decade are presented in detail in Chapter 2. Evaluation of the main and traditional source of information on adult mortality--the number and age distribution of registered deaths--shows that the age distribution of registered deaths (especially that of males) is severely distorted by consistent exaggeration of the reported age at death. Such distortions, if unchecked, tend to produce underestimates of adult mortality even when allowance is made for some degree of underregistration. A method that redistributes deaths when there is evidence of age exaggeration is used to obtain more reliable estimates of registration completeness. These estimates are reasonably consistent with those obtained on the basis of stable and quasi-stable analysis, a fact that validates them both.

For the 1963-65 period, independent estimates of adult mortality are obtained from the orphanhood and widowhood information gathered by the 1978 National Household Survey. Estimates for females obtained from questions on widowhood posed to males had to be discarded because they implied an unrealistically high e_5, but the other estimates (derived from orphanhood and female widowhood)

TABLE 2 Final Estimates of Expectation of Life at Birth (e_0) and at Exact Age 5 (e_5) by Sex, 1950-78: Colombia

	Female		Male	
Year	e_0	e_5	e_0	e_5
1950	46.74	53.93	43.71	51.75
1951	47.10	54.13	44.05	51.92
1952	47.83	54.55	44.74	52.29
1953	48.56	54.98	45.43	52.65
1954	49.29	55.40	46.13	53.03
1955	50.02	55.83	46.82	53.41
1956	50.74	56.27	47.51	53.80
1957	51.46	56.70	48.20	54.20
1958	52.18	57.14	48.89	54.59
1959	52.89	57.58	49.59	54.99
1960	53.60	58.02	50.28	55.40
1961	54.31	58.46	50.97	55.82
1962	55.01	58.91	51.66	56.24
1963	55.71	59.35	52.37	56.35
1964	56.40	59.80	53.06	56.81
1965	56.75	60.02	53.40	56.98
1966	57.10	60.23	53.73	57.12
1967	57.79	60.63	54.37	57.54
1968	58.46	61.04	55.01	57.96
1969	59.13	61.48	55.64	58.38
1970	59.79	61.97	56.26	58.80
1971	60.43	62.50	56.88	59.23
1972	61.06	63.01	57.49	59.64
1973	61.68	63.48	58.09	60.05
1974	62.26	64.01	58.68	60.51
1975	62.31	64.06	58.74	60.55
1976	62.36	64.10	58.80	60.60
1977	62.42	64.15	58.86	60.64
1978	62.47	64.20	58.92	60.68

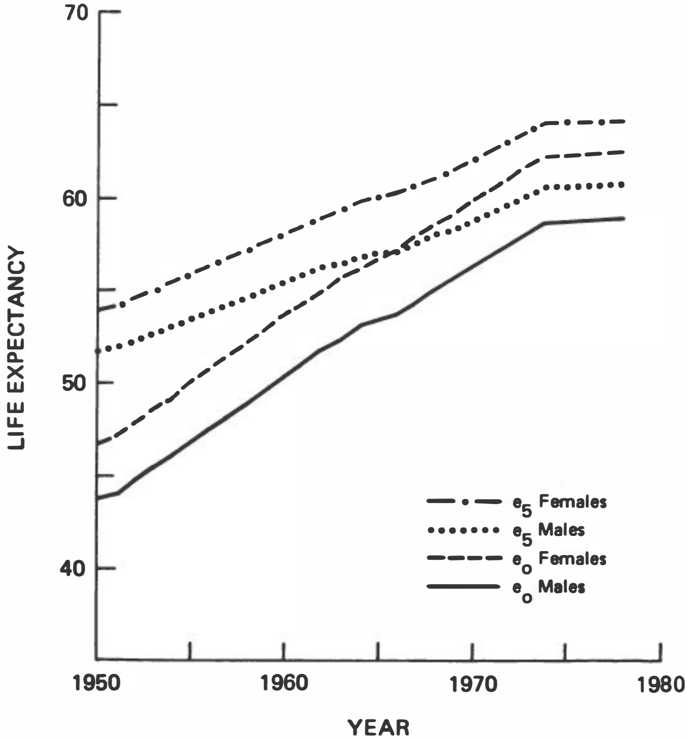


FIGURE 2 Final Estimates of Expection of Life at Birth (e_0) and at Exact Age 5 (e_5) by Sex, 1950-78: Colombia

Source: Table 2.

agree well with those for 1964 derived via quasi-stable analysis.

For 1970 onward, estimates obtained from orphanhood and widowhood information are in general too low (implying a very high e_5) and also had to be discarded. Therefore, the only sources of information that can be successfully exploited in estimating adult mortality during this period are death registration data and the 1973 census. The lack of stability of the population at that time, coupled with the likely distortions present in the age distribution of registered deaths, make the accuracy of the estimates obtained from these sources fairly uncertain. Hence, although a complete yearly series of life expectancy estimates (e_0 and e_5) is presented for the 1950-78 period (Table 2 and Figure 2), those for the 1970s should be viewed mainly as plausible approximations. According to these estimates, life expectancy at age 5 (e_5) among males increased from 51.8 years in 1950 to 58.8 years in 1970; among females, from 53.9 years to 62.0. Thus life expectancy for females increased slightly more (15 percent) than that for males (13.5 percent). By 1978 the tentative estimates show male life expectancy at age 5 to be just above 60 and female life expectancy to be around 64.

The estimates of life expectancy at birth (e_0) show greater improvements during the past three decades (males from 43.7 to 58.9 years and females 46.7 to 62.5 years between 1950 and 1978) because of the substantial contribution of reduced infant and child mortality to e_0. For this reason, the analysis of trends in adult mortality in Chapter 2 concentrates on constructing and comparing estimates of e_5.

Fertility

The available estimates of fertility indicate that it remained fairly constant up to 1964 or 1965, with a total fertility rate of 6.7 or 6.8 children per woman, and started to decline thereafter. The exact path followed by fertility as it declined cannot be determined, but it has been modelled by a simple linear trend, with the total fertility rate falling from about 6.8 in the mid-1960s to 5.1 to 5.2 children per woman in 1973 and then to a level of 4.2 by 1978. The yearly estimates, shown in Table 3, imply that total fertility decreased by nearly 40 percent within 15 years. Figure 3 presents age-specific fertility schedules for selected years during the 1965-78 period.

The decline in terms of birth rates is somewhat smaller (of the order of 34 percent) than that in total fertility, but it is still very impressive. The birth rate declined from about 47 in 1964 to about 31 in 1978 (see Table 4). It must be pointed out, however, that in 1978 the Colombian population was still growing at a rate of nearly 2.2 percent (disregarding migration) and that its birth rate was still 31 births per thousand. The birth rate has been greatly reduced and population growth has decelerated, but the population is still increasing rapidly.

TABLE 3 Total Fertility Estimates Implied by the Fitted Trend Line, 1964-78: Colombia[a]

Year	Estimated Total Fertility
1964	6.80
1965	6.62
1966	6.43
1967	6.25
1968	6.07
1969	5.88
1970	5.70
1971	5.52
1972	5.33
1973	5.15
1974	4.97
1975	4.78
1976	4.60
1977	4.42
1978	4.23

[a]The trend line is shown in Figure 16.

These declines in fertility have occurred as the use of contraception increased. Whereas in 1969 only about one-third of ever-married women reported having ever used contraception, the 1976 Colombian Fertility Survey showed that ever-use among this group had increased to 59 percent (69 and 41 percent in urban and rural areas respectively). The more important measure, current use, measured in the 1976 survey as use among nonpregnant, currently married women without a fecundity impairment, was in that year almost twice as high in urban areas (60 percent) as in rural areas (34 percent). The 1978 Contraceptive Prevalence Survey showed prevalence at 52 percent among currently married (defined as cohabiting) women, and 62 and 35 percent in urban and rural areas, respectively. (Preliminary results from the 1980 Contraceptive Prevalence Survey show similar prevalence rates.)

As in the case of child mortality, most of the data relevant to estimating fertility were gathered during the 1970s. Therefore, a detailed examination of the evidence

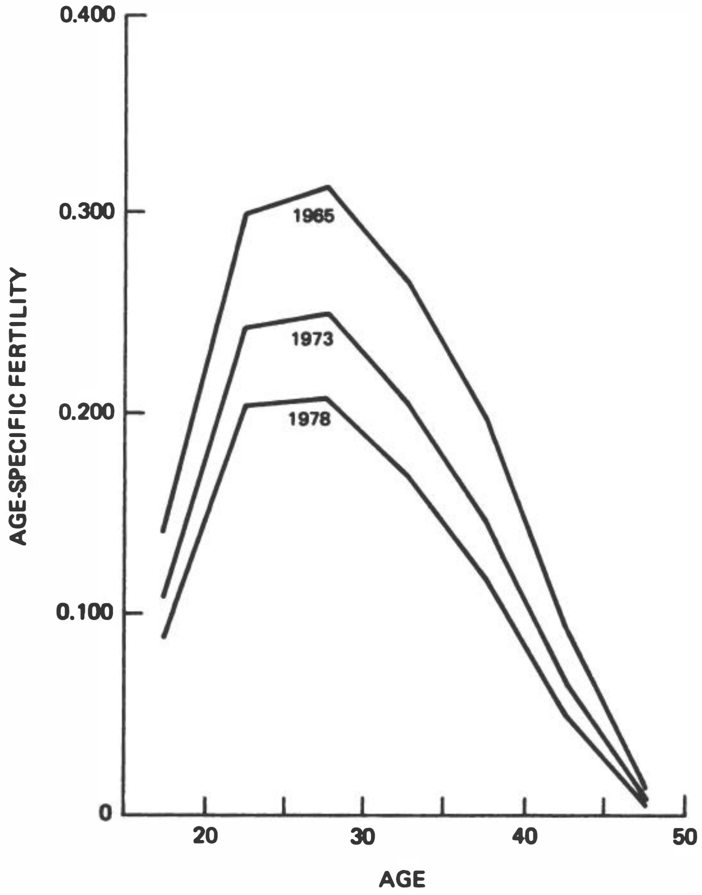


FIGURE 3 Fitted Age-Specific Fertility Schedules for 1965, 1973, and 1978: Colombia

Source: Table 86.

yields relatively reliable fertility estimates only for the 1964-78 period. This examination is presented in Chapter 3. The 1973 census sample and several other sample surveys constitute the main sources of fertility information. Each source is examined for internal consistency as well as for consistency with other sources. In general, the agreement between the different sources is high, although not perfect. Only one source, the 1969

TABLE 5 Regions Used for Demographic Analysis: Colombia

	Birth Rate (per thousand)		
Year	Male	Female	Both Sexes
1964	.0476	.0462	.0469
1965	.0466	.0452	.0459
1966	.0450	.0437	.0444
1967	.0436	.0423	.0430
1968	.0422	.0410	.0416
1969	.0409	.0397	.0403
1970	.0397	.0385	.0391
1971	.0385	.0373	.0379
1972	.0374	.0362	.0368
1973	.0363	.0352	.0357
1974	.0353	.0342	.0347
1975	.0343	.0332	.0338
1976	.0333	.0323	.0328
1977	.0324	.0314	.0319
1978	.0315	.0306	.0311

Note: Sex ratio at birth = 1.034.

National Fertility Survey, had to be rejected as consistently biased.

Although none of the estimates presented above should be interpreted strictly as "the" estimate, the overall magnitude of the fertility decline they imply is probably correct. Uncertainties remain, however, about when the decline started and about the exact trend it followed. The linear trend fitted seems acceptable, as does the assumption that fertility had remained constant prior to 1964. However, although the available evidence does not invalidate these assertions, it cannot confirm them with certainty.

In conclusion, the demographic profile of Colombia during the last decade can be fairly well established in terms of fertility and child mortality, but solid estimates of adult mortality are still lacking. It is hoped that the data on orphanhood and widowhood gathered by recent surveys may soon dispel the uncertainties remaining in this area.

1

INTRODUCTION

1.1 GENERAL CHARACTERISTICS OF THE COUNTRY

Located in northwest South America, Colombia is the only South American country with a substantial coastline on both the Atlantic and Pacific oceans. It has territorial borders with Panama to the west, Venezuela and Brazil to the east, and Ecuador and Peru to the south. Its total territory occupies approximately 440,000 square miles. This territory is divided into three types of major administrative units: departamentos, intendencias, and comisarias. The departamentos enjoy the greatest political autonomy and correspond to the most developed areas of the country. The intendencias and comisarias, often referred to collectively as the territorios nacionales (national territories), encompass larger, less-developed areas with low population density. Their fiscal and administrative autonomy is more limited than that of the departamentos. Each of the major administrative units is in turn subdivided into municipios. The municipio is the basic administrative unit and has considerable autonomy.

At present, Colombia is divided into 22 departamentos, 5 intendencias, 4 comisarias, and a distrito especial (special district) that contains the capital city, Bogota. For the purposes of demographic analysis, the 22 departamentos and the distrito especial are often grouped into the five regions shown in Table 5 and the map of Colombia.

In geographical terms, Colombia consists roughly of two regions: the humid, torrid plains of the southeast and the lofty Andean ranges of the northwest. Administratively, these regions correspond approximately to the national territories and the departamentos, respectively. Jungle lowlands make up about three-fourths of the

TABLE 4 Estimated Crude Birth Rates by Sex, 1964-78: Colombia

Region	Departamentos
Atlantic	Atlantico
	Bolivar
	Cesar
	Cordoba
	La Guajira
	Magdalena
	Sucre
Pacific	Cauca
	Choco
	Narino
	Valle de Cauca
Central	Antioquia
	Caldas
	Huila
	Quindio
	Risaralda
	Tolima
Eastern	Boyaca
	Cundinamarca
	Meta
	Norte de Santander
	Santander
Bogota	Bogota, Distrito Especial

country's area. The continental national territories alone comprise about half of the nation's land. They extend over a vast plain dissected by navigable rivers, which are tributaries of the Orinoco and Amazon systems. North of them (at Meta) lie the savannas (llanos) used for cattle and sheep grazing.

Due to their climate, the national territories have never attracted big population settlements. According to some estimates and the preliminary count of the 1973 census, only slightly over 2 percent of the country's

Source: Adapted from U.S. Bureau of the Census (1979).

population lived in the national territories (DANE, 1974a and 1974b). In contrast, the higher plateaus and valleys interspersed among Colombia's mountain ranges have traditionally been settlement sites. The Central and Eastern regions contain most of these sites. As of 1973, 48 percent of the nation's population inhabited these regions, and an additional 14 percent lived in the distrito especial, the capital city's metropolitan area located at the heart of the Eastern region.

The population has also been attracted to the lowlands flanking the oceans, which are located primarily in the Pacific and Atlantic regions. According to the 1973 preliminary census count, approximately 36 percent of the country's population lived in these two regions, equally divided between the two. The Atlantic region is fairly arid and can support agriculture only when irrigated. The Pacific region, in contrast, has a rainy tropical climate and is endowed with large, fertile agricultural valleys. Cali, Colombia's third largest city and an important industrial site, is located in the Pacific region.

The main body of this report describes the demographic characteristics of the Colombian population living in the five regions listed in Table 5. The inhabitants of the national territories usually have been eliminated from the population universe being studied via sample surveys. Hence, there is very little information about this portion of the population. The demographic data described below generally pertain to the other 98 percent of the population.

1.2 DATA SOURCES

The typical sources for demographic data are censuses, vital registration, and sample surveys; Colombia has used all three to gather information about its population. The sections below describe the type and quality of data produced by each of these typical data sources. (In addition, during the 21-month period from August, 1971 to April, 1973, a dual-record system was operated on an experimental basis in the departamentos of Bolivar and Santander by the Centro de Investigacion sobre Metodos de Estimacion Demografica (CIMED, 1973). However, since the data yielded by this system do not refer to the country as a whole, they are not used in this report.)

1.2.1 Censuses

Colombia has a fairly long history of census taking. During this century, eight censuses have been carried out, but not at regular intervals. The dates and total counts yielded by these censuses are presented in Table 6.

As Table 6 indicates, the results of at least two of the censuses have been sufficiently suspect so as not to be approved by Congress. Among the censuses whose counts were approved, several required a major adjustment of the official population count. In 1918 an upward adjustment of at least 5 percent was incorporated in the official population count (CIMED, 1973). A quotation from the 1928 census report (CIMED, 1973) indicates that a similar adjustment was made in 1928, partly because it was judged necessary to reduce the census's deficiencies and partly to ensure comparability with previous censuses for which the same practice had been adopted. Table 7, which shows the average annual intercensal growth rates implied by

TABLE 6 Reference Dates and Official Population Counts for Censuses Since 1900: Colombia

Reference Date	Population
June 15, 1905	4,143,632
March 5, 1912	5,072,604[a]
October 14, 1918	5,855,077
November 17, 1928	7,851,000[a]
June 5, 1938	8,701,816
May 9, 1951	11,548,172[b]
July 15, 1964	17,484,508
October 24, 1973	20,785,235

[a]Census results were not approved by Congress.
[b]Adjusted figure.

Sources: 1905 to 1964: CICRED (1974:22); 1973: DANE (1981).

TABLE 7 Annual Intercensal Growth Rates Implied by Official Census Counts, 1905-73: Colombia

Intercensal Period	Length of Intercensal Interval (years)	Average Annual Growth Rate (per thousand)
1905-12	6.73	30.1
1912-18	6.61	21.7
1918-28	10.09	29.1
1928-38	9.55	10.8
1938-51	12.92	21.9
1951-64	13.19	31.5
1964-73	9.27	18.7

the census counts shown in Table 6, indicates that the 1928 census results were clearly overinflated.

In 1938, apparently to avoid rejection by Congress, the census count was not adjusted at all, although it was believed to be an underestimate of the country's true population size. In 1951, deficiencies stemming from the failure to enumerate certain communities affected by social unrest were corrected by adding an estimated population of 191,683 to the observed count. This correction implies that the enumeration was thought to have been 98.3 percent complete. The 1964 census results do not appear to have been adjusted before publication.

At the time this report was prepared, the results for the 1973 census were still subject to controversy, since the final count had not yet been published. At present, although definitive results are available (DANE, 1981), there remain some questions about the exact meaning of the published figures. Furthermore, the existence of several different sets of figures labeled "preliminary counts" cannot be ignored. For these reasons Appendix A presents a fairly thorough discussion of the 1973 census, highlighting its scope and limitations.

The 1973 census was the first to gather information on parity, child survival, and date of most recent birth. This information, together with an age distribution, has been published on the basis of a 4-percent sample selected systematically from census returns (DANE, 1975a). Although the 4-percent probability of selection was maintained during the whole sampling process, at the point of expanding the data a somewhat higher weight was given to the population of Bogota (28 instead of 25) to allow for the fact that its population was differentially underenumerated.

1.2.1.1 *Completeness of Coverage*

PES Estimates of Completeness. Because none of the Colombian censuses can be considered entirely accurate, efforts have been made to estimate the completeness of coverage of the two most recent censuses via post-enumeration surveys (PES). In 1964 a PES was carried out by DANE in the six largest cities (Bogota, Cali, Medellin, Barranquilla, Barrancabermeja, and Cartagena) and in seven others selected on the basis of population size. The PES took place three months after the census, and according to its results and to other available information (including a preliminary urban count carried out three months before the census, the list of heads of household made in rural areas in preparation for the census, and the results of the agricultural census), DANE concluded that the 1964 census count was 98.2 percent complete (DANE, 1967). The completeness estimates derived from analytical techniques (see below) suggest that this estimate is somewhat optimistic, probably because completeness of enumeration was greater in urban areas.

A post-enumeration survey to check the census results was also planned for the 1973 census. However, due to field problems associated with the census operation, it did not take place until October 1974, on the occasion of the eighth round of the National Household Survey (DANE, 1977a). This PES covered only the population in private dwellings of the departamentos and Bogota. Therefore, the undercount estimate it produced referred only to these components of the census count (see Appendix A). According to DANE (1977a), a "field" estimate of census coverage in the departamentos and Bogota was obtained by a combination of two procedures: the PES itself and cartographic checks used to identify areas in 14 cities that were known not to have been enumerated on the census date. These procedures produced a final estimate of census coverage of approximately 93 percent: 94 percent in the cabeceras and about 90 percent in the other areas of the departamentos (DANE, 1981).

Based on these estimates, DANE inflated the figure for the population in private households of the departamentos. However, in the DANE (1977a) publication, the inflation factor was incorrectly applied to a base population count that included both the Indian population in the Cauca reservations (to which the PES results do not apply) and the adjusted population of Bogota (which already reflected an 11-percent undercount for the city). Hence, the final population estimate of about 23 million published in DANE (1977a) may be too high.

The correctly inflated results were published in DANE (1977c) and were adopted for some time as the official adjusted 1973 census count, amounting to 22,551,811 inhabitants. However, this total did not include the persons serving in the armed forces (see Appendix A) and no adjustment was made to the population living in the Indian reservations. In the final census report (DANE, 1981), the revised adjusted count is 22,915,229, implying an overall completeness of coverage of about 90.7 percent in comparison to the final, unadjusted 1973 census count shown in Table 6. Table 8 shows the decomposition of the adjusted count into its main components (see Table A.2 for the unadjusted equivalents).

Analytical Estimates of Completeness. In addition to PES-based estimates of coverage, several analysts have used other techniques to estimate the true population on the census dates. Lopez (1968) and Arevalo (1968), among others, have made extensive evaluations of the 1951 and 1964 censuses. Using techniques based on stable and quasi-stable population theory, Lopez concluded that the population under 10 in 1964 was underenumerated by about 4 percent and that males aged 15-44 were underenumerated by some 6 percent. His final adjusted estimates of the population, in terms of totals and age distribution, is similar to that proposed by Arevalo, who used intercensal comparisons to assess the relative coverage of the 1938, 1951, and 1964 censuses. The latter assumed that the 1938 count was correct and used a 1951 population that does not include the Indian and tribal count nor the 1.7 percent adjustment for underenumeration that was included in the official 1951 figure (see Table 6). Table 9 summarizes Arevalo's results. According to them, the 1964 census achieved higher completeness of coverage than the 1951 census, and in both censuses females appear, overall, to have been more completely enumerated than males.

TABLE 8 Adjusted Results of the 1973 Census: Colombia

Type of Population	Count	Total
Departamentos		19,261,772
Private households	17,147,984	
Adjustment to private households	1,770,612	
Collective households	343,176	
Bogota		2,861,913
Private households	2,530,467	
Adjustment to private households	290,365	
Collective households	41,081	
National territories	375,000	375,000
Armed forces	53,111	53,111
Indian population in reservations (not in national territories)	363,433	363,433
Total		22,915,229

Source: DANE (1981).

For 1973, several analysts have proposed alternative estimates of census coverage based on some version of the components method in which estimates of fertility, mortality, and migration are used to project the 1964 population to 1973. Therefore, differences among the various estimates arise from differences in the 1964 population used as a base and differences in the estimates of fertility, mortality, and migration used. Table 10 presents both DANE's completeness estimate (1977c), based on the PES results, and some of the estimates based on analytical techniques.

In deriving completeness estimates by the components method, the estimates of net migration used are the crudest, due to the paucity of data on that subject. The

TABLE 9 Arevalo's Estimates of Completeness of Census Counts, 1951 and 1964: Colombia

		1951 Census			1964 Census		
Sex	Age	Raw Count (thousands)	Estimated Count[a] (thousands)	Completeness (percent)	Raw Count (thousands)	Estimated Count[a] (thousands)	Completeness (percent)
Both	All	11,229	11,910	94.3	17,485	18,090	96.7
	Under 10	3,436	3,801	90.4	5,886	6,188	95.1
Male	All	5,579	5,954	93.7	8,615	9,009	95.6
	Under 10	1,746	1,910	91.4	2,981	3,132	95.2
Female	All	5,649	5,959	94.8	8,870	9,081	97.7
	Under 10	1,691	1,893	89.3	2,906	3,056	95.1

[a]Arevalo's adjusted 1951-64 growth rate was used to calculate population estimates for the exact census date.

Source: Arevalo (1968).

TABLE 10 Estimates of the Total Population on October 24, 1973, and Corresponding Estimates of Census Coverage: Colombia

Source	1973 Estimated Population, Excluding Migration	1973 Estimated Population, Including Migration	Percent Completeness of 1973 Census Coverage[a]
A. Based on the post-enumeration survey[b]			
DANE (1977e)	--	22,552	92.2
B. Based on analytical techniques			
Bayona (1977a)			
High	24,044	23,444	88.7
Low	23,339	22,739	91.4
Departmento Nacional Planeacion (1977)	23,773	22,233	93.5
Pierret (1979)	22,603	22,303	93.2
Potter and Ordonez (1976)	23,201	22,901	90.8
U.S. Bureau of the Census (1979)	--	23,241	89.4

[a]The base population used to estimate census coverage is that in Table A.1: 20,785,235.
[b]Two other such estimates, Gonzalez (1976) and DANE (1977a), have been excluded because they incorporate an overadjusted household population. (Bogota's population was adjusted twice.)

Additional source: Ochoa and Pardo (1979:11).

generally accepted estimates of intercensal migration during the 1964-73 period are those of Arbalaez (1977), who estimated that Colombia had lost 556,683 inhabitants. Arbalaez considered this figure a minimum estimate of migration and suggested that the true amount might be closer to 600,000. Bayona, the Departamento Nacional de Planeacion (DNP) and the U.S. Bureau of the Census (USBC) used estimates of migration borrowed from Arbalaez's results. These estimates are: Bayona, 600,000; USBC, 556,683; and DNP, 540,000. Other authors (Pierret, 1979; Potter and Ordonez, 1976) used 300,000 as a conservative estimate.

For the 1964 base population, Bayona and the USBC used that estimated by Arevalo (18,090,000), DNP used 17,905,000, and Pierret used 17,805,000 (consistent with a 1.8 percent underenumeration in 1964). Potter and

Ordonez used a 1964 population adjusted by smoothing irregularities in the observed sex ratios, hence their 1973 completeness estimates are relative to the completeness of enumeration of the female population in 1964.

In general, the fertility and mortality estimates used by all the analysts seem reasonable, but Bayona's high and low population estimates illustrate how differences of approximately 5 years in the estimated expectation of life and of 0.3 children in the total fertility estimates on which they are based may lead to a difference of about 705,000 persons in the total estimated count.

If the 92.2 percent estimate of completeness yielded by the post-enumeration survey is accepted as a maximum, the DNP and Pierret estimates of total population seem somewhat low. Among the remaining estimates, it is not possible to select the most plausible without further analysis. They are presented at this stage to serve as a frame of reference and to highlight the fact that, even according to the lowest of them, the 1973 census coverage is no better than 94 percent.

1.2.2 Vital Registration

In 1938, Decree No. 92 instituted a compulsory vital registration procedure, which was never fully implemented. In its absence, incomplete parish registers served as the primary source of demographic information on the occurrence of vital events (primarily births and marriages). Since it is estimated that 95 percent of Colombia's population is Catholic, the proportion of vital events that go unrecorded solely due to religious composition is potentially small. The registration of deaths has not been left entirely to the church. Burial permits, which are required in all instances, may be granted by municipal authorities who report deaths to the statistical officers in their departamentos so that vital statistics may be compiled (DANE, 1964).

In 1968, the 1938 decree was amended by Decree No. 3167, which established a recording system designed to gradually implement an obligatory national civil registration system called Servicio Nacional de Inscripcion (SNI). Its aim is to assign a different identification number to every Colombian so that all records the government keeps on an individual may be easily identified. In its 1975-76 report to Congress, DANE (1976b) reported that the birth registration branch of the SNI system was already operating in several cities and that preliminary tests had proved it produced better results than the traditional baptismal register. In the 1978-79 report, DANE (1979) claimed that by 1978, SNI was operating in most of the country recording births, marriages, and adoptions, and issuing ID cards.

In general, however, the vital registration data produced by the system so far are too deficient to provide accurate estimates of fertility. In fact, since the institution of SNI in 1968, vital statistics have been published only sporadically. Hence, a complete series of registered deaths and baptisms is available only for the period ending in 1969. DANE (1977d) states that the administrative reform implied by the 1968 decree reduced the vital statistics collection zones from 561 to 81, a change that resulted in a severe deterioration of registration completeness during 1968-69. By 1970, death registration was judged to have regained its previous level of completeness, and the deaths registered between 1970 and 1975 have been published (DANE, 1977d).

Even before the 1968 reform, the statistics yielded by the vital registration system were known to be deficient. In the course of evaluating the 1951 and 1964 censuses, Arevalo (1968) estimated the number of births occurring during the intercensal period. Comparing his estimates with the recorded number of baptisms in the 1949-64 period, Arevalo produced the following estimates of registration completeness: 77.2 percent in 1949-54; 79.7 percent in 1954-59; and 81 percent in 1959-64, or an average estimate of around 79 percent. According to Lopez (1968), the number of births recorded during the 1951-64 period amounted to only 67 percent of the total. The U.S. Bureau of the Census (1979) estimated that birth registration completeness around 1964 and 1973 was 81 percent and 52 percent respectively. Arevalo's five-year estimates show that the baptismal register was showing a slight, though steady improvement with time. The deterioration brought about by the institution of civil registration is evident in the U.S. Bureau of the Census estimates.

As for death registration, Lopez (1968) estimated that deaths were underregistered by about 19 percent during the 1951-64 period, while the U.S. Bureau of the Census estimated underregistration at 23 percent in 1964 and 26 percent in 1973. Taken as a series, these three estimates imply a steady deterioration of the completeness of death registration in the country. However, because different estimation methods were used, one can argue that Lopez's estimate is not comparable with those obtained by the USBC. Fortunately, Potter and Ordonez (1976) have published a series of comparable estimates for 1951, 1964, and 1971: 87, 88, and 71.5 percent for males and 86.5, 88, and 73 percent for females, respectively. Besides showing a higher completeness level for the earlier period than the Lopez and USBC estimates, the Potter and Ordonez series implies that death registration completeness remained more or less constant between 1951 and 1964 and declined only after the administrative reform of 1968. It is not possible to resolve the discrepancies between these figures at this point. The subject is discussed in more detail in subsequent chapters.

1.2.3 Sample Surveys

During the past two decades Colombia has carried out at least five surveys at the national level to investigate the demographic characteristics of its population. The first, conducted in 1965, was a morbidity survey that incorporated some questions on fertility. The next two, in 1969 and 1976, had as their main objective the measurement of fertility. The fourth, in 1978, was a general demographic survey that explored the main aspects of both fertility and mortality. The fifth, also conducted in 1978, focused mainly on contraceptive behavior, although it incorporated several questions designed to investigate current fertility levels. The sections below describe each survey in some detail.

1.2.3.1 *The 1965 National Morbidity Survey (NMS)*

The NMS was carried out by the Colombian Ministry of Health (Ministerio de Salud Publica, 1968) in collaboration with the Asociacion Colombiana de Facultades de Medicina (ASCOFAME). Its main objective was to gather information on the frequency, severity, causes, and consequences of morbidity and on the availability and use of health services in the country. A few demographic factors were also explored, such as the number of children ever borne by women aged 15 to 54 and the number of births occurring between January 1, 1965, and the time of interview.

Although the NMS was the first survey at the national level to include questions on demographic topics, the data it gathered are fairly limited in nature; they allow, at most, the estimation of fertility. Also, the published tabulations do not permit the application of the consistency tests that a thorough analysis of the results would require. Therefore, the NMS data are not used in this report.

1.2.3.2 *The 1969 National Fertility Survey (NFS)*

The NFS was carried out between January 15 and September 3, 1969, by the Asociacion Colombiana de Facultades de Medicina (ASCOFAME) in collaboration with the Centro Latinoamericano de Demografia (CELADE). Its purpose was to measure at the national level "the knowledge, attitude and behavior of Colombian women with respect to fertility and family planning" (ASCOFAME, 1973a). The survey was divided into two parts: an urban and a rural survey. The urban survey was carried out at ASCOFAME's initiative, the rural survey as part of the Programa de Encuestas Comparativas de Fecundidad en America Latina (PECFAL project) coordinated by CELADE. The questionnaires used in both surveys were quite similar, although not identical. Both included, however, complete pregnancy and nuptiality histories. Questions on desired family size, contraceptive knowledge and practice, and socioeconomic characteristics of the couple were also included.

Effectively, two slightly different samples were drawn for the two surveys. In theory, the rural NFS was to have as its universe all women between the ages of 15 and 49 living in towns with less than 20,000 inhabitants (rural population). In practice, areas with a very low population density (less than 10 inhabitants per square kilometer), or those with poor communication systems, were eliminated from the sampled population. The final sample was drawn from 85 percent of the rural population living in an area covering approximately 25 percent of the country's total territory (a substantial portion of the Pacific region was left out). A detailed description of the sample design used in this survey is presented in Appendix B; a description of the urban sample is also included there. The method used in selecting the urban sample implies that the probability of selecting cities with 20,000 inhabitants or more is determined by the size of their adjacent rural populations. Since the spatial distributions of the rural and urban populations are different, the urban sample resulting from this selection process is not self-weighting at the national level nor, technically, is it representative of the total urban population of the country. At most, it can be considered representative only of 60 percent of all urban females aged 15 to 49, the 60 percent residing in the cities actually included in the sample: Bogota, Cali, Medellin, Bucamaranga, Cartagena, Cienaga, Carmen de Bolivar, Armenia, and Villavicencio. Moreover, since Bogota, which amounts to approximately 40 percent of the urban areas, is included in this set, the urban sample in fact says little about the rest of the urban sector.

Approximately 6,000 interviews were attempted during the survey (3,000 rural and 3,000 urban). Of these, 91 percent and 86.3 percent, respectively, were successfully completed.

Because of the relatively high level of nonresponse (due to losses or refusals), the rural sample lost its self-weighting quality. The urban sample also lost the self-weighting properties it had within the already restricted universe it represented. To reduce biases associated with this nonresponse, weighting factors based on the distribution of eligible females within the municipios in the sample were used in producing the final survey results (though not consistently). These weights do not, however, adjust for the nonrepresentativeness of the urban sample.

1.2.3.3 *The 1976 Colombian Fertility Survey (CFS)*

Part of the World Fertility Survey program, the CFS was carried out between May 10 and August 10, 1976, by the Corporacion Centro Regional de Poblacion (CCRP) and the Departamento Administrativo Nacional de Estadistica (DANE) in collaboration with the International Statistical Institute. Its main objectives were similar to those of the 1969 survey, but they included also the gathering of data that could be used to evaluate the country's vital statistics and to estimate infant and child mortality (DANE, 1978).

Two types of questionnaires were used in the CFS: a household schedule and an individual questionnaire. The household schedule, which could be answered by any adult household member, included questions on the age, sex, educational attainment, occupation, and marital status of each household member. In addition, for every woman aged 15 and over, questions were asked about children living at home, children living elsewhere, children dead, and the date (month and year), sex, and survival status of most recent birth.

The individual questionnaire was used to interview selected respondents among all females aged 15 to 49. The questionnaire included complete pregnancy and nuptiality histories as well as a detailed history of contraceptive use.

The sample used for the CFS is part of the multipurpose Master Sample designed by the Ministry of Health (Ministerio de Salud), using the 1973 census results as the sampling frame. Its sampling universe is defined as the noninstitutional civilian population of Colombia, excluding all inhabitants of the national territories. This population amounts to an estimated 95.1 percent of the country's total population (DANE, 1978). Since the Master Sample has formed the basis of all the remaining national sample surveys discussed in this section, it is described in some detail in Appendix B.

In theory, the design of the Master Sample and of each of its subsamples ensures equal probability of selection for every household. However, because of changes in the sampling frame between 1973 and 1976, when the CFS was conducted, the self-weighting character of the household sample was lost. Expansion factors estimated on the basis of field observations were used to adjust for these changes (DANE, 1978).

The subsample of females selected for individual interviews was, in contrast, a properly self-weighting sample, since a variable sampling fraction was used to select eligible women for interviews. The fractions chosen in each case were designed to restore an equal probability of selection for each eligible woman (DANE, 1978). A total of 9,999 households was covered by the CFS, resulting in 5,685 individual interviews. The completion rates were 97.9 for the household visits and 94.6 for the individual interviews.

It is noteworthy that the completion rates for both parts of the CFS are substantially higher than those achieved in the 1969 NFS, probably because CFS interviewers were instructed to return up to four times to the same household in order to complete an interview, whereas in 1969 the number of visits to the same household was limited to two. Also interesting is the fact that the main single cause of nonresponse in the CFS was temporary absence from the household.

1.2.3.4 *The 1978 National Household Survey (NHS)*

The NHS was carried out between June 12 and July 2, 1978, by the Departamento Administrativo Nacional de Estadistica (DANE) in collaboration with the Population Laboratories of the University of North Carolina (POPLAB). The purpose of the survey was to gather information that would permit the estimation of fertility, mortality, and migration levels.

The topics investigated by the survey included age, sex, relationship to the head of the household, and maternal orphanhood status of every household member; mother's presence in the household for all children under 15; marital status and widowhood of first spouse for all the population aged 15 and over; children living at home, children living elsewhere, children dead, date of most recent birth, place of residence of absent children; and age at first marriage for women 15 and over. Information was also gathered on the deaths occurring during the two years preceding the survey (from May, 1976 to June, 1978).

The survey was carried out on the same subsample of the Master Sample used for the 1976 CFS (see Appendix B). All households found in the segments constituting that subsample were interviewed. Due to changes in the population over time, the self-weighting character of the theoretical design of the sample did not hold. Adjustment factors estimated on the basis of new household listings were used to weight the final results and hence reduce possible biases.

The segments in the sample potentially included 11,138 dwellings. Of these, 841 were empty at the time of the survey and 442 were either nonexistent, had been destroyed, or were placed outside the sample segments proper. Thus, among the remaining 9,855 households that could have been interviewed, 9,448 interviews were actually completed, implying a completion rate of 95.9 percent.

The region with the lowest completion rate was Bogota (92.1 percent), while the largest number of empty dwellings was found in the Eastern region. It is important to note that the 1978 NHS was carried out on exactly the same sample of dwellings as that used for the 1976 CFS. Of course, due to migration and other population changes, both samples are not constituted by exactly the same households. However, since the same dwellings were visited on both occasions, overlap between the two is substantial.

1.2.3.5 *The 1978 Contraceptive Prevalence Survey (CPS)*

The CPS was conducted by the Corporacion Centro Regional de Poblacion (CCRP) and the Ministry of Health in collaboration with Westinghouse Health Systems (CCRP, 1979). The field work was carried out between October 23 and December 17, 1978, with an additional period during the second week of January 1979 "to complete some interviews that had not been possible due to temporary absence of women from their households during the first phase of the field work" (CCRP, 1979:11).

The main purpose of the survey was to study the knowledge and practice of contraception among the Colombian population. A secondary goal was to obtain information on the use of and access to maternal and child care programs in the country. The questionnaire included questions on children surviving, children dead, children ever born, date of most recent birth, and current pregnancy status. Questions on desired number of children, knowledge and use of different contraceptive methods, and use of several health facilities were also included. The marital status, age, educational attainment, and occupation of each woman interviewed was recorded.

The CPS was carried out on the twin sample of that used for the 1976 CFS, so their sample designs are very similar. Variations were introduced only at the final selection stage, when women to be interviewed were chosen among all the eligible ones in a segment. Women aged 15 to 49 were all eligible. A controlled selection procedure based on broad age groupings (15-25 and 26-49) was used in conjunction with sampling fractions that ensured equal probability of selection for each eligible woman to choose a total of 4,090 women for interview. The completion rates for the survey were 93.3 percent in urban areas and 91.4 percent in rural areas, or 92.7 percent overall.

1.3 SUMMARY

This chapter presents a brief overview of Colombia as a country and a detailed description of its main demographic data sources. In the following chapters, data from these sources are examined and used to estimate levels and trends in Colombian fertility and mortality during the past three decades (approximately 1951 to 1977).

2

ESTIMATION OF MORTALITY

2.1 INTRODUCTION

In less-developed countries, a large proportion of the total number of deaths occurs to infants and young children, and infant mortality is of special interest to health administrators. The mortality of the whole population--as indicated by the expectation of life at birth--depends as well on the incidence of deaths among those over five. This chapter deals with deaths in these two segments of life in turn, discussing first infant and child mortality, then adult mortality.

2.2 CHILD MORTALITY

Using vital registration data to estimate infant and child mortality has often proved disappointing. Consider, for example, the problems inherent in estimating the infant mortality rate. Errors in either its numerator (the number of registered deaths among children less than a year old) or its denominator (the number of registered births) lead to a biased estimate. Although it is generally assumed that the underregistration of infant deaths is far greater than that of births--thereby producing an underestimate of infant mortality--this assumption does not hold in all cases. In Colombia, where births have been said to suffer from as much as 33-percent underregistration in 1951-64 (Lopez, 1968:68), every possibility must be explored.

When estimates derived from vital registration cannot be trusted, the use of survey data becomes mandatory. The simplest type of data gathered via sample surveys are the number of births and infant deaths (deaths of children under age one) occurring during some period preceding the survey (one year is the usual interval). This type of data, essentially an analog of vital registration data, has generally proved to be as disappointing as the one it mimics. In most cases, the infant mortality estimates it yields are too low.

A second type of survey data has been by far the most successful in yielding acceptable estimates. This is data on the number of children ever born and the number of children surviving, classified by age of mother. Brass (1964) developed the first technique designed to derive life table estimates from the observed proportions of children dead. At present, several variations and extensions of his method are available.

A third type of survey data is information obtained from detailed fertility histories. These data are in some ways ideal for estimating infant mortality. Potentially they allow mortality to be estimated for selected subgroups, such as birth cohorts, children born to women of a given age, etc. However, they may be affected by the usual errors present in fertility histories, such as the displacement and omission of events, especially those events (early deaths) that are most relevant for estimating child mortality.

In Colombia, all three types of survey data have been gathered at various times. Therefore, it represents an ideal test case for comparing the performance of the main estimation methods available.

2.2.1 Estimates Derived from Fertility Histories

Two of the national surveys carried out during the past decade, the 1969 National Fertility Survey (NFS) and the 1976 Colombian Fertility Survey (CFS), have gathered fertility histories.

The estimation of child mortality from fertility history data is fairly straightforward when the necessary tabulations are available. It usually involves only the careful accounting required to match events and population at risk. For this reason, estimates derived in this way are classified as "direct," since they do not depend on constraining assumptions about mortality or fertility patterns and trends. An excellent account on how to derive child mortality estimates from fertility history information can be found in Somoza (1980). His detailed analysis of the 1976 CFS serves as a basis for the discussion presented in this section.

2.2.1.1 *Estimates from 1969 NFS Data*

Since the main goal of the NFS was to estimate fertility, use of its data to estimate mortality has not attracted much attention. From the published tabulations it is possible to make direct estimates of infant mortality, either by age of mother or by time period, for rural areas only. The equivalent data for urban areas are not available.

Table 11 displays two sets of $_1q_0$ estimates by time period obtained from the NFS data. The first is based on data for all women, that is, all the available data were used. However, as earlier and earlier dates are considered, the deaths reported are increasingly limited to deaths of children born to younger women (only women aged 15 to 49 in 1969 were interviewed). Hence, $_1q_0$ estimates for earlier periods are based only on the experience of children born to younger women since, for example, the oldest women in the 1969 sample were 30-34 in 1954. To make the infant mortality estimates strictly comparable, a second set of estimates was generated using only data for women under 35 at the time of the child's birth.

From 1954 on, these estimates show a declining trend. The value for 1949-53, however, seems too low, implying an increase in infant mortality between the early and

TABLE 11 Direct Estimates of Infant Mortality for Different Time Periods, Rural Areas, from the 1969 NFS: Colombia

	Using Data for All Women		Using Data for Women Under 35	
Period	$_1q_0$	Number of Births	$_1q_0$	Number of Births
1949-53	.1000	1,436	.1000	1,436
1954-58	.1096	2,161	.1086	2,015
1959-63	.0735	2,750	.0708	2,331
1964-68	.0675	2,644	.0642	2,142

Source: ASCOFAME (1973b:21, 25).

late 1950s. Not only is such an increase implausible, but it is also evident from the data on reported births that older cohorts show a marked tendency to underreport their fertility. For example, the cohort born in 1919-23 reported a cumulated fertility of only 6.18 children by age 40, while the cohort born in 1929-33 reported 7.07 children on average by the same age. Since the $_{1}q_{0}$ estimate for 1949-53 depends mainly on data for older cohorts, its low value is probably due to failure to report dead children.

The estimates in Table 11 were obtained directly from the published tabulations of the 1969 NFS (ASCOFAME, 1973b). This source indicates that no weights were used in producing the estimates. Recall, however, that the rural sample of the NFS was designed to be self-weighting. Hence the weights calculated to account for the level of nonresponse encountered in the field are very close to one. Therefore, their use in tabulating the data is not expected to alter the final results substantially. Consequently, the differences between the estimates presented in Table 11 and another set calculated from the same data are surprising. The other estimates, calculated by Bayona (1975) while exploring the relationship between infant mortality rates and other demographic and socio-economic variables, are shown in Table 12. Unfortunately, the time periods used by Bayona do not coincide exactly with those originally used in tabulating the data. Nevertheless, it is evident that Bayona's estimates are not consistent with those derived from the published tabulations. The differences between the two sets are especially disturbing since they are unlikely to be

TABLE 12 Rural Infant Mortality Rates Estimated by Bayona from the 1969 NFS: Colombia

Period	$_{1}q_{0}$
1940-49	.123
1950-59	.116
1960-68	.079

Source: Bayona (1975:6).

accounted for by the use of the published weights (ASCOFAME, 1973a). Lack of access to the original survey results prevents us from establishing the cause of these discrepancies. We can only add that, due to its strictly decreasing trend with time, Bayona's set seems more plausible.

2.2.1.2 *Estimates from 1976 CFS Data*

Somoza's analysis of the 1976 CFS data (Somoza, 1980) reveals much about the child mortality estimates derived directly from the CFS fertility histories. In particular, it confirms that the overall pattern of mortality implied by the estimates is plausible (it is similar to that observed in other populations with acceptable data); that infant mortality increases as the age of the mother at the time of the survey increases; that the children of women with little or no education experience higher infant mortality than do children of more educated women; that the variation of infant mortality with respect to mother's age at the birth of the child is similar to that observed in populations with good data (children born to young mothers--under 20--and those born to older ones--over 30--have a higher probability of dying before their first birthday); that male infant mortality is higher than female infant mortality; and that mortality among children whose mothers live in rural areas is higher than among those born to women living in urban areas.

Given the detailed information contained in fertility histories, the data lend themselves to constructing a fairly good picture of the evolution of infant and child mortality during the 30 or 35 years preceding the survey. Somoza's estimates of the mortality experienced by different birth cohorts are shown in Table 13.

Because of essentially the same time reference, the $_1q_0$ value for the 1960-67 cohort according to the 1976 CFS (.0786) can be compared to that for the 1959-68 period yielded by the 1969 Rural NFS data (.0705). If both estimates were correct, this comparison would imply that urban areas in 1960-67 had a much higher infant mortality than their rural counterparts. Although this is possible, the differential usually runs in the other direction, as in the recent experience of less-developed countries. In fact, as shown in Table 14, the CFS data indicate that infant mortality is higher in rural (.0920) than in urban areas (.0722). Unfortunately, the CFS

TABLE 13 Probabilities of Dying Between Birth and Exact Age x ($_xq_0$) for Different Birth Cohorts from the 1976 CFS: Colombia

	Birth Cohort		
Age x (years)	1941-59	1960-67	1968-76
1/12	.0491	.0399	.0323
3/12	.0631	.0496	.0415
6/12	.0814	.0621	.0515
1	.1074	.0786	.0668
2	.1372	.0982	.0843
5	.1609	.1190	.1037
10	.1726	.1277	.1114
Total births	3,425	4,937	6,053
Deaths under age 10	591	627	560

Source: Somoza (1980:16-17).

estimates are based on data for all women and therefore represent the mixed experience of the 1941-76 period. A CFS estimate specifically for the 1959-68 period and for rural areas is not available, making a more appropriate comparison impossible. However, the evidence available does indicate that the published results of the Rural NFS are not consistent with the CFS results. There is much closer agreement between Somoza's and Bayona's estimates for 1960-68: .0786 and .079, respectively. However, since Bayona's estimate refers only to rural areas, its near coincidence with the overall average is also suspect.

2.2.1.3 *Selecting Appropriate Models of Colombian Mortality*

Proper exploitation of data from fertility histories can yield a wealth of information on child mortality. However, one must bear in mind that the women considered become fewer and younger the further one goes into the past. Therefore, given the relationship existing between child mortality and mother's age at the time of birth, estimates for earlier periods may be biased. The direction of this bias, however, is difficult to establish without knowing what the proportion of children born to

TABLE 14 Estimates of Childhood Mortality ($_xq_0$) by Rural/Urban Setting, Individual Interviews from the 1976 CFS: Colombia

Age x	Urban	Rural
1	.0722	.0920
2	.0918	.1160
5	.1086	.1434
10	.1168	.1553

Source: Somoza (1980:34).

women under 25 is during a particular period. If this proportion is relatively small, child mortality estimates based on the experience of women under 33 (as would be those for the 1941-59 birth cohort) would be under-estimates, since they would not incorporate the experience of children born to older women.

Bearing this caveat in mind, we use the birth cohort estimates obtained from the CFS to establish which of the four patterns of mortality embodied by the Coale-Demeny model life tables (Coale and Demeny, 1966) is the best model for child mortality in Colombia. Knowledge of the most representative pattern is crucial in the application of indirect estimation methods, as is demonstrated later. (See "model life tables" in glossary.)

Table 15 presents a comparison of the child mortality estimates obtained from all reported births and deaths under age 10 in the CFS and the four model mortality patterns. Each sex and both sexes combined are presented separately. In every case, the level of the model tables chosen as a basis for comparison is consistent with the observed l(1). The l(2), l(5), and l(10) values corresponding to this level were compared to the observed values by calculating the deviation of their ratio (fitted over observed) from unity. The closer these deviations are to zero, the better the fit. As Table 15 shows, the worst fits are obtained when using the "East" and "South" models, in that order. The "North" and "West" models are better, although neither is perfect. The "West" model yields a closer fit than "North" only for the l(10) of males and both sexes. In all cases, the

TABLE 15 Comparison of the Childhood Mortality Pattern from the 1976 CFS and the Patterns Contained in Model Life Tables: Colombia

		Model Life Table Regional Family							
	Observed	North		South		East		West	
Age x	$l_0(x)$	$l_N(x)$	$100\left(\frac{l_N(x)}{l_0(x)}-1\right)$	$l_S(x)$	$100\left(\frac{l_S(x)}{l_0(x)}-1\right)$	$l_E(x)$	$100\left(\frac{l_E(x)}{l_0(x)}-1\right)$	$l_W(x)$	$100\left(\frac{l_W(x)}{l_0(x)}-1\right)$
Both Sexes									
1	91,900	91,900	0.00	91,900	0.00	91,900	0.00	91,900	0.00
2	89,800	89,989	0.21	90,440	0.71	90,809	1.12	90,270	0.52
5	87,700	87,086	-0.70	89,120	1.62	89,782	2.37	88,624	1.05
10	86,700	85,064	-1.89	88,563	2.15	89,070	2.73	87,578	1.01
Male									
1	91,270	91,270	0.00	91,270	0.00	91,270	0.00	91,270	0.00
2	89,450	89,311	-0.16	89,716	0.30	90,181	0.82	89,647	0.22
5	87,320	86,362	-1.10	88,313	1.14	89,168	2.12	88,017	0.80
10	86,240	84,268	-2.29	87,689	1.68	88,437	2.55	86,965	0.84
Female									
1	92,640	92,640	0.00	92,640	0.00	92,640	0.00	92,640	0.00
2	90,170	90,806	0.71	91,294	1.25	91,564	1.55	91,027	0.95
5	88,030	87,983	-0.05	90,081	2.33	90,532	2.84	89,374	1.53
10	87,150	86,058	-1.25	89,606	2.82	89,846	3.09	88,340	1.37

Note: $l_0(x)$ is the proportion surviving to age x, based on observed data. $l_N(x)$, $l_S(x)$, $l_E(x)$, and $l_W(x)$ are the proportions surviving to age x in the North, South, East, and West families of regional model life tables, with the same l(1) as observed.

Source: Somoza (1980:11, 30).

fit of "North" to l(10) is off by at least 1 percent. For all l(x) values under age 10, "North" yields a better fit than "West" for both sexes combined and for females. The fit of "West" to male mortality under age 10 is only marginally better than that obtained by using "North."

Having identified the models that best fit the overall estimates, we can check their performance in fitting more detailed information. Table 16 shows the results obtained when fitting the l(2), l(5), and l(10) estimated values for each of the three birth cohorts considered and for each sex. Again, the level fitted in each case is determined by the observed l(1). Fits to the estimated l(10) values are generally poorer, implying that child and adult mortality probably are not well represented by the same model. For this reason, we now focus mainly on mortality up to age 5.

All the panels of Table 16 reveal more or less the same story: the mortality pattern up to age 5 in Colombia has changed from a "West" to a "North" pattern during the past four decades. The "North" model fits extremely well for both sexes of the 1968-76 cohort. However, consideration of each sex separately reveals that the close fit to both sexes combined is obtained by balancing less perfect ones deviating in different directions. In general, female mortality experience up to age 5 has tended to be better represented by "North" than by "West" (if only marginally for the 1941-59 cohort). In contrast, male mortality experience up to age 5 becomes unequivocally "North" only for the 1968-76 cohort.

In assessing these results one must remember that the definition and experience of the cohorts considered are affected by both truncation and censoring. Since only women aged 15-49 in 1976 were interviewed, truncation has its greatest effect on the 1941-59 birth cohort, which is made up mainly of children with fairly young mothers (under 33). Censoring, on the other hand, affects mainly the 1968-76 cohort, whose complete survival experience to age 10 has not yet been observed. Life table estimates are specifically designed to deal with censoring, but no safeguard has been taken to reduce the effects of truncation. Therefore, although a change of pattern from "West" to "North" seems plausible (the reduction of infant mortality brought about by better health services may lead to higher mortality between ages 1 and 4 relative to the reduced ${}_1q_0$), it may be that this change is just a reflection of the different age distributions of mothers considered in each case. This possibility does not, however, invalidate the main finding: The pattern prevalent in recent periods is fairly similar to that embodied by the "North" model life tables.

2.2.2 Estimation of Child Mortality Based on the Proportion of Children Dead Among Those Ever Born

In general, indirect techniques for estimating child mortality from data on the number of children ever born and the number surviving have proven fairly successful. In Colombia, the data needed to apply these techniques have been collected at several points in time and by slightly different data gathering mechanisms (a census in 1973 and sample surveys in all other instances); in fact, almost all the surveys described in Chapter 1 have gathered such information. Unfortunately, the required data have been published or are calculable for only a few sources: the 1969 NFS, the 1973 census, the 1976 CFS, and the 1978 NHS.

2.2.2.1 *Estimates Based on 1969 NFS Data*

The 1969 NFS is a source for which the appropriate tabulations have not been published. However, the main report on the survey (ASCOFAME, 1973a) contains a tabulation of women classified by five-year age groups and by number of children ever born and another tabulation of women by five-year age groups and their number of children surviving. Unfortunately, at least two of the classification criteria used (women with 7 or 8 children, and women with 9 or more) lead to uncertainties about the exact number of children born or surviving. In spite of this problem, an attempt was made to estimate child mortality by using approximations to the true data derived from the available tabulations. The estimated raw data are presented in Table 17 and the child mortality estimates obtained from them by using Trussell's method (United Nations, 1982) appear in Table 18.

The set of estimates presented in Table 18 is an expanded version of that usually obtained by applying indirect estimation methods. Ordinarily, the proportion of children surviving among women in a specified age group at the time of the survey is used to derive an estimate of child survival from birth to an age that

TABLE 16 Comparison of Childhood Mortality Patterns by Birth Cohorts and by Sex from the CFS with Model Life Tables: Colombia

	Observed	Model Life Table Regional Family			
		North		West	
Age x	$l_0(x)$	$l_N(x)$	$100(l_N(x)/l_0(x)-1)$	$l_W(x)$	$100(l_W(x)/l_0(x)-1)$
Both Sexes					
1941-59 Cohort					
1	89,260	89,260	0.00	89,260	0.00
2	86,280	86,353	0.08	86,788	0.59
5	83,910	82,215	-2.02	84,434	0.62
10	82,740	79,408	-4.03	83,023	0.34
1960-67 Cohort					
1	92,140	92,140	0.00	92,140	0.00
2	90,180	90,315	0.15	90,588	0.45
5	88,100	87,516	-0.66	89,003	1.02
10	87,230	85,565	-1.91	87,990	0.87
1968-76 Cohort					
1	93,320	93,320	0.00	93,320	0.00
2	91,570	91,904	0.36	92,124	0.61
5	89,630	89,616	-0.02	90,852	1.36
10	88,860	88,017	-0.95	90,010	1.29

Males					
1941-59 Cohort					
1	88,050	88,050	0.00	88,050	0.00
2	85,630	84,948	-0.80	85,478	-0.18
5	82,870	80,593	-2.75	83,066	0.24
10	81,630	77,652	-4.87	81,636	0.07
1960-67 Cohort					
1	91,910	91,910	0.00	91,910	0.00
2	90,240	90,180	-0.07	90,478	0.26
5	88,410	87,478	-1.05	88,994	0.66
10	87,390	85,558	-2.10	88,022	0.72
1968-78 Cohort					
1	92,600	92,600	0.00	92,600	0.00
2	91,050	91,102	0.06	91,372	0.35
5	89,150	88,673	-0.53	90,047	1.01
10	88,410	86,942	-1.66	89,162	0.85
Females					
1941-59 Cohort					
1	90,550	90,550	0.00	90,550	0.00
2	86,980	87,884	1.04	88,213	1.42
5	85,040	84,006	-1.22	85,941	1.06
10	83,950	81,379	-3.06	84,570	0.74
1960-67 Cohort					
1	92,380	92,380	0.00	92,380	0.00
2	90,120	90,450	0.37	90,680	0.62
5	87,770	87,499	-0.31	88,950	1.34
10	87,040	85,485	-1.79	87,874	0.96
1968-76 Cohort					
1	94,070	94,070	0.00	94,070	0.00
2	92,140	92,738	0.65	92,917	0.84
5	90,150	90,607	0.51	91,690	1.71
10	89,350	89,151	-0.22	90,894	1.73

TABLE 17 Estimated Numbers of Children Ever Born and Surviving, Derived from the 1969 NFS: Colombia

Age Group	Number of Women	Children Ever Born	Children Surviving
Total Country			
15-19	1,321	271	251
20-24	1,106	1,407	1,307
25-29	845	2,415	2,144
30-34	746	3,320	2,938
Urban Areas			
15-19	736	124	112
20-24	633	690	644
25-29	417	1,030	924
30-34	331	1,188	1,083
Rural Areas			
15-19	585	147	139
20-24	473	717	663
25-29	428	1,385	1,220
30-34	415	2,132	1,855

varies with the age of the mother. Data for age group 20-24 yields an estimate of ${}_2q_0$; for 25-29, ${}_3q_0$; for 30-34, ${}_5q_0$; for 35-39, ${}_{10}q_0$; for 40-44, ${}_{15}q_0$; and for 45-49, ${}_{20}q_0$. In Table 18, however, estimates of four mortality parameters (${}_1q_0$, ${}_2q_0$, ${}_3q_0$, and ${}_5q_0$) are shown for each age group of mother. At most, one of these parameters was estimated from the data; this is called a "true" estimate. The remaining ones were derived from the "true" estimate on the basis of the mortality level it implied within the model life table family used (either "North" or "West" on the basis of the findings presented in Section 2.2.1.3.). This mortality level is also presented in the table. Note, however, that a high mortality level in a model life table family indicates low actual mortality. In general, the model used has a relatively minor effect on the "true" estimates yielded by the method (${}_2q_0$ for age group 20-24, ${}_3q_0$ for age group 25-29, etc.). However, its effect on the "translated" estimates, that is, on those derived from the "true" ones solely on the

TABLE 18 Indirect Estimates of Child Mortality from the 1969 NFS: Colombia

Age Group	Reference Date	Mortality Level	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$
Part A. Total Country						
North Model						
20-24	1967.1	18.3	.0597	.0715	.0797	.0913
25-29	1965.4	16.4	.0784	.0966	.1084	.1245
30-34	1963.4	16.9	.0732	.0896	.1004	.1153
West Model						
20-24	1967.0	18.3	.0638	.0748	.0801	.0867
25-29	1965.2	16.3	.0868	.1050	.1133	.1229
30-34	1963.1	16.6	.0833	.1003	.1081	.1173
Part B. Urban Areas						
North Model						
20-24	1967.1	18.7	.0566	.0675	.0750	.0858
25-29	1965.4	17.0	.0727	.0889	.0996	.1143
30-34	1963.4	18.5	.0581	.0695	.0774	.0886
West Model						
20-24	1967.1	18.6	.0604	.0705	.0754	.0815
25-29	1965.3	16.9	.0804	.0965	.1040	.1129
30-34	1963.1	18.1	.0659	.0776	.0832	.0901
Part C. Rural Areas						
North Model						
20-24	1967.1	18.0	.0624	.0751	.0838	.0960
25-29	1965.3	16.1	.0818	.1012	.1136	.1306
30-34	1963.2	16.2	.0807	.0997	.1120	.1286
West Model						
20-24	1967.0	18.1	.0667	.0786	.0843	.0913
25-29	1965.1	16.0	.0909	.1104	.1191	.1293
30-34	1962.9	15.9	.0921	.1120	.1210	.1313

basis of an equivalent level within a given model, is substantial.

When mortality has been declining, the estimated mortality levels associated with different age groups of mother refer to periods progressively in the past. Table 18 includes estimated reference dates for each mortality estimate, which are rough indicators of a time trend when the mortality decline occurred in an approximately linear fashion. (For a detailed explanation on how these reference dates are estimated, see United Nations, 1982).

As expected, the results in Table 18 show that urban mortality is lower than that in rural areas. However, mortality does not appear to be consistently declining; a rise in level between the estimates associated with age groups 25-29 and 30-34 is apparent in almost all cases. This outcome is hardly surprising in light of the approximate nature of the data. In particular, older women are more likely to belong to the cells with an ambiguous or open-ended classification of the number of children (such as "7 or 8" or "9 and more"), so the uncertainty about their number of children ever born and surviving is greater. However, the estimates derived from data referring to younger women (20-24) tend to be associated with relatively high model mortality levels (which indicate lower child mortality), a relationship that would not be expected in view of the known inverse relationship between child mortality and age of mother up to age 30 or so. Furthermore, since the data for women 20-24 are relatively exact (only two of them belonged to the ambiguous categories), the unusually low proportion of children dead cannot be attributed to uncertainties in the data.

One must also note that the data have not been weighted. Therefore, in strict terms, the estimates for the total country (derived from the mere addition of the urban and rural information) are not valid since they incorporate an overweighted rural component. For this reason, one would expect them to be, if anything, somewhat high; however, comparisons with other estimates (presented later) show that this is not the case.

2.2.2.2 *Estimates Based on 1973 Census Data*

Table 19 shows the results of applying Trussell's method to data from the advance sample of the 1973 census. The mortality level estimates show a fairly smooth, declining trend, starting at age group 25-29.

TABLE 19 Indirect Estimates of Child Mortality from the 1973 Census Sample: Colombia

Age Group	Reference Date	Mortality Level	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$
North Model						
20-24	1971.7	17.3	.0698	.0850	.0951	.1092
25-29	1970.0	17.5	.0675	.0819	.0916	.1051
30-34	1967.9	17.3	.0698	.0850	.0951	.1092
35-39	1965.6	17.0	.0724	.0885	.0991	.1138
40-44	1963.1	16.6	.0766	.0941	.1056	.1212
45-49	1960.2	16.4	.0786	.0968	.1086	.1248
West Model						
20-24	1971.6	17.4	.0743	.0885	.0951	.1032
25-29	1969.8	17.4	.0746	.0889	.0956	.1037
30-34	1967.7	16.9	.0793	.0951	.1024	.1111
35-39	1965.2	16.6	.0834	.1004	.1083	.1175
40-44	1962.6	16.1	.0896	.1087	.1173	.1273
45-49	1959.6	15.8	.0931	.1133	.1224	.1329

Note: Since these data have been analyzed by others using either Trussell's method or related ones (Potter and Ordonez, 1976; Behm and Rueda, 1977), it should be noted that differences between the estimates presented here and those obtained by other authors arise mainly for two reasons: (1) Trussell's method has undergone slight modifications, so that the version used here may not be exactly the same as that used before; and (2) the number of women used as denominator here has been estimated by using El-Badry's technique to determine the true proportion of women with not-stated parity (see Table C-1 and Figure C-1 in Appendix C).

Another set of indirect estimates of child mortality based on data from the 1973 census are Palloni's estimates of $_1q_0$ (Palloni, 1979) shown in Table 20. Unfortunately, Palloni produced these estimates for only three of the four Coale-Demeny model patterns of mortality; "North" was left out. The reason given for its exclusion was: "Model North was discarded because it departs substantially from Latin American mortality experience" (Palloni, 1979:462). As the discussion in Section 2.2.1.3 has shown, this assertion is incorrect. However, the lack of reliable "direct" estimates of child mortality in most of Latin America often leads to assertions such as this, which only reflect our general uncertainty about prevalent mortality patterns. The estimates shown in Table 20, based on the "West" model, are very similar to those produced by Trussell's method also based on the "West" model, although Palloni's reference dates are generally

TABLE 20 Palloni's Estimates of Infant Mortality from 1973 Census Data, Using the West Model: Colombia

Age Group of Mother	Indirect $_1q_0$ Estimates	Reference Date
20-24	.0746	1970.3
25-29	.0751	1967.9
30-34	.0791	1965.2
35-39	.0827	1962.0
40-44	.0886	1958.4

Source: Palloni (1979:468).

placed further in the past than the equivalent Trussell estimates.

2.2.2.3 *Estimates Based on 1976 CFS Data*

The third source of information on children ever born and surviving is the 1976 CFS, which also served as the basis for the "direct" estimates presented in Tables 13 and 14. Part A of Table 21 summarizes the results obtained when Trussell's method is applied to the same data. In this case, both mortality models "North" and "West," yield an estimated mortality level for age group 20-24 that is distinctly out of line with the rest. This pattern is often observed in child mortality estimates derived via Brass-type methods from the observed proportions of children dead among women of different age groups, and it is probably due to the fact that child mortality levels are not independent of age of mother. In this report we use the term age-of-mother effect to refer to the influence that age of mother at the time of the birth exerts on the probability of survival of the child.

Biases due to this effect become even more evident when the data considered are classified according to nonstandard age groups (18-22, 23-27, etc.), and a modified Trussell procedure is used to estimate child mortality (Hill et al., 1982). The results obtained using this alternate approach are shown in Part B of

TABLE 21 Indirect Estimates of Child Mortality from Individual Survey of the 1976 CFS: Colombia

Age Group	Reference Date	Mortality Level	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$
Part A. Standard Age Groups						
North Model						
20-24	1974.3	17.0	.0723	.0883	.0989	.1135
25-29	1972.5	17.6	.0665	.0805	.0900	.1032
30-34	1970.4	17.8	.0647	.0782	.0874	.1002
35-39	1968.1	16.7	.0750	.0919	.1031	.1184
40-44	1965.5	16.6	.0768	.0944	.1059	.1216
45-49	1962.6	16.1	.0811	.1003	.1126	.1294
West Model						
20-24	1974.2	17.1	.0771	.0922	.0992	.1076
25-29	1972.4	17.5	.0736	.0875	.0941	.1021
30-34	1970.1	17.4	.0736	.0876	.0942	.1022
35-39	1967.7	16.3	.0865	.1046	.1128	.1224
40-44	1965.0	16.0	.0899	.1091	.1177	.1278
45-49	1962.1	15.5	.0962	.1174	.1269	.1378
Part B. Nonstandard Age Groups						
North Model						
18-22	1974.4	16.2	.0809	.1000	.1123	.1290
23-27	1973.1	18.2	.0607	.0729	.0813	.0932
28-32	1971.5	17.6	.0670	.0813	.0909	.1042
33-37	1969.9	16.5	.0770	.0946	.1062	.1219
West Model						
18-22	1974.4	16.4	.0858	.1037	.1118	.1213
23-27	1973.0	18.1	.0665	.0783	.0840	.0910
28-32	1971.3	17.3	.0751	.0896	.0964	.1045
33-37	1969.7	16.2	.0881	.1067	.1151	.1250

Table 21. According to the nonstandard classification of the data using the "North" model, the estimate derived from age group 18-22 is equivalent to a mortality level a full two levels lower than that associated with age group 23-27; for the "West" model the difference in levels is slightly less than two. Apparently the nonstandard age classification is more successful than the standard one in discriminating mothers whose children have higher-than-

average risks of dying. It also seems to have isolated in age group 23-27 those women whose children have an above-average probability of surviving through the first few years of life. Originally, the use of nonstandard age groups was intended to reduce the effects of age heaping on child mortality estimates. In this case, however, the effects of age heaping seem to be minimal when compared with the biases caused by the age-of-mother effect.

Recall that the CFS included two separate questionnaires: a household section and the individual interviews. The latter are usually considered the CFS proper. However, information on children ever born and surviving was also gathered at the household level and Table 22 shows the estimates obtained using these data. Since the household data refer both to women who were later interviewed individually and to other women not selected for individual interviews, one would expect the estimates it yields to be fairly similar to those obtained from the the individual CFS, as is in fact the case. If anything, the household estimates of $_xq_0$ tend to be slightly higher than those derived from individual interviews.

TABLE 22 Indirect Estimates of Child Mortality from Household Survey of the 1976 CFS: Colombia

Age Group	Reference Date	Mortality Level	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$
North Model						
20-24	1974.3	16.9	.0731	.0893	.1001	.1149
25-29	1972.5	17.5	.0676	.0821	.0918	.1053
30-34	1970.4	17.6	.0667	.0808	.0903	.1036
35-39	1968.0	16.7	.0755	.0926	.1038	.1192
40-44	1965.4	16.3	.0794	.0979	.1099	.1262
45-49	1962.5	16.2	.0801	.0989	.1110	.1275
West Model						
20-24	1974.2	17.1	.0779	.0931	.1003	.1088
25-29	1972.4	17.3	.0749	.0893	.0960	.1042
30-34	1970.1	17.2	.0759	.0905	.0974	.1057
35-39	1967.6	16.3	.0871	.1054	.1137	.1234
40-44	1964.9	15.8	.0930	.1132	.1223	.1327
45-49	1961.9	15.6	.0950	.1158	.1251	.1358

2.2.2.4 *Estimates Derived from the 1978 NHS*

The most recent information available on children ever born and children surviving is that gathered by the 1978 NHS. Part A of Table 23 shows the results of applying Trussell's method to these data using standard age groups. They confirm the findings of the CFS regarding the inverse relationship between child mortality and age

TABLE 23 Indirect Estimates of Child Mortality from the 1978 NHS: Colombia

Age Group	Reference Date	Mortality Level	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$
Part A. Standard Age Groups						
North Model						
20-24	1976.4	17.6	.0661	.0800	.0894	.1026
25-29	1974.6	18.6	.0567	.0676	.0752	.0861
30-34	1972.5	18.0	.0626	.0754	.0842	.0965
35-39	1970.0	17.0	.0721	.0881	.0987	.1133
40-44	1967.3	16.2	.0808	.0999	.1122	.1289
45-49	1964.4	16.3	.0790	.0974	.1093	.1256
West Model						
20-24	1976.4	17.8	.0702	.0831	.0893	.0968
25-29	1974.5	18.4	.0627	.0734	.0786	.0850
30-34	1972.5	17.7	.0712	.0845	.0908	.0984
35-39	1969.6	16.6	.0832	.1003	.1081	.1173
40-44	1966.8	15.6	.0949	.1156	.1249	.1357
45-49	1963.9	15.7	.0937	.1141	.1233	.1339
Part B. Nonstandard Age Groups						
North Model						
18-22	1976.7	18.0	.0624	.0751	.0838	.0960
23-27	1975.3	18.1	.0617	.0742	.0827	.0948
28-32	1973.6	18.0	.0624	.0751	.0838	.0960
33-37	1971.7	17.2	.0702	.0855	.0957	.1098
West Model						
18-22	1976.7	18.2	.0656	.0771	.0827	.0896
23-27	1975.2	18.0	.0672	.0793	.0850	.0921
28-32	1973.4	17.8	.0699	.0828	.0889	.0964
33-37	1971.5	16.8	.0805	.0966	.1040	.1129

of mother (up to age 30): regardless of the model used, the model mortality level associated with age group 20-24 is lower (implying higher child mortality) than that associated with age group 25-29. Furthermore, the mortality level associated with the NHS estimate for the 25-29 age group (18.6) is remarkably high when compared with the 1976 CFS estimate of 17.5 for the same age group. In addition, there are relatively big differences in the NHS estimates between the levels associated with age groups 25-29 (18.6), 30-34 (18.0), and 35-39 (17.0), a feature not seen in any of the previous sets of estimates for standard age groups.

Part B of Table 23 shows the NHS child mortality estimates classified according to nonstandard age groups. They contrast sharply with those obtained from the CFS data (Part B of Table 21), which had greater differences among themselves than did those derived from the same data classified by standard age groups. In the case of the 1978 NHS, the use of nonstandard age groups reduces the differences in levels relative to those observed between the estimates derived from standard groups. This means that the NHS data lend little if any support to the suggestion that mortality is higher among children of young mothers. This contradictory finding suggests that either the relationship between child mortality and age of mother revealed by the 1976 CFS data, and confirmed to a certain extent by the 1973 census (see the "North" estimates in Table 26), is spurious; that age reporting errors are somewhat more prevalent in the NHS survey; or that there is some interaction between a time trend of mortality decline and age of mother.

Consistency of age reporting in the NHS can be assessed by comparing the results obtained from data classified according to reported age with those derived from an age classification based on the reported date of birth. The following two examples illustrate the differences observed between these data sets: (1) The proportion of children dead among the offspring of women 15-19, according to the reported-age classification, is just 79 percent of the equivalent proportion for women classified as being 15-19 according to date-of-birth reports; (2) the proportion of children dead for women 20-24, according to the reported-age classification, is 6 percent greater than the equivalent proportion among women 20-24, according to the date-of-birth classification. Such discrepancies are likely causes of the fairly flat trend displayed by the mortality levels associated with nonstandard age groups.

Hence, at least for younger ages, NHS child mortality estimates are somewhat suspect, due apparently to the influence of age misreporting.

The data on children ever born and surviving in the NHS were gathered for each sex separately, and the resulting mortality estimates by sex are presented in Table 24. These results are interesting because they show that, although in most cases the $_{x}q_{0}$ value for males is greater than the corresponding one for females, the male mortality level is also usually greater than the one for females, implying therefore that the male-female differentials embodied by the model tables overstate the differentials prevalent among Colombian children. Similar differences are apparent in $_{x}q_{0}$ estimates for the 1968-76 cohort derived from the CFS fertility histories (see Table 25), so they cannot be ascribed to errors particular to the NHS data.

2.2.3 Estimation of Infant Mortality Based on Registration Data

Table 26 displays estimates of infant mortality for the cohorts born during the periods 1951-68 and 1973-74. These estimates are obtained directly from the numbers of births and deaths registered during the 1951-69 and 1973-75 periods. Registration data are not available for 1970-72. The separation factors used in estimating infant mortality have been calculated directly from the data. (In this case a separation factor estimates the fraction of deaths under one year of age registered in calendar year z which are to births occurring in the preceding year z-1.) They remain very consistent during the 1951-69 period (the only one for which the appropriate data are available), fluctuating around an average value of 0.300 for males, 0.330 for females, and 0.315 for both sexes combined.

2.2.4 Comparison and Assessment of Results

Most of the estimates of child mortality presented in previous sections have been accompanied by the reference date or period to which they apply. In some cases, the reference period encompasses a fairly long time span, thus curtailing the possibilities of detailed comparisons. However, single-year estimates can be constructed by

TABLE 24 Indirect Estimates of Child Mortality by Sex from the 1978 NHS, Standard Age Groups: Colombia

Age Group	Reference Date	Mortality Level	$_{1}q_{0}$	$_{2}q_{0}$	$_{3}q_{0}$	$_{5}q_{0}$
Part A. Females						
<u>North Model</u>						
20-24	1976.4	17.3	.0634	.0781	.0878	.1014
25-29	1974.7	18.2	.0547	.0665	.0744	.0856
30-34	1972.5	18.3	.0543	.0659	.0737	.0848
35-39	1970.1	17.0	.0657	.0812	.0914	.1056
40-44	1967.3	15.9	.0762	.0955	.1079	.1250
45-49	1964.4	15.9	.0764	.0958	.1083	.1254
<u>West Model</u>						
20-24	1976.4	17.3	.0671	.0811	.0877	.0957
25-29	1974.5	18.0	.0602	.0720	.0776	.0845
30-34	1972.2	17.9	.0614	.0736	.0794	.0865
35-39	1969.6	16.6	.0753	.0920	.0998	.1090
40-44	1966.8	15.4	.0888	.1101	.1199	.1312
45-49	1963.8	15.3	.0895	.1111	.1209	.1323
Part B. Males						
<u>North Model</u>						
20-24	1976.4	18.0	.0686	.0818	.0910	.1039
25-29	1974.6	19.0	.0585	.0686	.0760	.0866
30-34	1972.5	17.8	.0710	.0849	.0946	.1080
35-39	1970.0	17.1	.0782	.0946	.1056	.1206
40-44	1967.4	16.4	.0850	.1037	.1159	.1323
45-49	1964.4	16.8	.0810	.0983	.1098	.1254
<u>West Model</u>						
20-24	1976.3	18.1	.0730	.0850	.0908	.0980
25-29	1974.5	18.8	.0648	.0746	.0794	.0856
30-34	1972.2	17.4	.0810	.0953	.1021	.1102
35-39	1969.6	16.6	.0908	.1081	.1159	.1251
40-44	1966.9	15.9	.1003	.1206	.1295	.1397
45-49	1963.9	16.1	.0972	.1165	.1251	.1349

TABLE 25 Mortality Levels Associated with Direct Estimates of Child Mortality for the 1968-76 Cohort from Individual Survey of the 1976 CFS: Colombia

	North Mortality Level	
$_xq_0$	Male	Female
$_1q_0$	17.5	17.7
$_2q_0$	17.4	17.2
$_5q_0$	17.7	16.8
$_{10}q_0$	18.2	17.8

interpolating or extrapolating the period values calculated directly from the fertility history data.

Somoza (1980) has suggested using the logit system (see glossary) generated by the mortality experience of the 1968-76 cohort (see Table 13) as a basis for interpolation. Assuming that Somoza's period estimates presented in Table 27 refer to the midpoint of each period, interpolation within the logit system yields the estimates displayed in Table 28. This series, which will be compared with estimates obtained by other means, will be referred to as the 1976 CFS-Somoza series.

The three panels of Figure 4 plot the major infant mortality estimates ($_1q_0$) presented so far. The indirect estimates shown were all derived via the "North" model. The two sets of estimates represented by horizontal lines spanning periods of several years are those derived directly from the 1969 NHS data. The solid line in all three panels shows the trend derived from the CFS-Somoza series.

On the whole, the CFS-Somoza series seems a fairly good smoothed version of all the other estimates. It is worth noting, however, that from 1960 onward, the CFS-Somoza series falls consistently below the estimates obtained simply from vital registration data. Since the registration data on infant mortality also exceed most of the other estimates displayed for the period 1960-66, it is possible that they overestimate mortality. For example, the estimates obtained from registration data in

TABLE 26 Infant Mortality Estimates Derived from Vital Registration Data: Colombia

Birth Cohort	Both Sexes $_1q_0$	Male $_1q_0$	Female $_1q_0$
1951	.120	.128	.111
1952	.111	.117	.104
1953	.111	.119	.103
1954	.103	.110	.095
1955	.104	.111	.097
1956	.104	.111	.096
1957	.100	.108	.093
1958	.100	.107	.092
1959	.097	.104	.089
1960	.100	.107	.092
1961	.090	.096	.083
1962	.090	.097	.082
1963	.088	.095	.081
1964	.083	.090	.076
1965	.084	.091	.076
1966	.080	.087	.073
1967	.078	.085	.071
1968	.075	.082	.067
1973	.111	.120	.102
1974	.100	.108	.091
1973[a]	.094	.101	.086
1974[a]	.087	.094	.079

[a]Denominators of these rates have been adjusted for late registration of births, i.e., they incorporate the births occurring in those years but registered in subsequent ones (up to 1975).

1973 and 1974 are clearly too high (see Panel 1 of Figure 4).

Estimates derived from the fertility history data of the 1969 Rural NFS are relatively low. Those derived from the printed tabulations and referring to the 1960-70 decade fall below all other estimates for the same period, and Bayona's estimates, although apparently more

TABLE 27 Estimates of Childhood Mortality by Time Period, Individual Interviews from the 1976 CFS: Colombia

Period	$_1q_0$	$_2q_0$
1956-60	.0993	.1273
1961-65	.0782	.1006
1966-70	.0679	.0851
1971-75	.0662	.0837

Source: Somoza (1980:27).

consistent with the rest, are not satisfactory measures of infant mortality for the rural areas of the country.

Estimates yielded by indirect methods applied to 1969 NFS data are a bit higher than the CFS-Somoza series for 1965, but they are lower than the latter for 1963 and 1967. There is remarkable agreement between the CFS-Somoza series and the 1968 and 1970 estimates derived from age groups 25-29 and 30-34 of the 1973 census, but the census estimates based on older age groups (referring to 1966 and earlier) fall consistently below the CFS series. In fact, at these ages, the census estimates approximate fairly well the ones from the 1969 Rural NHS, whose quality is dubious.

Of special importance is the comparison of the CFS-Somoza series with indirect estimates based on the same data (see the CFS-Individual plots in Panel 2 of Figure 4). Since the data base is identical in both cases, one would expect a fairly good agreement between the two types of estimates obtained,[1] which is in fact the case. Differences, however, are evident, and although some can be explained by the age-of-mother effect (for example, on the 1974 estimates), differences observed between the estimates referring to the 1965-70 period suggest that the CFS-Somoza series is too low (see Panel 2 of Figure 4). The age-selective truncation affecting this series is probably one cause of this outcome, but selective omission of dead children may also be responsible.

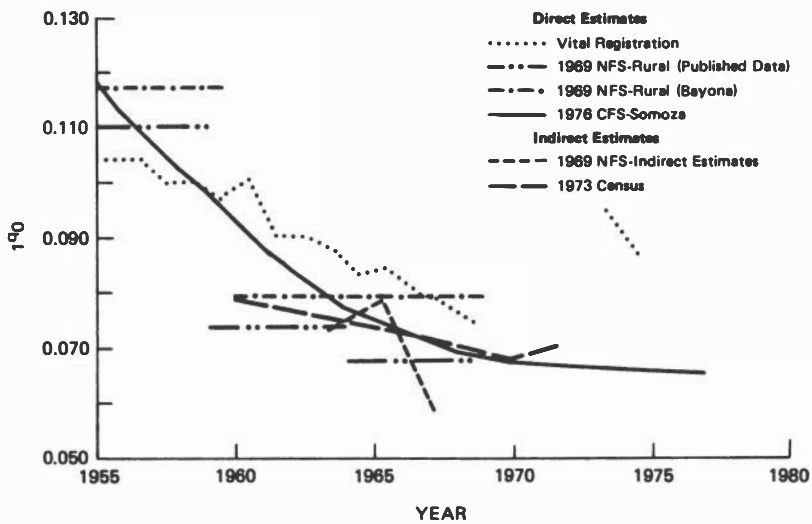
Panel 2 shows clearly that the 1976 CFS estimates derived from data classified by nonstandard age groups emphasize discrepancies, while those derived from the

TABLE 28 1976 CFS-Somoza Series: Child Mortality Estimates for Single Years Derived by Interpolating Between the Estimates Obtained Directly from CFS Fertility Histories: Colombia

	$_xq_0$				
Year	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$	$_{10}q_0$
1955	.1170	.1492	.1607	.1850	.1990
1956	.1117	.1428	.1536	.1777	.1905
1957	.1066	.1364	.1468	.1694	.1824
1958	.1017	.1303	.1403	.1619	.1744
1959	.0970	.1244	.1339	.1548	.1668
1960	.0925	.1187	.1279	.1479	.1594
1961	.0882	.1133	.1221	.1412	.1523
1962	.0841	.1080	.1165	.1348	.1455
1963	.0801	.1030	.1111	.1287	.1389
1964	.0771	.0989	.1066	.1234	.1331
1965	.0750	.0957	.1030	.1188	.1280
1966	.0730	.0926	.0994	.1144	.1231
1967	.0709	.0895	.0960	.1102	.1184
1968	.0689	.0866	.0927	.1061	.1138
1969	.0677	.0850	.0909	.1040	.1115
1970	.0674	.0847	.0907	.1038	.1113
1971	.0671	.0844	.0904	.1036	.1112
1972	.0667	.0841	.0902	.1034	.1111
1973	.0664	.0838	.0899	.1032	.1109
1974	.0660	.0836	.0897	.1030	.1108
1975	.0657	.0833	.0894	.1029	.1106
1976	.0654	.0830	.0892	.1027	.1105
1977	.0650	.0827	.0889	.1025	.1104
1978	.0647	.0825	.0887	.1023	.1102

1978 NHS data and classified in nonstandard form are less discrepant than the standard ones. However, relative to the extrapolated 1976 CFS-Somoza series, even the non-standard 1978 NHS estimates are somewhat low.

Essentially the same conclusions would have been reached if some other indicator of child mortality had been used. Infant mortality was chosen because it is readily available from some data sources (vital registration and the 1969 Rural NFS) while other parameters are not, and thus it permits the largest number of comparisons.



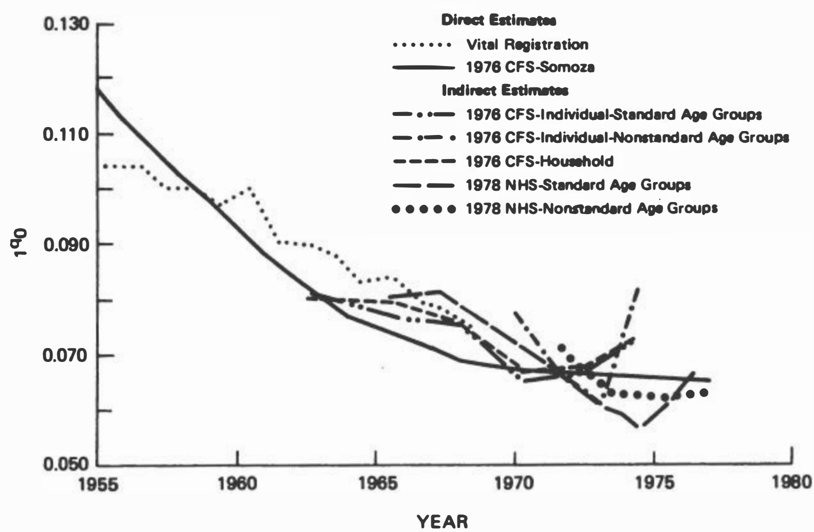


FIGURE 4 Comparison of Infant Mortality Estimates Based on North Model: Colombia

2.2.4.1 *Reassessment of Appropriate Models for Child Mortality*

To explore the effect that the choice of mortality model has on the indirect estimates obtained, $_2q_0$ values derived via the "North" and "West" model have been plotted in Figure 5 along with the direct estimates of the CFS-Somoza series. It is clear from the figure that the use of the "West" model yields overestimates of mortality, since even the indirect 1976 CFS estimates derived from individual interviews (Panel 2) fall consistently above the CFS-Somoza estimates, which were derived from the same data. Therefore, "West" by itself is not an appropriate mortality model for Colombia during the 1962-78 period. This conclusion would hold even if another child mortality parameter had been used.

However, in the earlier discussion of appropriate models for Colombian mortality, "West" emerged as a fairly good representation for the 1941-59 cohort and a reasonable one for the 1960-67 cohort. Furthermore, according to Table 16, for all cohorts the ratio of l(10) in the "North" model to the observed l(10) is less than one, while the ratio of "West" to the observed is greater than one. In addition, the deviations of these ratios from unity are fairly similar in magnitude, implying that the average of the "North" $l_N(10)$ and the "West" $l_W(10)$ is a better approximation to the observed $l_0(10)$ than either of them is separately. Note that in deriving $_1q_0$ or $_2q_0$ estimates via indirect methods one is translating not only the estimated l(10) value into equivalent $_1q_0$ and $_2q_0$ estimates, but also the l(15) and l(20) values, and no information is available about the relationship between $_1q_0$, say, and l(15) or l(20). Nevertheless, it seems reasonable to translate any l(x) estimate for $x > 10$ into a $_1q_0$ or $_2q_0$ value by taking an average of the "North" and "West" estimates when dealing with dates prior to 1967. The resulting "revised" $_1q_0$ and $_2q_0$ estimates are shown in Table 29 and the $_1q_0$ estimates are plotted in the panels of Figure 6. These estimates suggest that the 1976 CFS-Somoza series underestimates mortality during the 1962-70 period (see Panel 2), that the NHS estimates referring to periods close to 1978 are somewhat low (see Panel 3), and that the 1973 census estimates still underestimate mortality, although to a lesser extent than before (Panel 1).

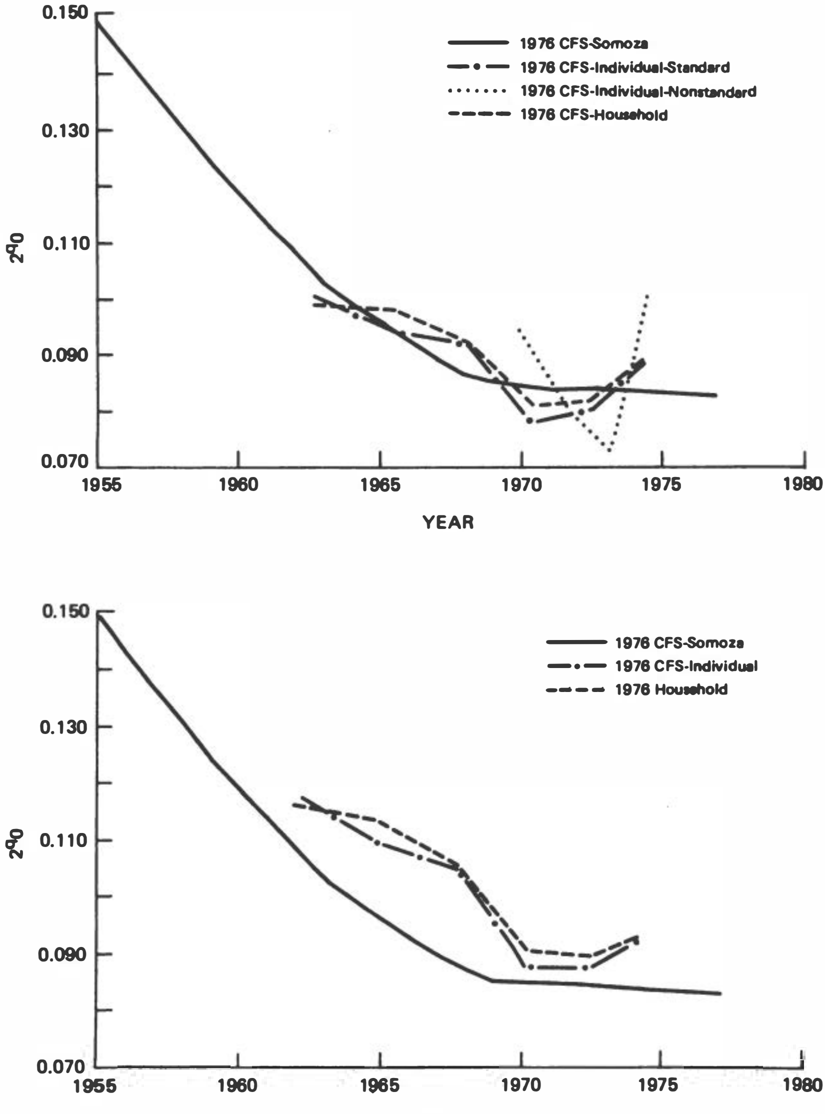


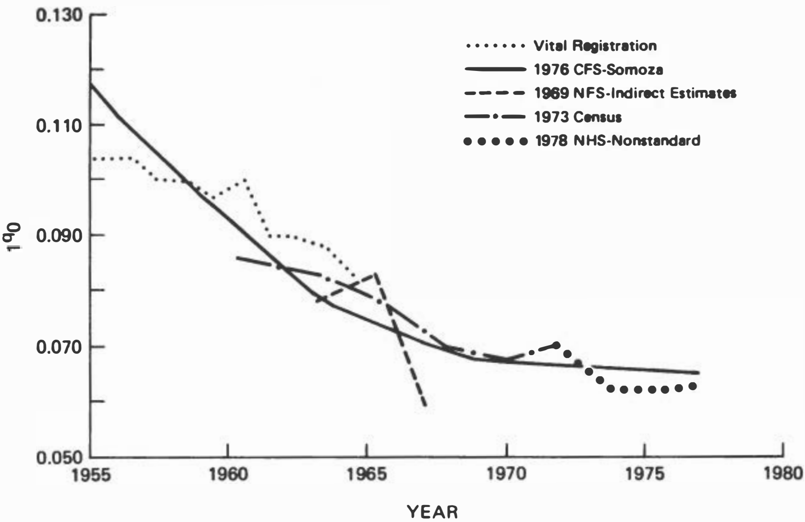
FIGURE 5 Comparison of CFS $_2q_0$ Direct Estimates with Indirect Ones Based on North and West Mortality Models: Colombia

TABLE 29 Revised $_1q_0$ and $_2q_0$ Estimates (Averaging North and West Models for Dates Prior to 1967): Colombia

Age Group	Reference Date	$_1q_0$	$_2q_0$
A. 1973 Census			
20-24	1971.7	.0698	.0850
25-29	1970.0	.0675	.0819
30-34	1967.9	.0698	.0850
35-39	1965.4	.0779	.0945
40-44	1962.9	.0831	.1014
45-49	1959.9	.0859	.1051
B. 1976 CFS - Individual			
20-24	1974.3	.0723	.0883
25-29	1972.5	.0665	.0805
30-34	1970.4	.0647	.0782
35-39	1968.1	.0750	.0919
40-44	1965.3	.0834	.1018
45-49	1962.4	.0887	.1089
C. 1976 CFS - Household			
20-24	1974.3	.0731	.0893
25-29	1972.5	.0676	.0821
30-34	1970.4	.0667	.0808
35-39	1968.0	.0755	.0926
40-44	1965.2	.0862	.1056
45-49	1962.2	.0876	.1074
D. 1978 NHS			
20-24	1976.4	.0661	.0800
25-29	1974.6	.0567	.0676
30-34	1972.5	.0626	.0754
35-39	1970.0	.0721	.0881
40-44	1967.1	.0879	.1078
45-49	1964.2	.0864	.1058

On the basis of these comparisons, the following conclusions can be drawn:

1. Estimates derived from the 1969 NFS are not reliable and tend to be too low.
2. The 1973 census seems to have suffered from generalized omission of children dead. Therefore, child mortality estimates derived from this source by using the best-fitting mortality model "North" are also too low. Some of these deficiencies are masked when the generally inappropriate "West" model is used. (Because of this masking, in the absence of any other information, Palloni's estimates are acceptable).
3. The CFS-Somoza estimates for 1962-70 are too low.
4. When derived from nonstandard age groups, the indirect child mortality estimates obtained from CFS data reveal strong age-related biases. Only the estimate associated with age group 28-32 seems acceptable.
5. Other indirect estimates derived from the CFS data classified according to the usual five-year age groups seem adequate. Those associated with ages ranging from 25-29 through 45-49 (referring to the 1962-72 period) are fairly similar to the ones associated with age groups 30-34 through 45-49 (referring to approximately the same period) of the 1978 NHS, although the latter tend to be slightly higher. However, it is possible that, especially at older ages, both sets of estimates may be affected by omission of dead children.
6. The 1978 NHS estimates associated with younger age groups (20-24 and 25-29) and referring to the period 1974-77 display an unacceptable trend. Errors in age reporting may be partly the cause, since the use of nonstandard age groups smoothes the estimates considerably. We believe the CFS-Somoza series for 1972-76 represents a reasonable, smooth approximation of the estimates available for this period.
7. In general, estimates derived directly from vital registration data tend to be higher than those obtained from other sources. For periods since 1972 it is clear that deficiencies in birth registration have led to overestimates of child mortality. During earlier periods, a similar type of problem may have been operating, but unfortunately the overlap between reliable indirect estimates and those derived from vital registration is too small to lead to any firm conclusions at this stage.



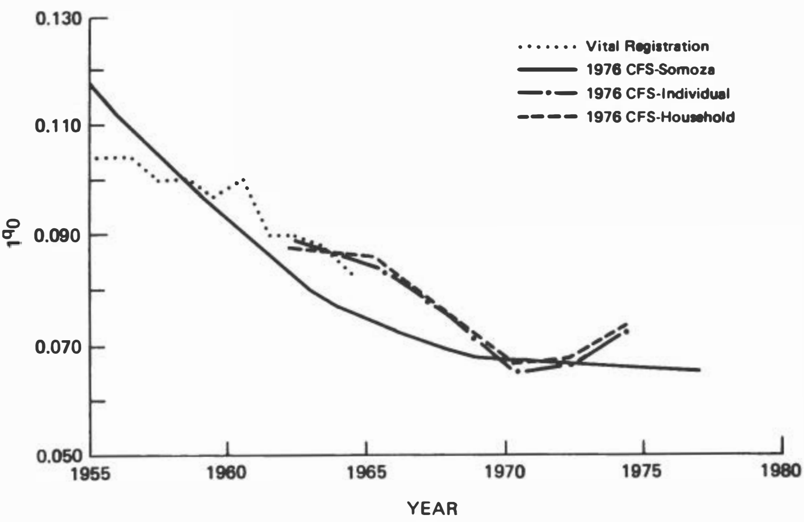


FIGURE 6 Comparison of Infant Mortality Estimates ($_1q_0$) Using Combination of North and North/West Models for Indirect Estimates: Colombia

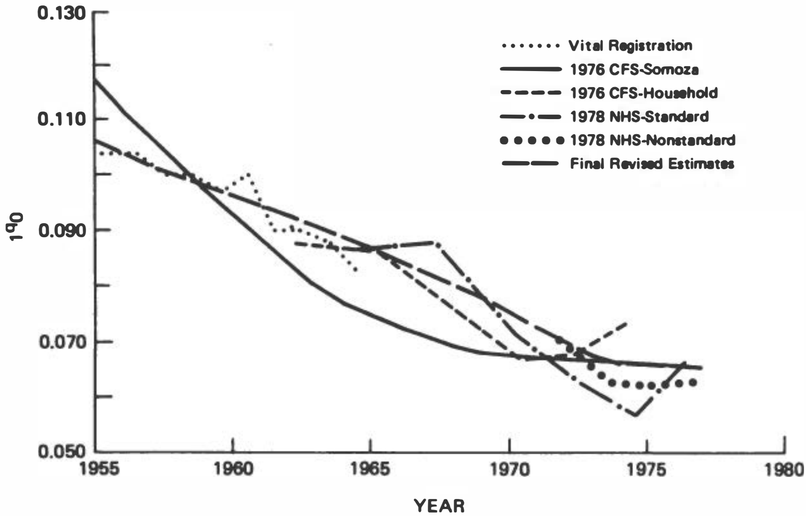


FIGURE 6 (continued)

2.2.5 A Revised Set of Child Mortality Estimates

Table 30 shows the set of key estimates of child mortality during the 1958-74 period selected on the basis of the conclusions reached above. For years prior to 1960, the best estimates are those obtained directly from the CFS fertility histories (see Table 27). Because these estimates refer specifically to the period 1956-60, its midpoint, 1958.5, was used as their reference date. For years since 1970, the direct CFS estimates were also judged to be adequate. Therefore, those corresponding to the period 1971-75 in Table 27 were adopted, and the reference date 1973.5 was assigned to them.

For 1960-69, the best estimates appeared to be the indirect estimates derived either from the CFS household data or from the 1978 NHS (see Table 29). The estimates produced by these sources do not, however, coincide. Furthermore, at older ages of mother (45-49, and even 40-44 for the CFS), the estimates seem to be affected by selective omission of dead children. Since it is not possible to establish with certainty which of the remaining estimates for the 1960-69 period are the most reliable, it was decided to average them. Because each estimate refers to a different time point, those derived from the CFS were used to obtain, by linear interpola-

TABLE 30 Key Child Mortality Estimates, 1958-74: Colombia

Source[a]	Time Reference	Estimate $_1q_0$	Estimate $_2q_0$
CFS Individual	1958.5	.0993	.1273
CFS Household	1965.2	.0862	.1056
NHS Standard	1967.1	.0879	.1078
CFS Household	1968.0	.0755	.0926
CFS Individual	1973.5	.0662	.0837
Mean Estimate (from CFS Household and NHS Indirect Estimates)	1967.1	.0834	.1023
Interpolated Estimate	1963.5	.0901	.1128
Interpolated Estimate	1968.5	.0796	.0982

[a]See text for explanation of mean and interpolated estimates.

tion, one referring to the same time as that obtained from the NHS (1967.1). Then, the interpolated CFS value and the observed one from NHS were averaged. The result is shown in Table 30 as the "mean estimate" for 1967.1. Finally, linear interpolation was used to estimate $_1q_0$ and $_2q_0$ values for 1963.5 and 1968.5 on the basis of the mean estimate for 1967.1 and the CFS direct estimates for 1958.5 and 1973.5, respectively. The resulting quinquennial series of estimates (1958.5, 1963.5, 1968.5, and 1973.5) was used to derive a yearly series of child mortality estimates for the 1955-73 period. This was accomplished by interpolating linearly within the logit system having as standard the mortality experience of the 1968-76 cohort as recorded by the 1976 CFS (see Table 13). For 1974-78, the yearly estimates were taken from the CFS-Somoza series. This revised set of child mortality estimates is displayed in Table 31.

Panel 3 of Figure 6 shows plots of the revised $_1q_0$ estimates from Table 31. Relative to these revised estimates, the original 1976 CFS-Somoza series appears to slightly overestimate mortality for years prior to 1958 and underestimate it, at times substantially, for the

TABLE 31 Child Mortality Estimates for Both Sexes, 1955-78: Colombia

	$_xq_0$				
Year	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$	$_{10}q_0$
1955	.1062	.1384	.1497	.1743	.1885
1956	.1042	.1351	.1460	.1696	.1833
1957	.1022	.1320	.1424	.1650	.1781
1958	.1003	.1288	.1388	.1605	.1731
1959	.0984	.1258	.1353	.1561	.1681
1960	.0965	.1228	.1320	.1519	.1633
1961	.0946	.1199	.1286	.1477	.1586
1962	.0928	.1170	.1254	.1436	.1540
1963	.0910	.1142	.1222	.1396	.1495
1964	.0890	.1113	.1189	.1356	.1451
1965	.0868	.1082	.1156	.1316	.1407
1966	.0847	.1053	.1124	.1277	.1364
1967	.0826	.1024	.1092	.1239	.1323
1968	.0806	.0996	.1061	.1202	.1282
1969	.0782	.0967	.1030	.1167	.1246
1970	.0753	.0936	.0999	.1136	.1214
1971	.0726	.0907	.0969	.1105	.1183
1972	.0700	.0878	.0940	.1075	.1153
1973	.0674	.0851	.0912	.1046	.1123
1974	.0660	.0836	.0897	.1030	.1108
1975	.0657	.0833	.0894	.1029	.1106
1976	.0654	.0830	.0892	.1027	.1105
1977	.0650	.0827	.0889	.1025	.1104
1978	.0647	.0825	.0887	.1023	.1102

1958-73 period. The apparent overestimation of the CFS-Somoza series at earlier periods is due entirely to the interpolation procedure used in deriving it and to the fact that the CFS fertility histories underestimate mortality for the 1961-65 period. This underestimation is probably due to a combination of the truncation effect and true omissions of reported children dead. Notice that prior to 1958 the revised set of infant mortality estimates matches closely those derived from vital registration, suggesting that these new estimates may still be flawed.

In the sections that follow, the set of estimates in Table 31 are subjected to further scrutiny. To facilitate comparisons, estimates of child mortality by sex are needed. Mortality differentials by sex, estimated on the basis of the CFS fertility history data (Somoza, 1980:30) and assuming a sex ratio at birth of 1.05, are used to derive the sex-specific estimates presented in Table 32. Since these mortality differentials may not have held for the entire period under consideration, the series presented in Table 32 should be considered at most a plausible approximation of true trends.

To conclude, we note that even according to these preliminary estimates, infant mortality in Colombia declined by about 40 percent during the 1955-78 period. Somewhat greater declines are observed in other child mortality parameters during the same period; for example, in 1978, ${}_5q_0$ was down to 59 percent of its 1955 level. Although still far above the mortality rates of more developed countries, the estimated rates imply that Colombia's success in reducing child mortality has been far from negligible.

2.3 ADULT MORTALITY

The major sources of data relevant to estimating adult mortality are the censuses, the death registration system, and national household surveys such as the 1978 NHS.

There are two major types of techniques designed to estimate mortality on the basis of census counts and census age distributions. One type uses data from two censuses to trace the experience of cohorts during the intercensal periods, which is appropriate whenever the population under study can be assumed to be closed, that is, not subject to migration. The other type of technique makes use of the age distribution observed at one point in time and requires that the population under study be stable or quasi-stable, that is, subject to constant or near-constant fertility and mortality.

If a death registration system has been operational for a complete intercensal period, the first type of technique can be enhanced by incorporating registration data on the number of deaths occurring to each cohort. The resulting modified method provides estimates of relative census completeness of enumeration and relative completeness of death registration (Preston and Hill,

TABLE 32 Child Mortality Estimates by Sex, 1955-78: Colombia

	$_xq_0$										
Year	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$	$_{10}q_0$	Year	$_1q_0$	$_2q_0$	$_3q_0$	$_5q_0$	$_{10}q_0$
Females						Males					
1955	.0974	.1336	.1445	.1683	.1821	1955	.1146	.1429	.1546	.1800	.1947
1956	.0956	.1305	.1409	.1638	.1770	1956	.1124	.1396	.1507	.1752	.1893
1957	.0938	.1274	.1375	.1594	.1720	1957	.1103	.1363	.1470	.1704	.1839
1958	.0920	.1244	.1340	.1550	.1671	1958	.1082	.1331	.1434	.1658	.1787
1959	.0902	.1215	.1307	.1508	.1624	1959	.1061	.1299	.1398	.1613	.1737
1960	.0885	.1186	.1274	.1466	.1577	1960	.1041	.1268	.1363	.1568	.1687
1961	.0868	.1157	.1242	.1426	.1532	1961	.1021	.1238	.1328	.1525	.1638
1962	.0851	.1130	.1211	.1386	.1487	1962	.1001	.1208	.1295	.1483	.1591
1963	.0835	.1103	.1180	.1348	.1444	1963	.0982	.1179	.1262	.1441	.1544
1964	.0816	.1074	.1149	.1309	.1401	1964	.0960	.1149	.1228	.1400	.1498
1965	.0796	.1045	.1116	.1270	.1359	1965	.0937	.1118	.1194	.1359	.1453
1966	.0777	.1017	.1085	.1233	.1318	1966	.0914	.1087	.1160	.1318	.1409
1967	.0758	.0989	.1054	.1196	.1278	1967	.0892	.1057	.1128	.1279	.1366
1968	.0739	.0962	.1025	.1160	.1238	1968	.0870	.1028	.1096	.1241	.1324
1969	.0717	.0933	.0995	.1127	.1203	1969	.0843	.0998	.1064	.1206	.1287
1970	.0691	.0904	.0965	.1097	.1173	1970	.0813	.0967	.1032	.1173	.1254
1971	.0666	.0876	.0936	.1067	.1143	1971	.0784	.0937	.1001	.1141	.1222
1972	.0642	.0848	.0908	.1038	.1113	1972	.0755	.0907	.0971	.1110	.1191
1973	.0619	.0821	.0881	.1010	.1085	1973	.0728	.0879	.0942	.1080	.1160
1974	.0606	.0807	.0866	.0995	.1070	1974	.0712	.0863	.0926	.1064	.1144
1975	.0603	.0804	.0864	.0993	.1068	1975	.0709	.0860	.0924	.1062	.1143
1976	.0600	.0802	.0861	.0991	.1067	1976	.0705	.0857	.0921	.1060	.1141
1977	.0597	.0799	.0859	.0990	.1066	1977	.0702	.0854	.0918	.1059	.1140
1978	.0594	.0796	.0856	.0988	.1064	1978	.0698	.0852	.0916	.1057	.1138

1980). The completeness of death registration can also be estimated from information on the number of deaths registered or reported during a given year, classified by age of the deceased (Brass, 1975; Preston et al., 1980).

Finally, estimates of mortality can be derived from information on the orphanhood status of a population or the widowhood status of the ever-married population. Data on these topics were gathered by the 1978 NHS. New versions of the methods first proposed by Brass and Hill (Hill et. al., 1982) are used in this report.

Since the levels of adult mortality in Colombia have already been estimated by several authors, most notably Lopez (1968) and Arriaga (1968), this section reviews their methods and results and evaluates them in light of recent methodological developments.

2.3.1 Existing Estimates

2.3.1.1 *Estimates by Lopez*

Lopez (1968) has provided the most thorough analysis of the development of the Colombian population from the point of view of stable and quasi-stable theory. His examination of the age distribution of the Colombian population as recorded by the 1938, 1951, and 1964 censuses led him to conclude that the population remained stable until approximately 1950. He attributed the observed rejuvenation of the population between 1951 and 1964 to the occurrence of a mortality decline that made the quasi-stable model appropriate for the population in 1964. The change in average annual intercensal growth rates, from 2.20 percent (.0220) during 1938-51 to 3.15 percent during 1951-64 according to raw figures, supported this conclusion. However, Lopez pointed out that the 1951 raw census count was known to be deficient and that several other estimates of the 1951 population had been proposed. These estimates ranged from a minimum of 11.9 million to a maximum of 12.3 million and implied quite different rates of change in the growth rate of the population between the two periods. By exploring the effects that the different pairs of intercensal growth rates (determined essentially by different estimates of the population in 1951) would have on the stable and quasi-stable estimates obtained by keeping the age distributions fixed (as observed), Lopez selected the most plausible combination among the set: a growth rate of .024 for 1938-51 and of .029 for 1951-64. These growth rates are those implied by accepting that the total population in 1951 was 11,862,000 and that the male population between the ages of 20 and 50 in 1964 was underenumerated by 86,000. The final growth rate estimates for each sex are displayed in Table 33.

Using these growth rates, the observed age distributions of the population (slightly modified in the case of males in 1964), and stable or quasi-stable models where appropriate, Lopez derived estimates of the birth rate, death rate, expectation of life at birth, and expectation of life at age 5 according to the "South" and "West" mortality patterns from the Coale-Demeny regional model life tables (see glossary). Estimates of the birth rate, death rate, and e_0 are substantially affected by the choice of regional family. For example, the birth rate calculated using the "South" model is at least 7 percent greater than that derived from the "West" model. Estimates of e_5, on the other hand, are very similar in both models. Since the evidence presented on child mortality estimates suggests that "West" is an adequate model for the 1950-59 period, the estimates presented in Table 33 are those derived using the "West" model.

By comparing the average birth and death rates observed during the intercensal periods with their estimated values, Lopez produced estimates of the completeness of birth and death registration. These estimates, displayed in Table 34, were based not on the "West" estimates displayed in Table 33 but on an average of the "West" and "South" estimates published by Lopez. Therefore, if the

TABLE 33 Demographic Parameters for 1938-64, Estimated by Lopez Using the West Model: Colombia

	1938-51		1951-64	
	Male	Female	Male	Female
West Mortality Level	10.9	11.4	12.9	13.9
Birth Rate	.0457	.0425	.0470	.0443
Death Rate	.0214	.0186	.0175	.0142
Growth Rate	.0243	.0239	.0295	.0301
e_0 (years)	41.9	46.0	46.8	52.2
e_5 (years)	50.7	53.4	53.5	57.1

Source: Lopez (1968:64-65).

TABLE 34 Percentage Completeness of Birth and Death Registration, 1938-64, Estimated by Lopez Using Average Results from South and West Models: Colombia

	1938-51	1951-64
Deaths	68.3	67.2
Births	71.2	81.4

Source: Lopez (1968:68).

"West" pattern is indeed the closest representation of the Colombian experience prior to 1960, Lopez's estimates of completeness are probably somewhat low.

In using stable models to analyze the 1938 and 1951 data, Lopez's estimates reflect the assumption that the age distribution of the Colombian population was constant over that period. In fact, the 1938 and 1951 age distributions are similar but not identical, and to avoid favoring one over the other, Lopez based his estimates on an average of the two. Furthermore, in selecting the female stable population that best approximated the observed, Lopez used an average of the mortality levels implied by both the male and female age distributions. He followed this strategy because his estimated growth rates by sex (Table 33) implied that the estimated mean mortality level for males was higher than that for females. Lopez argued that this apparently higher level of mortality was the result of the male population under 50 being underreported while the female population in the same age range was overreported.

In estimating demographic parameters for the 1951-64 period, Lopez used the procedure described in Manual IV (United Nations, 1967). As indicated in the manual, the age distribution in 1964, coupled with the estimated growth rate for the 1951-64 intercensal period and with an estimate of its rate of change, can be used to estimate other demographic parameters. However, the procedure described in the manual does not make clear whether the estimated parameters refer to the intercensal period or to 1964. Coale (1971) and Mari Bhat (1977) have pointed out that the estimation of parameters referring to 1964 is possible and that those derived as described in Manual IV do not strictly represent an intercensal average. Therefore, Lopez's estimates are not strictly correct from a methodological point of view, nor should they be used to estimate the average completeness of birth and death registration during 1951-64.

2.3.1.2 *Arriaga's Estimates*

Arriaga (1968) also estimated mortality using techniques based on stable population theory. However, his method of life table construction, although based on relationships that theoretically hold only in stable populations, is applied to cases in which only quasi-stability can be assumed. Arriaga's method uses the proportion of the population between ages 10 and 50, its age distribution, and model life tables to estimate a growth rate and a birth rate. These estimated values are then used to smooth the observed age distribution and to estimate the stable l(x) function. When mortality is assumed to be changing, the estimated growth and birth rates used must refer to exactly the year for which life table estimates are desired.

For Colombia, Arriaga obtained a preliminary growth rate estimate for 1951 from observed intercensal growth, assuming that the decline in the growth rate had been linear during the period. Then model life tables that produced values of the growth rate similar to the observed values were selected. The final growth rate estimates for males and females in 1951 were .0268 and .0276, respectively--higher than those of Lopez.

Table 35 shows the estimates of e_0 and e_5 obtained by Arriaga for 1938 and 1951. Their average, taken as roughly equivalent to an intercensal value, is compared to similar estimates obtained by Lopez. This comparison suggests that the sex differential in mortality implicit in Lopez's estimates is somewhat high.

2.3.2 Revised Stable and Quasi-Stable Estimates

Because of the questions raised above about both the Lopez and Arriaga estimates, it is necessary to reexamine the development of the Colombian population from 1938 to 1964 on the basis of stable and quasi-stable theory.

TABLE 35 Comparison of Estimated Expectations of Life: Colombia

	Arriaga			Lopez
	1938	1951	1938-51	1938-51
Males				
e_0	36.0	47.9	42.0	41.9
e_5	45.4	54.1	49.8	50.7
Females				
e_0	37.2	50.4	43.8	46.0
e_5	45.8	55.8	50.8	53.4

Source: Arriaga (1968).

According to the estimation procedures described in Manual IV (United Nations, 1967), a model stable population can be fitted to an observed population that has been subject to constant fertility and mortality during the past on the basis of its observed age distribution and its rate of natural increase. The latter is usually estimated from census counts which, unfortunately, do not often achieve the same degree of coverage at different points in time. As mentioned above, Lopez made a careful evaluation of the census counts since 1938, selecting a set whose implied growth rates were not inconsistent with other pieces of evidence. For reference, the set selected by Lopez and the raw census counts are shown in Part A of Table 36. The growth rates implied by different combinations of counts are shown in Part B of the table. Notice, however, that these growth rates are not exactly the same as those used by Lopez (see Table 33). For each sex, they are lower by 0.001. No reason could be found for this discrepancy. (Hereinafter, growth rates shown in Table 36 are referred to as "Lopez's estimates").

Table 37 shows the results obtained when the growth rates in Table 36 are used to fit a "West" model stable population to the average male and female age distributions observed during the 1938-51 period. Only the proportions under age x [C(x)] for x ranging from 10 to 40 were used, following Lopez's example. The results shown in Table 37 are very similar to those obtained by Lopez (Table 33).

TABLE 36 Raw and Adjusted Population Counts for 1938, 1951, and 1964, and Implied Growth Rates: Colombia

Census Date	Type of Count	Male Population	Female Population	Total Population	Sex Ratio (M/F)
Part A: Census Counts for 1938, 1951, and 1964					
1938.43	Raw	4,312,423	4,389,313	8,701,736	0.9825
1951.35	Raw	5,579,259	5,649,250	11,228,509	0.9876
	Lopez	5,894,031	5,967,969	11,862,000	0.9876
1964.54	Raw	8,614,652	8,869,856	17,484,508	0.9712
	Lopez	8,700,652	8,869,856	17,570,508	0.9809
Part B: Growth Rates Implied by Different Combinations of Census Counts					
1938-51	Raw-Raw	.0199	.0195	.0197	
	Raw-Lopez	.0242	.0238	.0240	
1951-64	Raw-Raw	.0329	.0342	.0336	
	Lopez-Lopez	.0295	.0300	.0298	

Two features of Table 37 are remarkable: first, the levels associated with the different C(x) values for males are relatively consistent, while those for females display a wider range of variation and a fairly consistent declining trend with age; second, the mean mortality level associated with male data is higher than that for females. Although this does not mean that estimated female mortality is higher than that of males (compare the estimated death rates for each sex), it does imply that the estimated male-female mortality differential in Colombia is smaller than that in the model life tables.

Apparently, it was this outcome that led Lopez to suggest that the male and female age distributions were affected by opposite biases, with too few males tending to be reported in the 15-39 age range and too many females appearing in the same age range because of age-reporting errors. However, although these types of biases are common, they do not entirely explain the observed difference in estimated mean levels. This is because the estimation method used is based on all the observed proportions under age x, for x ranging from 10 to 40, and even

TABLE 37 Fitting a Stable Population to the Colombian Population, 1938-51, Using Lopez's Growth Rates: Colombia

Part A: Age Distributions and Mortality Levels

	Male		Female	
Age x	C(x)	West Mortality Level	C(x)	West Mortality Level
10	.3075	11.72	.2959	12.66
15	.4322	11.07	.4135	12.60
20	.5299	12.13	.5209	11.81
25	.6248	11.43	.6169	10.79
30	.7003	11.59	.6973	10.17
35	.7616	12.13	.7574	10.69
40	.8210	11.46	.8172	9.85
Mean		11.65		11.22

Part B: Selected Parameters by Sex Corresponding to the Mean Mortality Level

	Male	Female
Birth Rate	.0441	.0426
Death Rate	.0199	.0188
Growth Rate	.0242	.0238

when the proportion in some age group (15-39, for example) is overstated, different C(x) values may be overstated or understated depending on the extent and pattern of other age-reporting errors. For example, notice that in the case of females, C(10) and C(15) are understated while C(30) and C(40) are probably overstated, but that it is difficult to decide whether C(20) is overstated or understated. Hence, opposite biases are likely to cancel each other when the mean is calculated, and a bias in one age range (15-39 in this case) need not necessarily lead to the equivalent bias on the mean level.

Although these observations cast doubts on Lopez's arguments, they do not explain why the apparent discrepancy in mortality levels arises nor do they reconcile other inconsistencies in the estimates presented. For example, note that the estimated male and female birth rates are very similar. Since the sex ratio at birth is known to be fairly constant and its value, according to birth registration during the 1941-51 period, was 1.056 (Lopez, 1968), the observed sex ratio of the population should be 1.0201 if the estimated birth rates were correct. However, according to Table 36, the mean population sex ratio during 1938-51 amounted to only .9851. Although the difference between these two figures is not large in absolute terms, its implications in terms of mortality estimation are important. For example, notice that according to the observed sex ratio at birth and the mean sex ratio of the population just cited, the female birth rate consistent with the estimated male birth rate would be .0411; hence, given that the growth rate for females is .0238, the estimated death rate would be .0173, and these two values define a "West" female stable population with mortality level 12.08. In a similar way, to make the estimated female birth rate consistent with the one for males, one would have to assign to the male population a mortality level of 10.90. The large differences between these "consistent" mortality levels (10.90 and 12.08 for males and females, respectively) and those derived directly from the data in Table 37 (11.65 and 11.22) are disturbing.

The stable estimates suggested by Lopez are not the only ones leading to inconsistencies. Table 38 shows his quasi-stable estimates for 1951-64, obtained by assuming that the growth rate for each sex started to decline in mid-1949.[2] The most striking feature of this set of estimates is that the mortality differential between the sexes is in the opposite direction from that observed in the stable estimates for 1938-51: in 1964, estimated female mortality was approximately one level higher than that estimated for males. It must be pointed out that this reversal occurs even though the 1964 male population used during estimation had already been adjusted for the possible excess mortality (or excess undercount) caused by political strife during the 1960s (see the discussion of "violencia" in Lopez [1968]).

2.3.2.1 *Modifying Assumptions About Growth Rates*

Since Lopez's estimates appear to be unsatisfactory in several respects, we have attempted to reduce their

TABLE 38 Estimates of Quasi-Stable Parameters for 1951-64, Using Lopez's Growth Rates: Colombia

Part A. Age Distributions and Birth Rates

	Male			Female		
		Birth Rates			Birth Rates	
Age x	C(x)	Preliminary	Adjusted	C(x)	Preliminary	Adjusted
10	.3426	.05020	.04948	.3276	.04449	.04374
15	.4746	.05248	.05297	.4539	.04554	.04603
20	.5707	.04931	.05061	.5587	.04587	.04729
25	.6502	.04659	.04812	.6429	.04504	.04677
30	.7153	.04414	.04569	.7123	.04402	.04583
35	.7746	.04354	.04512	.7721	.04364	.04549
40	.8271	.04390	.04545	.8263	.04471	.04655

Part B. Selected Parameters by Sex

	Male	Female
1938-51 Growth Rate	.0242	.0238
1951-64 Growth Rate	.0295	.0300
t_o	1949.50	1949.50
t_m	1957.95	1957.95
Δt	8.45	8.45
Δr	.000627	.000734
k	.01116	.01306
1964 Birth Rate	.0482	.0460
1964 Death Rate	.0146	.0112
1964 Growth Rate	.0336	.0348
1964 North Mortality Level	14.98	16.06

deficiencies by adopting alternative assumptions. For the 1938-51 period, one questionable aspect of Lopez's data is that different growth rates apply to males and to females. If the population had truly been stable prior to 1951, growth rates differing by sex would be unlikely. Therefore, it seems more reasonable to assume that the growth rates during 1938-51 should be the same for both sexes. Finding the most plausible value for these rates, however, is not possible without making further assumptions. To limit the number of choices, it was assumed that either the male growth rates or the female growth rates estimated by Lopez were correct. Hence, two new sets of stable and quasi-stable estimates were calculated: one assuming that the growth rate of females for 1938-51 applied to males (Set 1), and the other assuming that the growth rates of males for the same period applied to females (Set 2).

Tables 39 and 40 show the results obtained under the Set 1 assumption. The first result of interest is that the mean mortality level for males during 1938-51 (Table 39) is 11.25, a value very close to the one estimated for females (11.22) using the same growth rate of .0238 (see Table 37). Adopting the male birth rate in Table 39 increases the sex differential in birth rates over that shown in Table 37, but not enough to account for the relatively low overall sex ratio of .9851 of the

TABLE 39 Stable Estimates for Males Using the Growth Rate of Females, 1938-51 (Set 1): Colombia

Part A. Age Distributions and Mortality Level

	Male	
Age x	C(x)	West Mortality Level
10	.3075	11.29
15	.4322	10.66
20	.5299	11.71
25	.6248	11.03
30	.7003	11.21
35	.7616	11.76
40	.8210	11.12
Mean		11.25

Part B. Selected Parameters Corresponding to the Mean Mortality Level

Birth Rate	.0445
Death Rate	.0207
Growth Rate	.0238

TABLE 40 Quasi-Stable Estimates for Males Using the Growth Rate of Females, 1951-64 (Set 1): Colombia

Part A. Age Distributions and Birth Rates

Age x	Male C(x)	Birth Rates Preliminary	Birth Rates Adjusted
10	.3426	.04963	.04880
15	.4746	.05184	.05240
20	.5707	.04864	.05014
25	.6502	.04601	.04778
30	.7153	.04370	.04550
35	.7746	.04313	.04496
40	.8271	.04354	.04533

Part B. Selected Parameters

1938-51 Growth Rate	.0238
1951-64 Growth Rate	.0300
t_o	1949.50
t_m	1957.95
Δt	8.45
Δr	.000734
k	.01306
1964 Birth Rate	.0478
1964 Death Rate	.0130
1964 Growth Rate	.0348
1964 North Mortality Level	15.94

population. (Birth rates of .0445 for males and .0426 for females imply an overall population sex ratio of 1.0109 when the sex ratio at birth is 1.056.) In addition, the revised quasi-stable mortality estimates for males for 1964 (Table 40) are fairly consistent with those estimated for females; for example, compare the 1964 male mortality level of 15.94 (in Table 40) with the estimated female level of 16.06 (shown in Table 38). Once more, however, the birth rate differential by sex is inconsistent with the sex ratio of the population in 1964, even though the sex ratio at birth had declined to 1.034 for the 1953-69 period.

Tables 41 and 42 show the results of using the male growth rates to estimate stable and quasi-stable parameters for females (the Set 2 assumption). In addition, Table 42 shows the quasi-stable estimates for males using the male growth rates estimated by Lopez, but assuming that mortality started to decline in mid-1950 rather than in mid-1949 (see footnote 2). The estimates for females in Table 42 are also based on this assumption. Note the consistency between the estimated 1938-51 mean mortality level for females (Table 41) and that for males (Table 37). The birth rate differential implied by these estimates is still insufficient to account for the low population sex ratio observed, but it is slightly more favorable than that implied by the estimates obtained when the female growth rate is used (Set 1 assumption). The quasi-stable estimates (Table 42) also yield similar mortality levels for both sexes in 1964, although again the birth rate differential by sex is inconsistent with the observed population sex ratio.

Notice that in Table 42 the 1951-64 growth rates used for the two sexes are not identical. The reason is that once the same male growth rate was applied to both sexes during the 1938-51 period, the census counts had to be modified to make them consistent with the selected rates. The modification of the counts was somewhat arbitrary, but two guidelines were followed in the process:

(a) The overall population sex ratios (shown in Table 36) seem rather low. Hence, a modification that increased them was preferred over one that reduced them.
(b) Undercounts are more likely than overcounts. Hence, it was preferable to increase a count rather than to reduce it.

TABLE 41 Stable Estimates for Females Using the Growth Rate of Males, 1938-51 (Set 2): Colombia

Part A. Age Distributions and Mortality Level

	Female	
Age x	C(x)	West Mortality Level
10	.2959	13.33
15	.4135	13.07
20	.5209	12.25
25	.6169	11.18
30	.6973	10.54
35	.7574	11.06
40	.8172	10.19
Mean		11.66

Part B. Selected Parameters Corresponding to the Mean Mortality Level

Birth Rate	.0422
Death Rate	.0180
Growth Rate	.0242

Following these guidelines only one count needs to be modified in each instance to obtain sets consistent with the assumed growth rates. For Set 1, where the growth rate is .0238 for both males and females, the male count for 1938 was modified to 4,334,917. For Set 2, with a growth rate of .0242, the female count for 1951 was modified to 5,998,913.

TABLE 42 Quasi-Stable Estimates for Both Sexes Obtained by Using the Male Growth Rates Estimated by Lopez, 1951-64 (Set 2): Colombia

Part A. Birth Rates by Sex

Age x	Male Birth Rates Preliminary	Male Birth Rates Adjusted	Female Birth Rates Preliminary	Female Birth Rates Adjusted
10	.05020	.04947	.04484	.04418
15	.05248	.05287	.04599	.04634
20	.04931	.05045	.04633	.04742
25	.04659	.04793	.04545	.04678
30	.04414	.04549	.04441	.04579
35	.04354	.04493	.04398	.04541
40	.04390	.04524	.04507	.04647

Part B. Selected Parameters by Sex

	Male	Female
1938-51 Growth Rate	.0242	.0242
1951-64 Growth Rate	.0295	.0296
t_o	1950.50	1950.50
t_m	1957.95	1957.95
Δt	7.45	7.45
Δr	.000711	.000725
k	.01266	.01291
1964 Birth Rate	.0476	.0462
1964 Death Rate	.0134	.0118
1964 Growth Rate	.0342	.0344
1964 North Mortality Level	15.72	15.62

2.3.2.2 *Assessing the Modified Adult Mortality Estimates by Reference to Corresponding Child Mortality Estimates*

Evidence presented earlier in this chapter suggests that the "West" model represented Colombian child mortality during 1938-51 quite closely, while the observed pattern was closer to the "North" model around 1964. Since the stable and quasi-stable estimates for these two time periods have been presented in terms of the "West" and "North" models, respectively, it is possible to derive from them a series of child mortality estimates comparable to those presented in Table 32. This derivation was carried out by means of the logit system (see glossary) with female level 16 of the "West" model as standard.

The alpha and beta parameters relating this standard to the stable and quasi-stable estimates presented above were interpolated linearly to generate a series of yearly child mortality estimates. Two combinations of stable and quasi-stable estimates (with growth rates shown in Table 43) were used, reflecting the two growth-rate assumptions made above (Sets 1 and 2). Figure 7 compares the $_1q_0$ estimates for males and females. Figure 8 shows the estimated $_2q_0$, $_3q_0$, and $_5q_0$ values.

Figure 7 reveals fairly good correspondence around 1960-62 between the stable estimates (Sets 1 and 2) and those presented in Table 32. However, before that point the estimates of Table 32 are lower than the stable estimates, while for later years the reverse is true. In both cases, the "low" estimates approximate those obtained directly from vital registration, which makes their accuracy doubtful.

According to both Figures 7 and 8, the estimates in Table 32 for the years prior to 1960 seem too low. However, for 1961-65 the general consistency of estimates obtained from very different sources and using completely different methods is reassuring. Furthermore, notice that circa 1964, the consistency increases as the x of $_xq_0$ increases. This tendency is indicative of the fact that the "North" model does not fit perfectly the Colombian experience, although it probably provides the best possible fit among the models available. Also worth noting is that the sex differential implicit in the stable estimates is greater than that estimated on the basis of CFS data (as in Table 32). However, the differ-

TABLE 43 Summary of Growth Rates Used in Deriving the Revised Sets of Stable and Quasi-Stable Estimates: Colombia

	Growth Rate	
Assumption	1938-51	1951-64
Set 1	.0238	.0300
Set 2	.0242	.0295 (males) .0296 (females)

ential is smaller than that implied by the preliminary stable and quasi-stable estimates (Tables 37 and 38). In other words, consistency between the estimates derived from different sources has been greatly enhanced by using the same growth rate for both sexes in 1938-51.

2.3.2.3 *Selecting Optimal Estimates for Each Time Period*

Although one cannot be certain which set of estimates above is closer to the truth, the following observations have been used as a guide in selecting the most satisfactory set:

1. As stated earlier, the Table 32 estimates for years prior to 1959 are fairly weak, since they were derived mainly by extrapolation. Furthermore, those corresponding to the 1958-59 period were obtained from the CFS fertility history data (the only source yielding estimates for such period, if vital registration is disregarded). Given the biases that often affect such information and the close coincidence of CFS estimates of infant mortality with those obtained from vital registration, it seems possible that both may be too low.
2. Sets 1 and 2 yield very similar sets of estimates for males. Around 1964, Set 1 seems somewhat better behaved in terms of ${}_2q_0$, ${}_3q_0$, and ${}_5q_0$ (Figure 8), but Set 2 is acceptable and, if anything, implies a slight downward bias in some of the 1964-65 child mortality estimates of Table 32.
3. Sets 1 and 2 differ more markedly for females than for males, and Set 1 implies consistently that female mortality is overestimated in 1964-65 by Table 32. Since overestimation is less likely than underestimation, Set 2 seems preferable.

It would seem therefore that the Set 2 estimates could be adopted for years prior to 1960; that for 1960-66 some smoothed average of the estimates of Set 2 and Table 32 would be acceptable; and that for 1967 and later, the estimates in Table 32 could be adopted.

2.3.3 Intercensal Estimates

Colombia's vital registration system published an uninterrupted series of registered deaths for the period 1951-64. It therefore presents an ideal opportunity for applying the Preston and Hill (1980) method of estimating

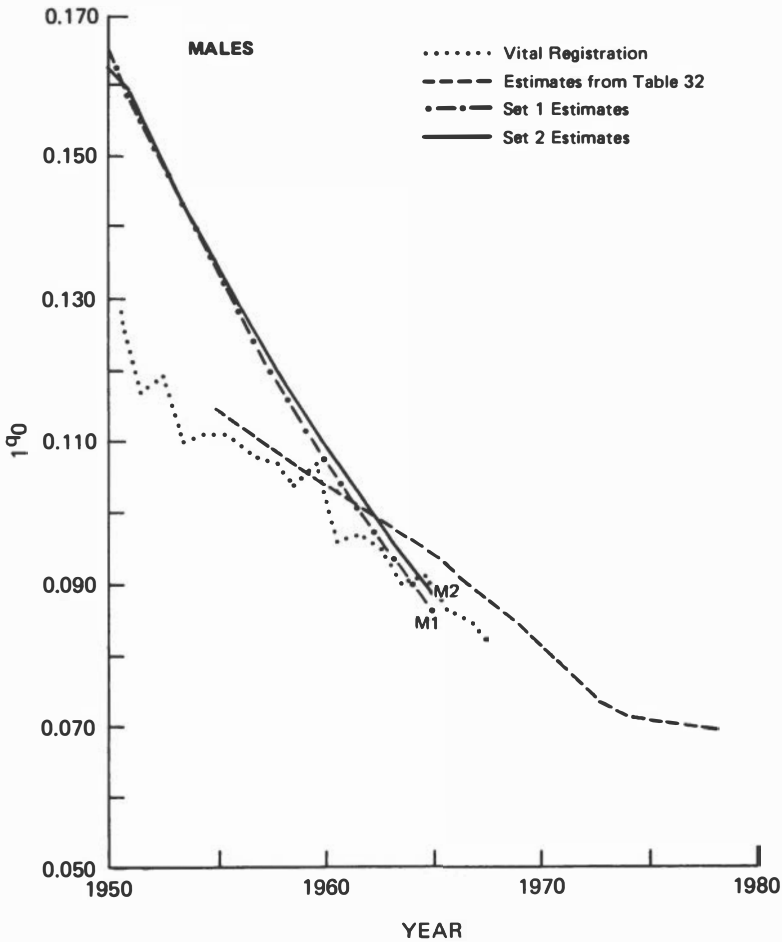


FIGURE 7 Comparison of Infant Mortality Estimates ($_1q_0$), 1950-78: Colombia

the completeness of death registration and the completeness of enumeration of the second census, both relative to the completeness of the first.

This method is based on the following equation:

$$\frac{P_1(x)}{C_1} = \frac{P_2(x+t)}{C_2} + \frac{D(x)}{k} \qquad (1)$$

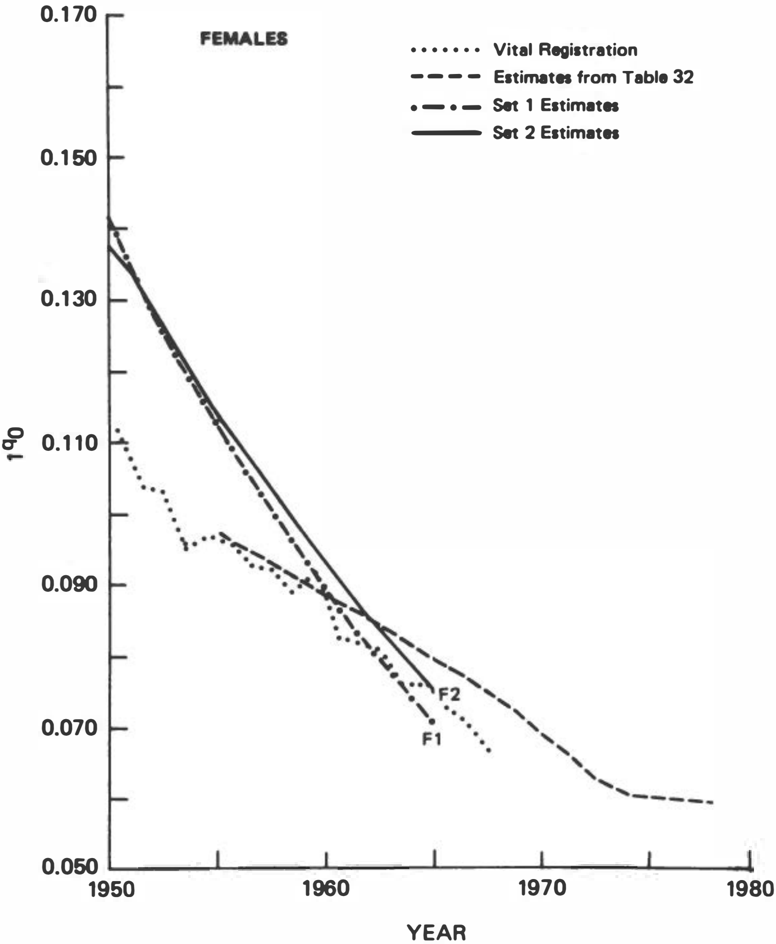
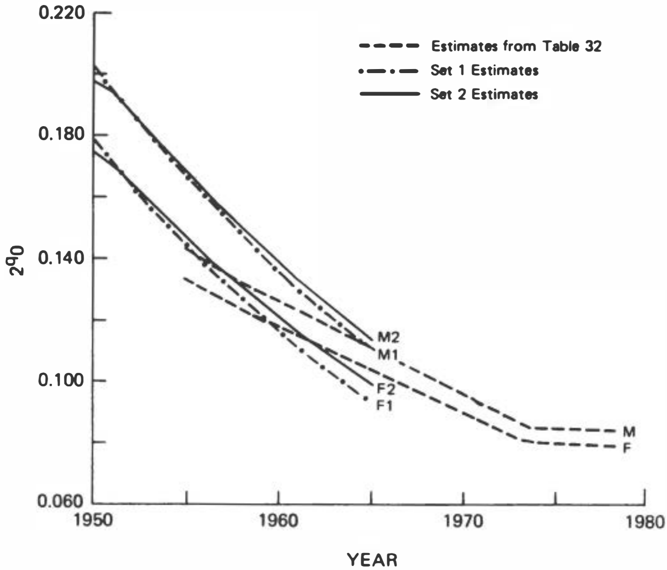


FIGURE 7 (continued)

where t is the length of the intercensal period; $P_1(x)$ is the population aged x at the first census; $P_2(x+t)$ is the population aged x+t at the second census; D(x) are the deaths that occurred during the intercensal period to the cohort aged x at the first census; C_1 and C_2 are the completeness of enumeration of the first and second censuses, respectively; and k is the completeness of death registration. Equation (1) holds true in populations where there is no migration (i.e., the population



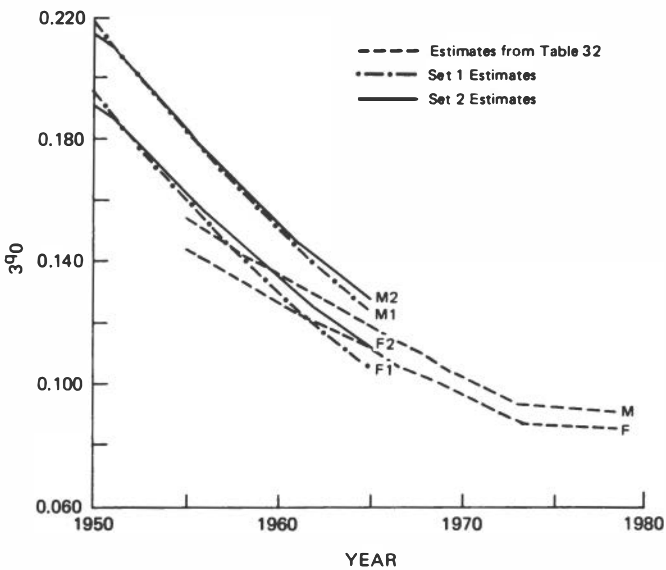


FIGURE 8 Comparison of Child Mortality Estimates ($_2q_0$, $_3q_0$, and $_5q_0$), 1950-78: Colombia

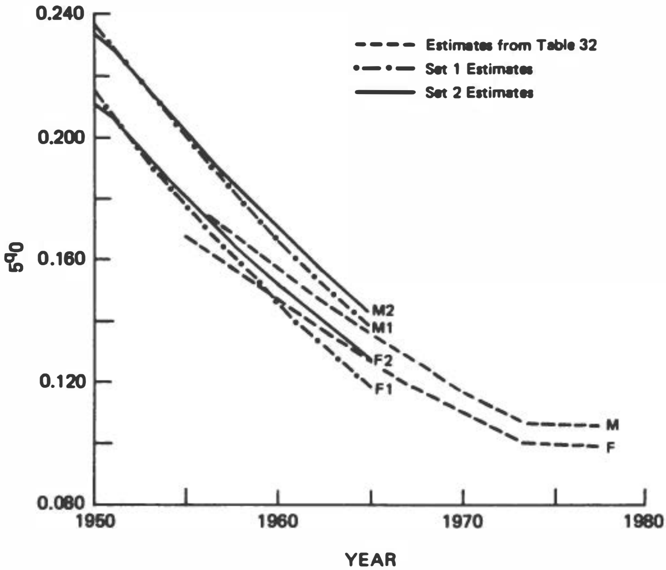


FIGURE 8 (continued)

is closed) and where the completeness of coverage of both censuses and vital registration is independent of age. In the case of Colombia, migration during the 1951-64 intercensal period was very low (Lopez, 1968), so, at least for exploratory purposes, the population may be considered closed. The second assumption can be treated in a similar way, because although it is likely that underenumeration of young children may be greater than that at other ages, younger ages have relatively little weight in the application of the method.

Equation (1) can be rewritten thus:

$$\frac{P_1(x)}{P_2(x+t)} = \frac{C_1}{C_2} + \frac{C_1}{k}\left(\frac{D(x)}{P_2(x+t)}\right) \qquad (2)$$

Hence, a line fitted to the points $[(P_1(x)/P_2(x+t), D(x)/P_2(x+t)]$ would have as its slope the value of C_1/k and as its intercept the value of C_1/C_2. If one assumes then that $C_1 = 1$, that is, that the first census is complete relative to itself, then the slope of this line is a correction factor for deaths while the y-intercept is a correction factor for the second census. The reciprocals k/C_1 and C_2/C_1 are, respectively, the completeness estimates of death registration and of enumeration at the second census with respect to the completeness of the first.

Equations (1) and (2) are also valid if, instead of using cohorts of a given age, one uses open-ended cohorts, that is, the population aged x and over at the first census $[P_1(x+)]$, the population aged (x+t) and over at the second census $[P_2((x+t)+)]$, and the intercensal deaths to this cohort, denoted by D(x+). In populations where age-reporting errors are frequent, this cumulated version of equation (2) is preferable, since it reduces the effects that such errors may have on the completeness estimates.

Table 44 shows the results of applying the cumulated version of the Preston-Hill method to the 1951-64 Colombian data by sex. Part A shows an index of enumeration by cohort, U(x+), where

$$U(x+) = \frac{P_2[(x+t)+] + D(x+)}{P_1(x+)} \qquad (3)$$

If death registration and census enumeration were complete, and both were free of age-reporting errors, U(x+) should be identical to one in a closed population. Deviations from one occur because of incompleteness in one of the sources or because of age-reporting errors, whose effects are reduced but not entirely eliminated by using the cumulated version of equation (2).

Since the data used to generate Table 44 refer to cohorts aged x and over in 1951, only net transfers across their lower age boundary affect the final results. That these transfers exist is shown by the very high values of U observed at older ages among males. From age 55 on, U is consistently greater than one and increasing. This behavior implies that either the deaths or the population enumerated at the second census have been consistently shifted to older ages or that the population in 1951 was shifted to younger ages. Detailed examination of the raw data reveals no evidence of a net downward shift of the population over age 55 in 1951. In fact, when the 1951 age distribution is compared with any of the fitted stable models presented in the last section, it becomes clear that the male population over 55 in 1951 was, if anything, slightly exaggerated. Hence, one must

TABLE 44 Estimates of the Completeness of Enumeration and of Death Registration Using the Preston-Hill Intercensal Estimation Method, 1951-64: Colombia

Part A. Index of Enumeration U(x+)

Age x	Male	Female
0	0.9836	1.0220
5	0.9714	0.9969
10	0.9750	0.9806
15	0.9866	0.9653
20	0.9855	0.9636
25	0.9944	0.9663
30	0.9807	0.9583
35	0.9811	0.9507
40	0.9817	0.9572
45	0.9942	0.9727
50	0.9861	0.9503
55	1.0232	0.9698
60	1.0028	0.8896
65	1.1215	0.9689
70	1.1413	0.8347
75	1.3932	0.8641
80	1.5678	0.7350

Part B. Estimates of Completeness of Enumeration and of Death Registration

	Male			Female		
		Estimates of Completeness			Estimates of Completeness	
Range of Points Used	Correlation Between Points	Deaths	Second Census	Correlation Between Points	Deaths	Second Census
0-35	.9954	1.01	0.98	.9889	0.75	1.03
0-40	.9979	0.99	0.98	.9906	0.81	1.01
0-45	.9987	1.01	0.98	.9898	0.88	1.00
0-50	.9994	1.00	0.98	.9949	0.89	0.99
0-55	.9988	1.05	0.97	.9963	0.93	0.98
0-60	.9994	1.03	0.97	.9956	0.85	1.01
0-65	.9951	1.14	0.94	.9948	0.91	0.99
Mean		1.03	0.97		0.86	1.00

conclude that either age at death or the age of the population in 1964 has been exaggerated. In the case of males, both processes appear to be operating.

In the case of females, the picture is not so obviously inconsistent. Only one value of U, that for the first age group, is greater than one. The most likely causes of this discrepancy are the relatively greater under-enumeration of young female children in 1951 or a net upward transfer of females through the 13-year boundary in 1964. Both processes may have been operating, but their net effect (a 2-percent excess) is small.

As expected, the points defined by the $D(x+)/P_2[(x+t)+]$ and $P_1(x+)/P_2[(x+t)+]$ ratios display fairly linear trends. The only exceptions are, possibly, the last two or three points of each set (corresponding to ages 70 and over), so they were not used in fitting a straight line. Part B of Table 44 shows the completeness estimates obtained by fitting straight lines to several sets of points using the least-squares method. In general, the correlations between the points used in each case are fairly close to one, implying that the linear relationship is strong. However, for a given sex, the completeness estimates associated with different lines are not all identical. Thus, selection of the line that is most likely to represent reality must be based on independent evidence about the quality of the data at hand.

In this respect, it is important to note that the data used in deriving the estimates presented in Table 44 include the raw census counts and age distributions. It has already been noted that the male age distribution produced by the 1964 census is very likely to be deficient because of selective underenumeration of adult males. Since the Preston-Hill method assumes that underenumeration is constant over the whole age range, a bias of this type may seriously affect the completeness estimates that the method yields. To ascertain the magnitude of these effects, completeness estimates were derived using an adjusted 1964 male age distribution. The results are shown in Table 45.

2.3.3.1 *Comparing Adjusted and Unadjusted Intercensal Estimates*

Comparison of the three sets of completeness estimates for 1951-64 (males and females in Table 44 and "adjusted" males in Table 45) leads to three main observations. First, within each set the variability of the census completeness estimates (C_2/C_1) is usually less than that of the estimates of completeness of death registration. This apparent robustness of the C_2/C_1 estimates has led investigators to assert that the Preston-Hill method usually yields better estimates of relative census coverage than of death registration completeness. This assertion, although basically valid, should not be interpreted too strictly because, although the absolute bias in C_2/C_1 may be smaller than that affecting k/C_1,

TABLE 45 Estimates of the Completeness of Enumeration and of Death Registration for Males Using the Preston-Hill Intercensal Estimation Method, 1951-64, with an Adjusted 1964 Age Distribution: Colombia

Part A. Index of Enumeration U(x+)

Age x	Male
0	1.0195
5	1.0145
10	1.0145
15	1.0221
20	1.0155
25	1.0169
30	0.9928
35	0.9811
40	0.9818
45	0.9942
50	0.9861
55	1.0232
60	1.0028
65	1.1216
70	1.1413
75	1.3932
80	1.5678

Part B. Estimates of Completeness of Enumeration and of Death Registration

Range of Points Used	Correlation Between Points	Estimates of Completeness	
		Deaths	Second Census
0-35	.9964	0.85	1.05
0-40	.9982	0.87	1.05
0-45	.9977	0.91	1.03
0-50	.9987	0.93	1.03
0-55	.9973	1.00	1.01
0-60	.9988	1.00	1.01
0-65	.9939	1.12	0.97
Mean		0.95	1.02

its implications in terms of growth rate estimates may be significant.

The second observation concerns the behavior of the k/C_1 estimates (the completeness of death registration relative to the completeness of the first census). Notice that in all three sets of estimates the completeness of death registration tends to increase as the number of points used in fitting the line increases. This outcome is probably a consequence of the tendency to exaggerate age at death. It is interesting to note that the tendency seems to affect both males and females, even though the enumeration indices U(x+) for females (see Table 44) do not show any marked inconsistency.

Thirdly, the means of the census completeness estimates in Table 44 imply that the 1951 and 1964 census counts achieved very similar levels of coverage for males and females (0.97 and 1.00, respectively), despite the relative undercount of males in 1964. In contrast, when the 1964 male population is adjusted (Table 45), the 1964 population appears to be overcomplete by about 2 percent relative to the 1951 count.

2.3.3.2 *Comparing Intercensal Estimates to Stable and Quasi-Stable Estimates*

To make valid comparisons, the stable and quasi-stable estimates presented in the previous section were used to generate a starting stable age distribution, which was then projected to 1951 and 1964 by means of mortality schedules consistent with the estimated stable and quasi-stable parameters. These estimated age distributions, in conjunction with estimated population counts consistent with the stable and quasi-stable growth and birth rates of Tables 39 through 42 (see Table E.1 in Appendix E), were used to generate completeness estimates directly comparable with those that the Preston-Hill method should yield in theory. These estimates are presented in Table 46.

A comparison of the estimates presented in Table 46 with those of Tables 44 and 45 leads to the following conclusions:

1. The Preston-Hill completeness estimates for intercensal male deaths based on the observed data (Table 44) are too high, mainly due to the relative underenumeration of the 1964 adult male population and exaggeration of age at death.

TABLE 46 Preston-Hill Equivalent Estimates Obtained by Using Stable and Quasi-Stable Parameters, 1951-64: Colombia

Estimates and Reference Population	Estimates of Completeness: Death Registration $\frac{k}{C_1}$	Estimates of Completeness: 1964 Census Relative to 1951 Census $\frac{C_2}{C_1}$
Set 1		
Males - Observed	0.803	1.009
Males - 1964 Adjusted	0.803	1.050
Females - Observed	0.754	1.054
Set 2		
Males - Observed	0.801	1.012
Males - 1964 Adjusted	0.801	1.053
Females - Observed	0.743	1.061

2. Most of the completeness of death registration estimates produced by the Preston-Hill method are subject to an upward bias brought about by the exaggeration of age at death. Only when the set of points used is truncated at fairly young ages (35 or so) are the estimates somewhat similar to those implied by the stable and quasi-stable parameters (Table 46), ignoring estimates obtained from the unadjusted data for males (Table 44).
3. Biases in the estimates of relative census coverage are certainly smaller than those in the estimates of death registration completeness, but they exist nevertheless. In the case of females, for example, the mean value of C_2/C_1 according to the Preston-Hill method is 1.00, while it would be near 1.06 according to the stable and quasi-stable estimates. Although the latter is not necessarily correct, the Preston-Hill results are more likely to be affected by age-reporting errors. The fact that the best consistency between the two sets of estimates is attained by considering only the first few

points in applying the Preston-Hill method (0-35) lends support to this conclusion.

4. In general, once the estimates for males using unadjusted data are discarded, the Preston-Hill estimates associated with points 0 to 35 are acceptably close to those implied by the stable and quasi-stable fits.

Table 47 presents a comparison of the observed age distributions of the population and of intercensal deaths with the ones implied by a projection based on the stable and quasi-stable parameters associated with Set 2. (The Set 1 parameters yield very similar results that are not presented here.) The most important fact revealed by these comparisons is that age tends to be exaggerated in all the age distributions considered. This is especially so for age at death, where deviations of the observed from the estimated age distributions are mainly positive and increase with age. For the age distribution of the population, high levels of age exaggeration are concentrated mostly at relatively advanced ages (60 and over) and the magnitude is fairly similar for males and females. In contrast, female deaths exhibit much lower levels of

TABLE 47 Comparison of the Age Distributions Used in Applying the Preston-Hill Method and Those Derived from Stable and Quasi-Stable Estimates, 1951-64 (Set 2): Colombia

	1951		Intercensal Deaths			1964		
	$100(C_0(x+)/C_e(x+)-1)$		$100(D_0(x+)/D_e(x+)-1)$			$100(C_0(x+)/C_e(x+)-1)$		
Age x	Male	Female	Male	Female	Age y	Male Raw	Male Adjusted	Female
5	-0.20	0.36	0.73	-2.12	18	-1.53	-0.63	-1.88
10	-0.72	0.52	1.79	-0.84	23	-1.46	-0.90	-3.09
15	-1.20	1.02	3.37	0.99	28	-0.47	-0.32	-3.93
20	0.00	0.35	4.97	2.83	33	1.03	0.64	-4.51
25	-1.52	-1.90	6.72	4.21	38	0.46	-0.75	-6.31
30	-0.88	-3.51	9.11	5.35	43	-0.49	-2.85	-8.65
35	0.36	-2.59	11.24	5.79	48	1.33	-2.64	-7.70
40	-0.75	-5.83	13.26	5.73	53	-0.01	-3.93	-9.82
45	-0.09	-5.38	15.68	5.95	58	2.87	-1.16	-5.50
50	2.83	-4.00	18.36	6.74	63	6.51	2.33	-4.65
55	0.46	-4.97	21.10	7.09	68	9.53	5.23	0.77
60	9.86	5.37	28.72	8.80	73	23.79	18.94	9.85
65	10.72	4.96	41.23	10.29	78	62.94	56.55	50.66
70	29.22	25.04	68.87	12.68	83	131.97	122.87	108.67
75	54.39	42.93	146.01	28.53	88	432.43	411.55	384.24
80	140.07	124.46	335.95	77.32	93	--	--	--

$C_0(x+)$: Observed proportion of the population aged x and over.
$C_e(x+)$: Estimated proportion of the population aged x and over.
$D_0(x+)$: Observed deaths to the cohort aged x and over in 1951.
$D_e(x+)$: Estimated deaths to the cohort aged x and over in 1951.

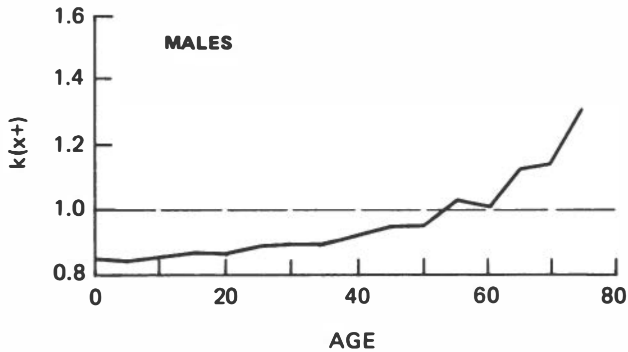
exaggeration than those of males. This observation is consistent with the evidence yielded by the enumeration indices U(x+) of Table 44.

2.3.4 Estimates of Death Registration Completeness Based on the Age Distribution of Deaths

Further indications of exaggeration of age at death in the 1951 data were obtained using an estimation method recently developed by Preston and Coale (United Nations, 1982). This method is essentially based on the same set of assumptions underlying the Brass (1975) growth balance equation method (stability being the main one), but it also requires as input an estimate of the growth rate. In the case of Colombia, this requirement presents no problems because the available growth rate estimates all fall within a fairly narrow range and are not expected to seriously distort the estimates yielded by the method.

Figure 9 shows the age-specific estimates of completeness of death registration obtained for 1951 using a growth rate of 0.0238 for both males and females. (Each estimate represents the completeness of registered deaths over age x.) The semi-cumulated version of the Preston-Coale method was used in deriving these estimates, the population being truncated at age 80. (Therefore, semi-cumulation implies that only the population aged x to 79 is considered). The most important feature of the graphs presented is that the completeness estimates increase with age. Such an increase might be attributed to any of several causes: a consistently greater incompleteness of the population as age increases; an increasing completeness of death registration as age increases (or, equivalently, the exaggeration of age at death); or, a faulty estimate of the growth rate. Of these three causes, the first seems unlikely on the basis of the comparisons of observed and estimated age distributions shown in Table 47. The third can be rejected because, especially in the case of males, the curves in Figure 9 deviate substantially from the almost linearly increasing trend that would be expected if the growth rate were underestimated. Thus, the second alternative, exaggeration of age at death, seems the most plausible explanation.

Preston et al. (1980) have pointed out that when exaggeration of age at death is prevalent, the completeness curve typically displays a plateau at younger ages and increases only after the age at which exaggeration



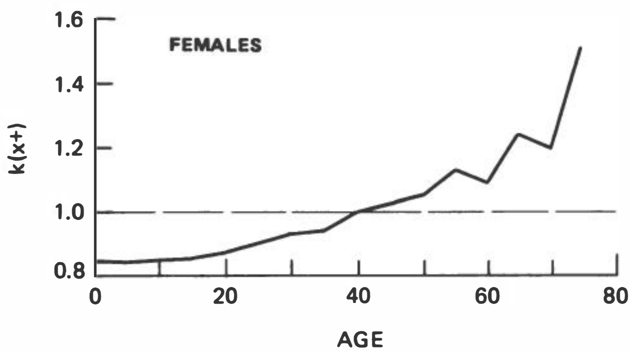


FIGURE 9 Estimated Completeness of Death Registration by Age, Using the Preston-Coale Method Truncated at Age 80, with Growth Rate 0.0238, 1951: Colombia

becomes substantial. In the case of Colombia, this description fits well the 1951 curves for both males and females. For females the plateau is somewhat less flat, but it exists nonetheless, and the female curve certainly does not approximate a linear trend.

A final piece of evidence that supports the existence of some distortion in the age distribution of deaths at older ages is provided by comparing the mean completeness estimates obtained by truncating the population at ever decreasing ages. The nature of the Preston-Coale method is such that if the population is truncated at age x (that is, only the population under age x is considered), the age distribution of deaths over age x has no influence on the completeness estimates obtained. That is, truncation minimizes the biases introduced by the possible age exaggeration of deaths. Therefore, in a population where such exaggeration exists, one expects the mean completeness estimates to increase as the truncation age increases. As Table 48 illustrates, this is exactly what happens in the case of the 1951 Colombian data.

Similar tests of consistency can be applied to the 1964 data, although the picture for 1964 is somewhat less precise because of the quasi-stable character of the population. However, as Figure 10 and Table 49 show, the same characteristics detected in 1951 are present in the 1964 data. Therefore, one must conclude that significant exaggeration of age at death exists at both points in time.

Since the data at hand do not satisfy the assumptions on which the Preston-Coale method operates, the estimates it would produce would be biased. Fortunately, even when the estimates of completeness increase with age, those forming the initial plateau are subject to less bias than the rest. Therefore, it is possible to use the estimates

TABLE 48 Estimated Mean Completeness of Death Registration for Different Truncation Points of the Population, 1951: Colombia

	Estimated Mean Completeness Over Age 5	
Truncation Age	Male	Female
45	0.808	0.781
50	0.831	0.806
55	0.810	0.808
60	0.860	0.883
65	0.845	0.864
70	0.890	0.932
75	0.910	0.942
80	0.966	1.028
85	0.983	1.033

Note: Growth rate = 0.0238.

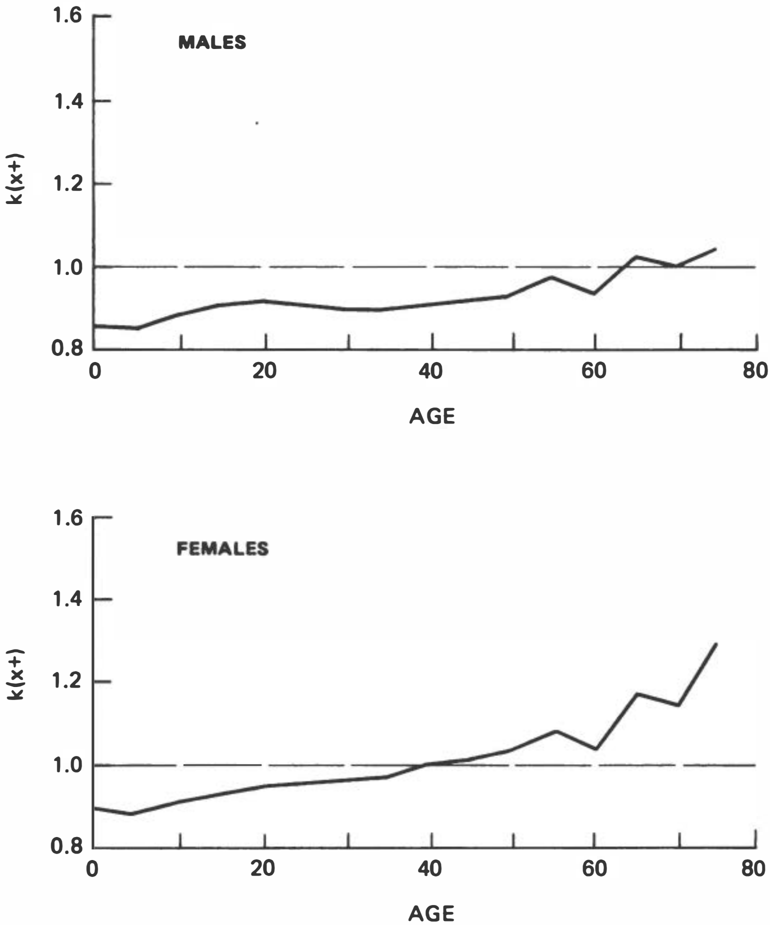


FIGURE 10 Estimated Completeness of Death Registration by Age, Using the Preston-Coale Method Truncated at Age 80, with Growth Rates 0.0295 and 0.0296, 1964: Colombia

constituting the plateau as guidelines for redistributing the excess deaths in the open interval being used. An iterative procedure that operates on this principle has been devised by Zlotnik (1981) and was applied to the Colombian data. The results are presented in Table 50. Estimates are displayed for each of the growth rates defining Sets 1 and 2 of the stable and quasi-stable parameters (see Table 43).

TABLE 49 Estimated Mean Completeness of Death Registration for Different Truncation Points of the Population, 1964: Colombia

	Estimated Mean Completeness Over Age 5	
Truncation Age	Male	Female
45	0.951	0.944
50	0.951	0.951
55	0.923	0.939
60	0.952	0.986
65	0.901	0.935
70	0.918	0.972
75	0.913	0.972
80	0.928	1.021
85	0.936	1.035

Note: Growth rate for males = 0.0295; females = 0.0296.

Also presented in Table 50 are estimates based on projections consistent with the stable and quasi-stable parameters. These were obtained by dividing the observed death rate over age 15 by the one estimated via projection. Therefore, in strict terms, the projection estimates refer only to deaths over 15. This choice was made because in 1964 the deaths under 15 were more likely to be affected by nonstable conditions and because the completeness of registered deaths at young ages (at both points in time) was likely to be different from that of adult deaths. The last observation applies especially to females, for whom the plateaus were chosen so as to exclude the younger ages.

Comparison of the two types of estimates shows that they are fairly consistent. Overall, the projection estimates derived from Set 2 are closer to the Preston-Coale estimates obtained by redistributing deaths than are the Set 1 projection estimates. If the projection estimates are assumed to be correct, the Preston-Coale estimates tend to slightly underestimate completeness.

TABLE 50 Estimates of Death Registration Completeness Based on Application of the Preston-Coale Method to Redistributed Data,[a] 1951 and 1964: Colombia

	Male[b]		Female	
Parameter	Set 1	Set 2	Set 1	Set 2
1951				
Growth Rate	.0238	.0242	.0238	.0242
Plateau's Range	0-35	0-35	15-30	15-30
Preston-Coale Estimate	.755	.768	.700	.712
Projection Estimate	.786	.788	.747	.748
1964				
Growth Rate	.0300	.0295	.0300	.0296
Plateau's Range	0-35	0-35	20-35	20-35
Preston-Coale Estimate	.819	.800	.794	.776
Projection Estimate	.831	.818	.830	.801

[a]Based on use of Zlotnik (1981) adjustment for age exaggeration, with truncation at age 85; see text for explanation.
[b]An adjusted age distribution was used for 1964.

Although these comparisons do not allow us to establish with certainty the best completeness estimates for 1951 and 1964, they do show that the stable and quasi-stable estimates presented in Tables 39 through 42 are not inconsistent with other evidence, once the deficiencies of the latter are taken into account.

2.3.5 The Special Problems of Estimating Mortality in 1973

To conclude, we consider the case of the 1973 census and death registration around that year. This case has not been mentioned in previous sections for two reasons: in terms of quasi-stable models, the 1973 population does not fit the assumptions underlying them (both fertility and mortality started to decline prior to 1973); and in terms of intercensal comparisons, not only is there lack of a complete set of registered deaths for the 1964-73 period, but also the population during that period is less likely to be closed. Since both quasi-stable estimates and those yielded by the Preston-Hill method may be severely affected by such departures from their basic assumptions, no attempt was made to apply them. Unfortunately, the arguments just noted could also be used to invalidate the use of the Preston-Coale method. However, its relative simplicity and the fact that recent changes in fertility are not very likely to affect its results, make it worth using, if only for exploratory purposes.

The first problem one faces in trying to apply the Preston-Coale method to the 1973 data is the need to estimate an appropriate growth rate. Since evidence suggests that the 1973 census achieved a considerably lower completeness of coverage than the 1964 census (see Chapter 1), direct calculations of intercensal growth rates are likely to yield seriously biased estimates. However, the 1974 post-enumeration survey (PES) provides some guidelines regarding possible correction factors for the 1973 census count. According to the PES, 92.8 percent of the private-household population in Colombia's departamentos was enumerated by the 1973 census (DANE, 1981). If we take into account that this population excludes all those living in the national territories, in collective dwellings, in Indian reservations, or serving in the armed forces, a 10-percent correction does not seem high. When this correction is applied to the 1973 data and an intercensal growth rate is calculated on the basis of the 1964 unadjusted census count, the value obtained is 0.0283 for both sexes combined. Since the adjustment factors produced by the 1974 post-enumeration survey do not provide a breakdown by sex, and in any case the exclusion of the armed forces implies that males require a greater correction factor than females, we decided to use the same growth rate for the two sexes.

The data used in applying the Preston-Coale method were the 1973 age distribution of the population in private households published in the final 1973 Census Report (DANE, 1981) and the mean age distribution of deaths registered during the years 1972, 1973, and 1974 (DANE, 1977d). Figure 11 plots the age-specific completeness estimates implied by these data. Once more, a certain tendency to overstate age at death is noticed

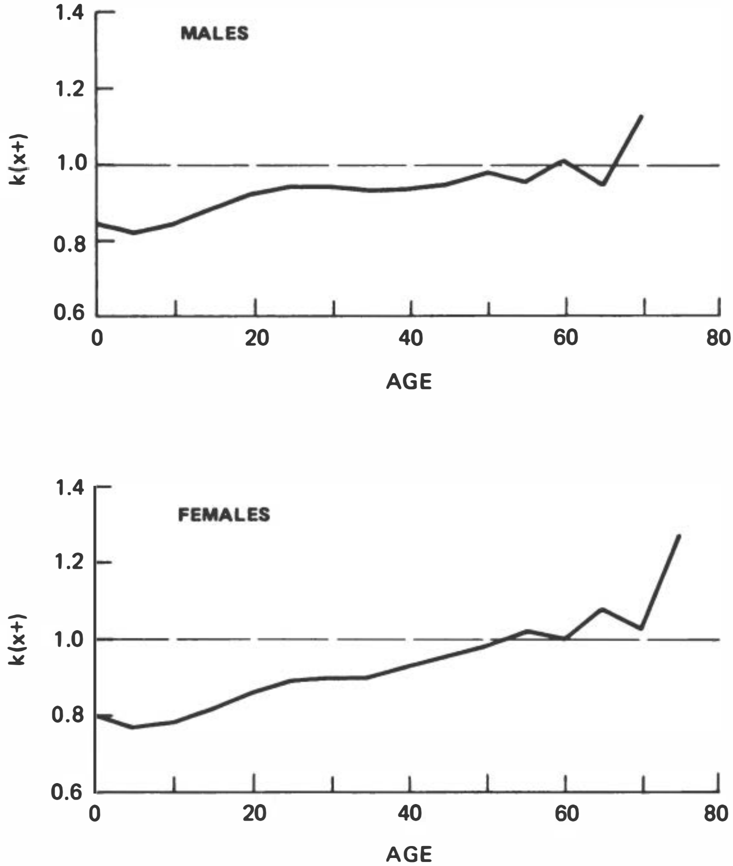


FIGURE 11 Estimated Completeness of Death Registration by Age, Using the Preston-Coale Method Truncated at Age 80, with Growth Rate 0.028, 1973: Colombia

among both males and females. For males, the tendency of completeness estimates to increase as age increases is less marked than for females, and for both sexes the U-shaped curve at younger ages, which was barely suggested in the 1964 plots (Figure 10), has become more accentuated. This initial curvature is caused by deviations from stability.

As in Table 50, the completeness estimates in Figure 11 were derived by applying the Preston-Coale method to redistributed data, generated by Zlotnik's plateau-based redistribution technique. The plateau for males ranged from ages 10 to 30; for females, it ranged from 20 to 35. The mean of the mean estimates of completeness obtained by truncating the redistributed data at several ages (45 to 85) was accepted as a final completeness estimate. Its value was 0.825 for males and 0.735 for females. Since the general consensus is that completeness of registration deteriorated after the changes made in the vital registration system in the late 1960s, these estimates may seem at first rather high. However, one must remember that they represent death registration completeness with respect to the completeness of enumeration of the 1973 census. Since the latter is certainly less than one, absolute completeness of death registration is lower than the 0.825 and 0.735 values. It is also likely that sex differentials in the completeness of census coverage may be at least partly responsible for the increased sex differential in death registration completeness.

Due to lack of other mortality estimates for the period, it is not possible to compare these 1973 completeness estimates with any others. However, their plausibility can be assessed by using the adjustment factors they imply to estimate a series of adjusted $_5m_x$ values. Table 51 shows some of these values and the levels in the "North" family of model life tables to which they correspond. The adjusted $_5m_x$ values are far from regular, since they are associated with different mortality levels at different ages. However, the median levels seem reasonable and the similarity between the two sexes is reassuring.

Although we cannot pretend that these estimates of median mortality levels are solid, they may be the best available for the 1970-80 decade. Due to the paucity of data and the defects plaguing the few sources available, the reliability and consistency of estimates for recent periods cannot be tested. There is, therefore, an unavoidable gap in our knowledge about recent adult mortality levels in Colombia.

2.3.6 Estimation of Adult Mortality Based on Orphanhood Information

Data on the maternal orphanhood status of the population were gathered in 1978 by the National Household Survey

TABLE 51 $_5m_x$ Rates Adjusted According to the 1973 Estimated Completeness of Death Registration and the Levels They Imply in the Coale-Demeny North Model Life Tables: Colombia

	Male		Female	
Age x	$_5m_x$	North Mortality Level	$_5m_x$	North Mortality Level
15	.002288	19.92	.001729	19.52
20	.003809	18.94	.002270	19.48
25	.004365	18.38	.002670	19.39
30	.004736	18.90	.003590	18.36
35	.005615	17.69	.004790	17.43
40	.006588	18.00	.006307	16.80
45	.009382	16.83	.008138	15.68
50	.013091	16.67	.011877	14.41
Median		18.19		17.90

Note: Estimated completeness of death registration for males = .825; females = .735.

(NHS). Brass and Hill (1973) were the first to suggest a method to convert the observed proportions orphaned to life-table probabilities of surviving from age 25 to age 25+N (N depending on the age of respondents). Later, Hill and Trussell (1977) proposed a modified version of the original technique, which has been used here to estimate female adult mortality.

Table 52 shows the results of applying this method to the 1978 NHS data. In addition to the observed proportions orphaned, the method requires as input an estimate of the mean age at which women bear their children. This value, denoted by M, was estimated on the basis of the NHS data themselves and is equal to 27.07 years when the data are classified according to standard five-year age groups and to 27.23 when nonstandard age groups (18-22, 23-27, 28-32, etc.) are used.

The use of data classified according to nonstandard age groups has proved effective in reducing biases due to age-heaping (Hill et al., 1982). In the case of mortality estimation based on orphanhood, the systematic over-reporting of age that results from the combination of

TABLE 52 Estimates of Adult Female Mortality Based on Orphanhood Information from the 1978 NHS: Colombia

Age Group	Proportions Not Orphaned	N	$\frac{l(25+N)}{l(25)}$	North Mortality Level (Females)	Time Reference
Standard[a]					
15-19	.9401	20	.9366	19.63	1970.7
20-24	.9187	25	.9182	20.04	1969.0
25-29	.8492	30	.8530	18.08	1967.5
30-34	.7528	35	.7613	16.04	1966.1
35-39	.6668	40	.6799	15.87	1965.1
40-44	.5574	45	.5690	15.72	1964.4
45-49	.4389	50	.4392	16.04	1964.0
Nonstandard[b]					
18-22	.9251	20	.9365	19.62	1969.7
23-27	.8798	25	.8989	18.65	1968.1
28-32	.7969	30	.8344	17.03	1966.7
33-37	.7070	35	.7631	16.12	1965.5
38-42	.6002	40	.6762	15.71	1964.7
43-47	.4823	45	.5710	15.80	1964.2
48-52	.3480	50	.4285	15.63	1963.4

[a] M = 27.07.
[b] M = 27.23.

heaping on ages ending in 0 or 5 and the use of five-year age groups starting at those ages leads to an overestimation of the length of exposure to the risk of dying among the respondents' mothers and hence to underestimates of female mortality. In the Colombian data, the existence of such biases can be noticed by comparing the mortality levels associated with equivalent l(25+N)/l(25) values derived from standard and nonstandard age groups. In general, those associated with the nonstandard groups are lower than those associated with the standard, and it is clear that the time trend implied by the nonstandard estimates is more consistent (closer to being strictly declining) than that implied by the standard age groups.

Mortality estimates derived from orphanhood information do not refer to only one point in time but represent the average mortality experience over some period preceding the survey. Obviously, if mortality had remained fixed, the exact period to which the estimates refer would be irrelevant. But in cases such as the one at hand, where mortality has not been constant and where the estimates themselves suggest some change over time, it is important to establish precisely the time reference of the estimates obtained.

Brass and Bamgboye (1981) have suggested a method of estimating this reference period. The method assumes that mortality has been changing smoothly and it uses as input the same data as the mortality estimation method (that is, the proportions not orphaned and the mean age of mothers at the birth of their children). The last column in Table 52 shows the time reference estimates associated with each estimated mortality level.

These time references make it possible to compare the mortality estimates in Table 52 with those obtained earlier. In doing so, we have used the estimates derived by using nonstandard age groups, since their biases are likely to be smaller. The obvious comparison possible is that of the mortality level estimated for 1964 and the one obtained on the basis of quasi-stable models. According to Table 52, in 1964 females were subject to a mortality level of about 15.7 or 15.8. According to the Set 1 and Set 2 of estimates in Tables 40 and 42, respectively, the levels in 1964 were 16.1 and 15.6, respectively. Set 2 is closer to the orphanhood-based estimates than Set 1, but the overall consistency is reassuring.

As a check for more recent periods, the mortality estimates derived from the 1973 data (Table 51) can be compared with those derived from orphanhood information about younger respondents. If we accept, as the census data indicate, that level 18 is an appropriate mortality estimate for 1973, the orphanhood estimates whose time reference is close to this point (those associated with age groups 18-22, 23-27 and, even, 28-32) are too high (implying very low mortality). The existence of positive biases in the estimates of mortality level derived from data for young respondents is well documented (Brass and Hill, 1973) and is usually ascribed to the "adoption effect," that is, the tendency of young respondents whose biological mothers have died to report the survival status of their stepmothers. Although it seems somewhat unlikely that the adoption effect would be operating at relatively advanced ages such as 23-27, its residual influence, coupled with some tendency (especially among males) to overstate age may be causing the low mortality estimates observed. In any case, the mortality trend implied by the orphanhood estimates seems suspect even when judged independently: changes of one level or more between time points that are not even two years apart are clearly implausible.

In conclusion, the mortality estimates derived from orphanhood information and referring to years prior to 1966 are acceptable and consistent with other evidence. Those for 1967 and later imply relatively high model mortality levels (i.e. low mortality) that do not seem plausible.

2.3.7 Estimates of Adult Mortality Based on Widowhood

Tables 53 and 54 present estimates of survival probabilities derived from information on the survival of first spouse, gathered by the 1978 NHS. The estimation method used is that presented in U.N. Manual X (United Nations, 1982). Also displayed are the mortality levels implied by each of the estimated survival probabilities within the "North" family of model life tables. Once more, two groupings of the basic data have been used in each case: standard and nonstandard five-year age groups.

A rapid comparison of the levels associated with the survival estimates shows that mortality among males

TABLE 53 Estimates of Adult Female Mortality Based on Widowhood Information from the 1978 NHS: Colombia

Age Group	Proportion Not Widowed (Males)	N	$\frac{l(N)}{l(20)}$	North Mortality Level (Females)	Time Reference
Standard[a]					
25-29	.9909	25	.9906	20.45	1978.0
30-34	.9883	30	.9878	22.48	1975.7
35-39	.9740	35	.9728	21.22	1973.4
40-44	.9501	40	.9466	19.64	1971.2
45-49	.9274	45	.9244	19.48	1969.2
50-54	.9005	50	.8992	19.42	1967.5
55-59	.8958	55	.9009	21.39	1966.4
Non-Standard[b]					
28-32	.9874	30	.9811	20.78	1976.6
33-37	.9828	35	.9783	22.10	1974.4
38-42	.9643	40	.9560	20.64	1972.1
43-47	.9284	45	.9130	18.59	1969.9
48-52	.9150	50	.9018	19.58	1968.2
53-57	.9048	55	.8935	20.97	1966.8
58-62	.8393	60	.8185	19.24	1965.6

[a] $SMAM_f = 22.85$; $SMAM_m = 26.33$
[b] $SMAM_f = 22.84$; $SMAM_m = 26.41$

TABLE 54 Estimates of Adult Male Mortality Based on Widowhood Information from the 1978 NHS: Colombia

Age Group	Proportion Not Widowed (Females)	N	$\frac{l(N)}{l(20)}$	North Mortality Level (Females)	Time Reference
Standard[a]					
20-24	.9847	25	.9790	18.09	1978.6
25-29	.9785	30	.9656	19.68	1976.4
30-34	.9646	35	.9497	19.99	1974.1
35-39	.9371	40	.9219	19.18	1971.8
40-44	.8869	45	.8740	17.57	1969.8
45-49	.8250	50	.8174	16.46	1967.9
50-54	.7565	55	.7581	16.14	1966.4
55-59	.6671	60	.6792	15.56	1965.0
Nonstandard[b]					
23-27	.9873	25	.9861	21.04	1977.3
28-32	.9678	30	.9651	19.58	1975.0
33-37	.9469	35	.9450	19.38	1972.7
38-42	.9006	40	.9042	17.51	1970.5
43-47	.8624	45	.8739	17.56	1968.7
48-52	.7763	50	.8043	15.71	1966.9
53-57	.7147	55	.7611	16.28	1965.6

[a] $SMAM_f$ = 22.85; $SMAM_m$ = 26.33
[b] $SMAM_f$ = 22.84; $SMAM_m$ = 26.41

(estimated on the basis of answers by female respondents) is consistently higher than that among females, the differential being of at least two mortality levels for each estimate. Several factors may cause such unexpected differentials, including consistent exaggeration of male ages, consistent understatement of female ages, or the fact that males report less accurately the survival of their first spouses than do females. The last is a fairly common cause of bias in populations like Colombia's where consensual unions are frequent and men tend to report the survival status of their current spouse rather than that of their first spouse. Comparison of the dated mortality estimates for females (Table 53) with those derived from orphanhood information (Table 52) shows that the levels obtained from widowhood data are too high, even for the earlier periods. Hence, these estimates have to be rejected.

In contrast, the estimates of male mortality derived from the widowhood status of females (Table 54) are not entirely inconsistent with other estimates of male mortality. Those derived from reports by younger women (less than 39) are, however, fairly high. Although no estimate refers exactly to 1964, the one derived from age group 55-59, which refers to 1965 (15.56) is fairly close to the estimates derived by using quasi-stable models (15.94 according to Set 1 data and 15.72 according to Set 2 data). However, it is difficult to establish with certainty which of these estimates is "best," and if one rejects the estimates referring to the 1970s, only a rather rough indication of trend can be obtained from those corresponding to the 1960s.

To conclude, we stress that for males the estimated levels for recent periods are unrealistically high, so they do not invalidate the estimates made above on the basis of the 1973 census and death registration data. Estimates for earlier periods seem acceptable, although it is difficult to establish whether the standard or the nonstandard set is better. The consistency between the 1965 estimates and those derived via quasi-stable models is reassuring. The widowhood-based estimates for females, on the other hand, are disappointing. Both their internal inconsistencies (the trend they imply is far from smooth) and their marked deviations from comparable estimates derived from other sources render them highly suspect. Their future use, therefore, is not recommended.

2.3.8 Final Mortality Estimates for 1950-75

In general, the revised stable and quasi-stable estimates of adult mortality presented in Tables 39 through 42 appear satisfactory on the basis of all possible consistency tests. Hence, they have been adopted as basically representative for the 1950-64 period. The evidence referring to subsequent years is both sparse and weaker in nature. The best possible estimates for the 1970-79 decade are probably those derived from the 1973 census and from registered deaths adjusted for underregistration. When interpreted in terms of the "North" family of model life tables, such estimates yield median levels that are both plausible and in line with reliable estimates derived from other sources (orphanhood and female widowhood). Hence, they have also been adopted as satisfactory.

Due to the availability of abundant and better quality data, fairly reliable estimates of childhood mortality can be obtained for the 1965-75 period. Although some estimates are available for years prior to 1965 (see

Table 32), their reliability is open to question, especially because they approximate too closely the flawed infant mortality estimates obtained from vital registration. Compared to those implied by the stable and quasi-stable estimates for the same period, they appear to underestimate mortality.

To produce a complete final series of mortality estimates for the 1950-78 period, we used yearly life tables generated on the basis of stable and quasi-stable estimates of Set 2 (Tables 41 and 42) via linear interpolation within the logit system, with "West" female level 16 as the standard. This set was complemented by a series of yearly life tables for 1964-73, which were obtained by the same process using "North" level 18 for both males and females as an estimate for 1973. A mixed mode of extrapolation was used to prolong the series beyond 1973. Linear change was assumed only until 1975 and from then on the rate of change in mortality was drastically reduced. Uncertainty about the true levels prevalent in the most recent periods made the use of almost unchanging mortality seem reasonable.

Once a series of consistent life tables for the 1950-78 period had been calculated, they were merged with the child mortality estimates for 1962-78 from Table 32. Two levels of consistency were maintained during the merging process: internal consistency of each life table that was generated, and longitudinal consistency of the estimates (in the sense that their trend over time should be reasonable). The first type of consistency was given priority, and therefore a certain roughness was tolerated in the time trend of some parameters. The merging process altered little the final child mortality estimates for females, but it modified the male estimates somewhat more. Table 55 shows our final child mortality estimates by sex for 1950-78.

Table 2 (in the summary at the beginning of the report) presents yearly estimates of the expectation of life at birth, e_0, and of the expectation of life at age 5, e_5, for the 1950-78 period. Abridged life tables, by sex for 1950, 1955, 1960, 1965, 1970, and 1975 appear in Appendix F (Tables F.1 through F.6).

2.3.8.1 *Comparison of Final Mortality Estimates With Earlier Estimates*

Arriaga's estimates of e_0 and e_5 for 1951 (Table 35) are higher than the final estimates presented in Table 2

TABLE 55 Final Child Mortality Estimates by Sex, 1950-78: Colombia

	Female					Male				
Year	$_{1}q_{0}$	$_{2}q_{0}$	$_{3}q_{0}$	$_{5}q_{0}$	$_{10}q_{0}$	$_{1}q_{0}$	$_{2}q_{0}$	$_{3}q_{0}$	$_{5}q_{0}$	$_{10}q_{0}$
1950	.1375	.1740	.1908	.2107	.2322	.1619	.1983	.2147	.2337	.2533
1951	.1347	.1709	.1876	.2072	.2287	.1587	.1948	.2111	.2300	.2497
1952	.1294	.1647	.1811	.2004	.2218	.1524	.1879	.2040	.2227	.2426
1953	.1242	.1589	.1748	.1938	.2151	.1464	.1813	.1971	.2157	.2356
1954	.1193	.1530	.1687	.1874	.2085	.1405	.1748	.1904	.2087	.2287
1955	.1145	.1474	.1628	.1811	.2021	.1349	.1685	.1839	.2020	.2220
1956	.1098	.1419	.1570	.1750	.1958	.1294	.1624	.1775	.1954	.2155
1957	.1053	.1366	.1514	.1690	.1897	.1242	.1565	.1714	.1889	.2090
1958	.1010	.1315	.1460	.1633	.1837	.1191	.1507	.1654	.1827	.2028
1959	.0969	.1266	.1407	.1576	.1779	.1142	.1451	.1595	.1766	.1966
1960	.0924	.1215	.1356	.1522	.1722	.1095	.1397	.1539	.1706	.1906
1961	.0884	.1168	.1307	.1468	.1666	.1049	.1345	.1484	.1648	.1848
1962	.0852	.1128	.1259	.1417	.1612	.1006	.1294	.1430	.1592	.1791
1963	.0829	.1097	.1212	.1367	.1560	.0973	.1212	.1320	.1489	.1735
1964	.0813	.1071	.1167	.1318	.1508	.0942	.1173	.1278	.1442	.1681
1965	.0796	.1045	.1145	.1295	.1483	.0920	.1146	.1249	.1408	.1654
1966	.0777	.1017	.1122	.1268	.1453	.0901	.1120	.1220	.1375	.1623
1967	.0758	.0989	.1076	.1215	.1393	.0875	.1085	.1181	.1329	.1563
1968	.0739	.0962	.1032	.1165	.1336	.0849	.1051	.1142	.1284	.1505
1969	.0717	.0933	.0994	.1124	.1280	.0822	.1016	.1104	.1242	.1449
1970	.0691	.0904	.0962	.1090	.1221	.0793	.0982	.1067	.1201	.1395
1971	.0666	.0876	.0934	.1063	.1165	.0765	.0949	.1032	.1162	.1342
1972	.0642	.0848	.0908	.1038	.1119	.0738	.0917	.0997	.1124	.1291
1973	.0619	.0821	.0881	.1010	.1082	.0712	.0885	.0963	.1087	.1241
1974	.0606	.0807	.0866	.0995	.1066	.0693	.0861	.0937	.1059	.1193
1975	.0603	.0804	.0864	.0993	.1068	.0690	.0858	.0934	.1056	.1189
1976	.0600	.0802	.0861	.0991	.1067	.0687	.0855	.0931	.1053	.1184
1977	.0597	.0799	.0859	.0990	.1066	.0684	.0852	.0928	.1050	.1179
1978	.0594	.0796	.0856	.0988	.1064	.0681	.0849	.0925	.1047	.1175

because they depend on the assumption that mortality started to decline in 1938. Under this assumption, the growth rate for 1951 was greater than the one implicit in our estimates and, coupled with a fixed age distribution, it produces lower estimates of mortality (i.e., greater expectations of life). Although Arriaga's assumption cannot be totally disproved, the similarity between the 1938 and 1951 age distributions (Lopez, 1968) does not suggest that mortality had been changing for a long time by 1951. Furthermore, Arriaga does not address the case of the 1964 population. If his assumptions about declining mortality were correct, mortality in 1964 would be lower than the estimates in Table 2 (since the estimated growth rate for 1964 would be higher than the ones used in Tables 39 through 42). However, as the orphanhood and female widowhood estimates suggest, this was not the case.

The Table 2 estimates can also be compared to Potter and Ordonez's e_5 estimates for 1938, 1951, and 1973, shown in Table 56. As with Arriaga's estimates, the Potter and Ordonez estimates are higher than those in Table 2, a fact that is not suprising given the positive bias that exaggeration of age at death introduces in the completeness estimates, a bias which was not taken into account by Potter and Ordonez. Even so, the difference between the two sets of estimates for 1973 is small.

A third set of mortality estimates that has been widely used is Bayona's estimates for 1964 and 1973, which were derived via a regression model (Bayona, 1977b). Bayona used data from several departamentos with relatively good data to estimate the parameters of linear equations relating the values of a variable representing the level of "modernization" to estimates of mortality (the overall death rate and the expectation of life at birth). Then, the estimated linear equations were used to predict the mortality parameters prevalent in departamentos with inadequate mortality data. The expectation of life for the country as a whole was obtained in a similar fashion. "South" model life tables were then selected on the basis of the estimated e_0 values, and all other parameters were derived from these life tables. Table 57 displays Bayona's estimates of e_0 and e_5 for the country as a whole. Bayona's e_0 estimates agree fairly well with

TABLE 56 Potter and Ordonez's Estimates of Death Registration Completeness and e_5 by Sex, 1951, 1964, and 1973: Colombia

	Male		Female	
Year	Completeness	e_5	Completeness	e_5
1951	.870	54.9	.865	57.5
1964	.880	59.7	.880	63.2
1973	.740	61.1	.740	64.8

Source: Potter and Ordonez (1976).

TABLE 57 Bayona's Estimates of e_0 and e_5 by Sex, 1964 and 1973: Colombia

	Male		Female	
Year	e_0	e_5	e_0	e_5
1964	53.66	59.82	56.99	62.79
1973	57.14	61.82	60.82	65.07

Source: Bayona (1977b).

those in Table 2, but his e_5 estimates are higher than the Table 2 values. This discrepancy arises because the model chosen by Bayona to represent mortality, namely "South", does not approximate adequately true mortality experience in Colombia. In fact, it is interesting to note that even though Bayona himself asserts that the estimates proposed by Potter and Ordonez are too high, his own e_5 values are, in general, higher. Therefore, although the e_0 estimates he proposes seem reasonable, it seems unwise to use any other parameters derived from his set of life tables.

Finally, we consider the U.S. Bureau of the Census (1979) estimates of e_5 in 1973: 59.8 for males and 63.3 for females. These estimates are very close to those in Table 2, but the corresponding e_0 estimates (57.1 for males and 60.8 for females) are noticeably lower than those in Table 2 (58.09 and 61.68, respectively). The reason for this discrepancy is that the child mortality estimates proposed by the U.S. Bureau of the Census are derived via the "West" model which, as illustrated earlier in this chapter, does not adequately represent recent Colombian mortality.

Thus, most of the discrepancies observed between the final set of mortality estimates presented here and those proposed elsewhere can be attributed to known causes of error. No evidence of serious and consistent biases in the set proposed here could be found.

2.4 SUMMARY

Mortality levels in Colombia have declined consistently during the past three decades. From 1950 to 1975 the country experienced on average annual gain in the expectation of life at birth of approximately 0.60 years for males and 0.62 years for females. A substantial proportion of these gains was due to large declines in childhood mortality. During the same period, infant mortality decreased by some 57 percent, while the reduction in mortality from birth to age 5 amounted to about 55 percent. Although reliable estimates for the most recent years are not yet available, it is likely that this decline has continued.

3

ESTIMATION OF FERTILITY

According to all available estimates, Colombia has experienced a rapid decline in fertility during the past 15 years. This decline was first documented by the analysis of the 1969 NFS data (ASCOFAME, 1973b). Data from the 1973 census sample confirmed it (Potter and Ordonez, 1976; Potter et al., 1976; DANE, 1976a), as did the data gathered by all the more recent surveys (1976 CFS, 1978 Contraceptive Prevalence Survey, and 1978 NHS). The fact that a decline has taken place is undeniable, but uncertainties remain about what the current level is and about what the level was before the decline began.

In this chapter the available evidence is examined in an attempt to find the best answer to these two questions. Estimates of fertility levels and trends have been obtained essentially from three types of information: fertility histories; births in a given year and parity reports; and the enumerated children, classified by age of child and age of mother.

3.1 DATA FROM FERTILITY HISTORIES

The fertility history (or maternity history) of a woman is a list of the children she has borne and the times at which they were born. Information about pregnancies not resulting in live births may also be included, together with information about the survivorship status of each child. Fertility histories are usually recorded by means of fairly lengthy questionnaires. Two surveys that gathered fertility histories have been carried out at the national level in Colombia: the 1969 NFS and the 1976 CFS.

3.1.1 Data from the 1969 NFS

In principle, fertility history information is ideal for studying fertility levels and trends through time. In practice, however, errors often present in the data lessen their value. Therefore a thorough scrutiny of the data's quality is necessary before accepting the validity of estimates derived from them. In the case of Colombia, it seems fair to say that only the CFS data have been subjected to deep scrutiny. Lack of adequate tabulations has prevented more thorough analysis of the NFS data, summarized in Tables 58 and 59. For example, detailed estimates of age-specific fertility rates by five-year cohorts are available only for rural areas. For urban areas, the published age-specific fertility rates by five-year periods cover only the 10 years preceding the survey, so it is not possible to estimate cohort fertility. This limitation severely reduces the possibilities for assessing the overall quality of the data.

Yet, even from these sketchy tabulations, some conclusions can be drawn. For example, notice how for every age group in the rural section of Table 58 the rates in the earliest period are the lowest (except for age group 40-44). This would imply that the 1934-38 cohort (women aged 45-49 in 1969 who were at the beginning of their childbearing--ages 15-19--in 1934-38) had lower fertility than its successors. In addition, according to Table 59 the average number of children reported by this cohort is similar to the average reported by the 1944-48 cohort (women aged 35-39 in 1969), even though the latter was 10 years younger at the time of interview. Since the increase in fertility that this implies is so unlikely, one must search for a more plausible explanation of the reported data. Event omission by older women, an error commonly observed in fertility-history data, is a possible one. The fact that mortality levels estimated from NFS data are also too low (see Figure 4) supports this possibility.

Further evidence in its support is obtained from the 1976 CFS data. Table 60 compares the period estimates of age-specific fertility rates derived from the NFS with those from the CFS maternity history data. In most cases the CFS estimates are higher. The differences in terms of fertility cumulated to age 35 imply that the NFS underestimated fertility by about 3 percent in the last two periods. For 1960-64, the agreement between the two sources is much closer.

TABLE 58 Age-Specific Fertility Rates by Five-Year Periods from the 1969 NFS: Colombia

	Age Group						
Period	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Rural[a]							
1934-38	.083	--	--	--	--	--	--
1939-43	.126	.255	--	--	--	--	--
1944-48	.154	.303	.318	--	--	--	--
1949-53	.154	.316	.331	.322	--	--	--
1954-58	.158	.334	.355	.343	.258	--	--
1959-63	.144	.333	.385	.331	.265	.112	--
1964-68	.143	.323	.361	.323	.257	.109	.026
Urban[b]							
1959-63	.117	.265	.284	.270	.188	--	--
1964-68	.096	.227	.242	.204	.134	.071	--
Total[b]							
1959-63	.129	.299	.337	.304	.230	.098	--
1964-68	.118	.270	.229	.272	.195	.090	.010

Sources: [a]ASCOFAME (1973a:208).
[b]Pierret (1979:6, 8).

An additional set of estimates based on the 1969 NFS is the period age-specific fertility rates calculated by Elkins for 1960-68 (ASCOFAME, 1973b), which appear in Tables 61 and 62. As expected, rural fertility is higher than urban fertility, and fertility is indeed declining over time. Notice, however, that the total fertility rate estimated for 1968-69 (shown in Table 61) is about 12 percent higher than that for 1967-68. The data upon which the 1968-69 estimates are based were also gathered by the 1969 survey but were tabulated only recently (Ochoa and Ordonez, 1980). These estimates, although internally consistent, are higher than those derived from other sources for the same period, in spite of the general downward bias that seems to affect the other NFS estimates.

TABLE 59 Reported Average Parity from Fertility Histories of the 1969 NFS: Colombia

Age Group	Rural[a]	Urban[a]	Total[b]
15-19	0.2	0.2	0.20
20-24	1.5	1.1	1.27
25-29	3.2	2.4	2.85
30-34	5.1	3.5	4.43
35-39	6.6	4.8	5.78
40-44	7.3	5.7	6.60[c]
45-49	6.8	5.6	6.30[c]

Sources: [a]ASCOFAME (1973a:204).
[b]Hobcraft (1980:50).
[c]CCRP (1980:15).

The reasons for this puzzling outcome are unknown, but they may be related to the character of the NFS sample.

3.1.2 Data from the 1976 CFS

Detailed analysis of the CFS maternity history data have shown them to be adequate. In particular, Hobcraft (1980) showed that estimates derived from these data are consistent with those derived from other sources, including the CFS own household survey, the 1973 census, and the 1969 NFS. Table 63 presents the total and age-specific fertility rates by time period estimated from the CFS maternity histories. One problem underlying these data is that arising from truncation at the time of interview (only women 15 to 49 in 1976 were eligible for individual interview). The further one moves into the past, the more the recorded fertility experience is curtailed, so comparisons with other data sources become more difficult and unreliable (estimates for earlier periods are based on fewer recorded events and are therefore subject to greater variability). To enhance the possibilities for comparison, some values presented in Table 63 were derived by using the experience of cohorts whose recorded fertility experience was more complete to estimate the missing rates.

TABLE 60 Comparison of Age-Specific Fertility Rates for Different Periods, Estimated from CFS and NFS
Data: Colombia

	Period					
	1960-64		1965-66		1967-68	
Age Group	CFS	NFS	CFS	NFS	CFS	NFS
15-19	.131	.129	.146	.125	.110	.110
20-24	.308	.299	.301	.270	.287	.270
25-29	.340	.337	.302	.321	.314	.278
30-34	.300	.304	.265	.267	.253	.277
35-39	--	.230	.230	.214	.204	.176
Cumulated Fertility						
20	0.655	0.645	0.730	0.625	0.550	0.550
25	2.195	2.140	2.235	1.975	1.985	1.900
30	3.895	3.825	3.745	3.580	3.555	3.290
35	5.395	5.345	5.070	4.915	4.820	4.675
40	--	6.495	6.220	5.985	5.840	5.555

Source: Hobcraft (1980:50).

3.2 DATA ON AVERAGE PARITY AND BIRTHS OCCURRING DURING A GIVEN YEAR

Data on births occurring during a given year, gathered by either a survey or a census, have become the most widely used source of period fertility estimates. Part of their success is due to the existence of the Brass P/F ratio method (see glossary), an estimation technique that checks the consistency and adjusts the deficiencies of observed data.

Unfortunately, the adjusting capabilities of the Brass P/F ratio method are heavily dependent on the assumption of constant fertility. In cases where a decline in fertility is suspected, the method becomes a valuable confirmatory tool but loses its power to measure deficiencies.

At present, there is no P/F-type method available that can adjust current fertility when fertility levels have been declining. However, a variation of the original P/F method that comes close to satisfying these requirements

TABLE 61 Age-Specific Fertility Rates for Different Periods from the 1969 NFS: Colombia

Age Group	Period 1960-64	1965-66	1967-68	1968-69
15-19	.129	.125	.110	.099
20-24	.299	.270	.270	.269
25-29	.337	.321	.278	.305
30-34	.304	.267	.277	.275
35-39	.230	.214	.176	.247
40-44	.098[a]	.095	.085	.128
45-49	.010[b]	.010[b]	.010[a]	.025
Total Fertility Rate	7.035	6.510	6.030	6.740

[a]Adjusted.
[b]Projected from later period.

Sources: 1960-64, 1965-66, and 1967-68: ASCOFAME (1973b:31). 1968-69: Ochoa and Ordonez (1980:5).

is the first-birth P/F ratio method, an analog of the usual Brass method applied only to first-birth data (United Nations, 1982). Its use for adjusting observed current fertility depends on two assumptions: that first births are under- or overreported to the same degree as those of other orders and that the first-birth age-specific fertility rates have remained constant. In the case of Colombia there is no direct evidence substantiating either of these hypotheses. The second assumption might be violated if age at first marriage had been changing. Unfortunately, data on marital status and age at marriage in most of Colombia's data sources have been poor. Both the relatively high incidence of consensual unions and the use of various definitions when data on this subject were gathered have contributed to the many inconsistencies observed in the available information. However, the best evidence available (obtained from the nuptiality histories gathered by the CFS) shows that the mean age at first marriage has remained almost unchanged during the last 20 or 30 years (Florez and Goldman, 1980). Therefore, at least on these grounds, there is no reason

TABLE 62 Rural and Urban Age-Specific Fertility Rates for Different Periods from the 1969 NFS: Colombia

Age Group	Period 1960-64	1965-66	1967-68
Urban			
15-19	.117	.099	.093
20-24	.265	.241	.214
25-29	.284	.261	.223
30-34	.270	.206	.201
35-39	.188	.150	.118
40-44	.082[a]	.078	.064
45-49	.004[b]	.004[b]	.004[a]
Total Fertility Rate	6.050	5.195	4.585
Rural			
15-19	.144	.159	.132
20-24	.331	.300	.336
25-29	.382	.373	.331
30-34	.331	.320	.340
35-39	.263	.265	.223
40-44	.111[a]	.107	.102
45-49	.016[b]	.016[b]	.016[a]
Total Fertility Rate	7.890	7.625	7.400

[a]Adjusted.
[b]Estimated from previous periods.

Source: ASCOFAME (1973b:31).

TABLE 63 Estimated Age-Specific Fertility Rates from Individual Maternity Histories from the 1976 CFS: Colombia

Calendar Year	Total Fertility	Age Group						
		15-19	20-24	25-29	30-34	35-39	40-44	45-49
1976	4.47	.1015	.2335	.1929	.1657	.1151	.0640	(.0218)
1975	4.56	.0904	.2013	.2351	.1751	.1401	.0471	[.0222]
1974	4.28	.0997	.2265	.2024	.1485	.1073	.0505	[.0209]
1973	4.69	.1034	.2288	.2210	.1734	.1293	.0601	[.0229]
1972	5.05	.1067	.2564	.2282	.1842	.1376	.0728	[.0246]
1971	5.34	.1157	.2586	.2544	.2014	.1438	[.0682]	[.0260]
1970	5.71	.1197	.2649	.2908	.2075	.1591	[.0730]	[.0279]
1969	5.89	.1075	.2698	.2771	.2314	.1881	[.0752]	[.0287]
1968	6.79	.0966	.2741	.3303	.2958	.2406	[.0867]	[.0331]
1967	5.81	.1235	.3006	.2603	.2084	.1668	[.0742]	[.0283]
1966	6.60	.1305	.3138	.2840	.2748	[.2008]	[.0843]	[.0322]
1965	6.75	.1629	.2874	.3200	.2555	[.2053]	[.0862]	[.0329]
1964	7.06	.1160	.3283	.3461	.2821	[.2147]	[.0902]	[.0344]
1963	6.93	.1206	.3022	.3507	.2799	[.2108]	[.0885]	[.0338]
1962	7.01	.1385	.3059	.3136	.3077	[.2133]	[.0896]	[.0342]
1961	- -	.1338	.2892	.3425	(.3077)			
1960	- -	.1547	.3148	.3451	(.3357)			
1959	- -	.1287	.3109	.2982	(.3096)			
1958	- -	.1437	.3292	.3609	(.3574)			
1957	- -	.1318	.2610	.2960	(.4437)			
1956	- -	.1429	.3214	(.3657)				
1955	- -	.1401	.3115	(.3061)				
1954	- -	.1351	.3005	(.3320)				
1953	- -	.1156	.3238	(.2918)				
1952	- -	.1173	.2960	(.3170)				
1951	- -	.1078	(.2295)					
1950	- -	.1524	(.2798)					

Note: ( ) indicates that the cohort experience was incompletely recorded. [ ] indicates that data were estimated by prorating the rates observed in previous calendar years.

Source: Hobcraft (1980:42).

to expect that first-birth fertility at younger ages has changed during that period.

Finally, even when fertility has been changing, a P/F-type method can be used to both explain and adjust fertility estimates whenever data on births in a year and on average parity are available for two points in time approximately five years apart (Zlotnik and Hill, 1981). When the data are adequate, the use of synthetic or hypothetical cohorts subject to the intersurvey or intercensal fertility experience of the population make it possible to estimate an adjusted fertility schedule for the intersurvey period. Application of this technique usually highlights inadequacies in the data so its use is always valuable for exploratory purposes.

In Colombia, data on births occurring during the year prior to the survey have been gathered by the 1969 NFS, the 1973 census, the 1976 CFS at the household level, the 1978 NHS and the 1978 Contraceptive Prevalence Survey. The data from each of these sources are discussed in the following sections.

3.2.1 The 1969 National Fertility Survey

Ochoa and Ordonez (1980) estimated a fertility schedule for the year preceding the 1969 survey using information about births occurring during that year as reported in the maternity histories (Table 61). These data are sufficient to estimate the values of F (United Nations, 1982) and since information on the average parity of the interviewed women has also been published (Table 59), it is possible to assess the consistency of the data using the P/F ratio method. Table 64 shows the P/F ratios obtained. With the exception of the P(1) and P(7) values, the consistency between the two sets P and F is very good. The slight rise in the P/F ratios as age increases suggests some change in fertility, but the increase is too small to conclusively indicate a trend.

The estimated age-specific fertility rates displayed in Table 64 [f(i)] have been adjusted only to account for

TABLE 64 Application of the P/F Ratio Method to the 1969 NFS Data: Colombia

Age Group	i	Parity[a] P(i)	Fertility[b] F(i)	P/F	Estimated f(i)
15-19	1	0.20	0.22	0.93	0.1176
20-24	2	1.27	1.27	1.00	0.2801
25-29	3	2.85	2.76	1.03	0.3054
30-34	4	4.43	4.19	1.06	0.2722
35-39	5	5.78	5.52	1.05	0.2399
40-44	6	6.60	6.41	1.03	0.1142
45-49	7	6.30	6.71	0.94	0.0186

Sources: [a]Hobcraft (1980:50).
[b]Ochoa and Ordonez (1980).

the fact that the rates proposed by Ochoa and Ordonez (Table 61) probably refer to women who at the time of their most recent birth were on average half a year younger than at the time of interview. A procedure for making half-year adjustments, including the necessary equations and weighting factors, is described in U.N. Manual X (United Nations, 1982). The total fertility implied by the adjusted rates is 6.74, which, as noted above, differs substantially from that estimated by Elkins for 1967-68 (6.03). Deeper scrutiny of the NFS data, probably requiring retabulations of the raw data, would be necessary to establish the causes of this discrepancy. Faced with the impossibility of carrying out such an exercise, we simply note that although the results in Table 64 attest to the internal consistency of the 1968-69 data, problems relating to the NFS sampling scheme and other inconsistencies in the overall data set lead us to doubt the validity of any estimates derived from this source.

3.2.2 The 1973 Census Sample

The 1973 census included two questions on fertility: number of children ever born and date of most recent live birth. Tabulations of these data have only been made on the basis of the advance census sample (see Chapter 1), and variations in the treatment of the basic data have led to nontrivial differences between the published sets. Some of these differences may stem from the treatment of women of not-stated parity when calculating age-specific fertility rates or mean numbers of children ever born. Both the addendum to the advance census sample (DANE, 1977b) and the final census results (DANE, 1981) show the number of women who provided valid responses to the fertility questions. According to both sources, there was a fairly large incidence of nonresponse. Table C.1 of Appendix C shows the levels derived from the census sample. (Those from the final count are very similar and are not displayed.) The high correlation between the proportions of nonrespondents classified by age and the proportions of women who declared having no children suggests that most of the cases of nonresponse were, in fact, coding errors: no entry was marked for women who declared having zero children. This type of error arises frequently in censuses and surveys. El-Badry (1961) has proposed a method to adjust parity information by estimating the true level of nonresponse. Its application to the 1973 census sample is shown in Figure C.1 of Appendix C.

Another source of discrepancy is the fact that fertility rates calculated directly from the number of births occurring during the year preceding the census and the number of women classified according to their reported age at the time of the census refer to age groups shifted by half a year (since the women who had a child during the year in question were, on average, half a year younger at the time of the birth than at the time of the census). It is possible to adjust these rates for this half-year age shift (United Nations, 1982). Therefore, differences in the age-specific fertility rates obtained from different sources may result from the fact that some sets incorporate this adjustment while others do not.

The two panels of Table 65 illustrate these differences. All the rates in Part A refer to age groups shifted by half a year, while those in Part B refer to the standard age groups, adjusted for this shift. Potter and Ordonez (1976) adopted the adjusted rates shown in column 2 of Table 65 as representative of fertility in Colombia during 1972-73, whereas DANE (1976a) adopted the unadjusted rates (Part A, column 3). Because one set is adjusted and the other is not, their direct comparison is unwarranted. Comparison of sets that are equally adjusted (or unadjusted) shows that the DANE estimates are consistently higher than those by Potter and Ordonez. There are two possible causes for this discrepancy: Potter and Ordonez use all women as denominator and adjust the number of births so that they refer exactly to a 12-month period (the date of the most recent birth was coded only by month and year, hence some type of adjustment is necessary to estimate the number of births occurring between October 24, 1971 and October 23, 1973, the day before the census date). DANE (1976a) does not indicate what adjustments were made in calculating the rates, but if births for a period slightly longer than a year were included or if only women with valid responses to the question on date of most recent birth were used as denominator, the observed descrepancies would be expected.

A more serious inconsistency between the different sources of data from the 1973 census sample is noticed when fertility rates are calculated by dividing the number of births in the year preceding the census (DANE, 1976a:38) by the number of women in the sample (DANE, 1975a:25). The last column of Table 65 shows the results

TABLE 65 Comparison of Age-Specific Fertility Rates Calculated on the Basis of the 1973 Census Sample: Colombia

Age Group	Potter and Ordonez[a]	DANE[b]	Calculated from Published Data[c]
Part A: Observed Data			
14.5-19.5	.063	.065	.070
19.5-24.5	.200	.207	.226
24.5-29.5	.206	.213	.233
29.5-34.5	.176	.183	.201
34.5-39.5	.135	.145	.160
39.5-44.5	.068	.072	.080
44.5-49.5	.023	.024	.027
Part B: Rates Adjusted for Half-Year Age Shift			
15-19	.077	.079	.086
20-24	.207	.215	.235
25-29	.205	.212	.232
30-34	.172	.179	.197
35-39	.130	.140	.154
40-44	.063	.065	.072
45-49	.019	.019	.021
Total Fertility Rate	4.365	4.545	4.984

Sources: [a]Potter and Ordonez (1976:386).
[b]DANE (1976a:43).
[c]DANE (1975a:25; 1976a:38).

obtained. Both the adjusted and the unadjusted rates are consistently greater than either the DANE estimates or the ones by Potter and Ordonez, producing a total fertility rate that is at least 10 percent higher than the other two. No documented explanation has been found for this unexpected outcome. It is suspected, however, that the weighting schemes used in producing the 1975 and the 1976 tabulations may have been different.

These observations raise questions about the true meaning of the published figures. In order to establish which sets are valid estimates of fertility as measured by the 1973 census sample, age-specific fertility rates were recalculated from the basic data[3] and are presented in Table 66. The numerators of these rates were adjusted to reflect only those births occurring between October 24, 1972 and October 23, 1973, and rates were derived using as denominator either all women or the number of

TABLE 66 Age-Specific Fertility Rates Recalculated from the Original 1973 Census Sample: Colombia

	Denominator of Rate	
Age Group	All Women	Women as Adjusted by El-Badry Method
Part A: Observed Rates		
14.5-19.5	.064	.065
19.5-24.5	.204	.206
24.5-29.5	.210	.213
29.5-34.5	.180	.182
34.5-39.5	.138	.140
39.5-44.5	.069	.070
44.5-49.5	0.24	.024
Part B: Rates Adjusted for Half-Year Age Shift		
15-19	.079	.080
20-24	.211	.214
25-29	.209	.211
30-34	.176	.179
35-39	.133	.134
40-44	.063	.064
45-49	.019	.019
Total Fertility Rate	4.447	4.503

women that resulted after applying El-Badry's adjustment techniques (see Appendix C). The second set is almost identical to that published by DANE (1976a). It indicates that total fertility during 1972-73 was 4.503. From here on, this set will be adopted as the "unadjusted" measure of current fertility yielded by the 1973 census.

Table 67 shows average parities by age using the adjusted number of women as denominator (see Appendix C), the F values obtained from the age-specific rates presented in Part A, column 3 of Table 66 by using the method described in U.N. Manual X (United Nations, 1982), and the corresponding P/F ratios. As expected, these ratios show an increasing trend with age, indicating that the 1973 census data are consistent with a decline in fertility.

First-birth age-specific fertility rates based on the 1973 census sample were published by Potter and Ordonez (1976). In fact, these authors were first to apply a version of the first-birth P/F ratio method to such data. However, they attributed the results obtained to the effects of changing age at marriage. Yet, as we pointed out above, the only reliable and consistent data set on nuptiality in Colombia (the 1976 CFS) shows no evidence in support of the existence of such a change

TABLE 67 Application of the P/F Ratio Method to the 1973 Census Sample: Colombia

Age Group	Observed Parity P(i)	Estimated Parity F(i)	P(i)/F(i)
15-19	0.144	0.137	1.05
20-24	1.050	0.924	1.14
25-29	2.440	2.003	1.22
30-34	3.935	2.984	1.32
35-39	5.107	3.774	1.35
40-44	5.866	4.243	1.38
45-49	6.108	4.475	1.36

Note: The denominator used are women as adjusted by the El-Badry method (see Appendix C).

(Florez and Goldman, 1980). Hence, the results of the first-birth P/F ratio technique should not be automatically discarded as indicators of the degree of reference-period error in the data.

Table 68 shows the results obtained by applying a revised version of the first-birth P/F ratio method (United Nations, 1982) to the 1973 census data. These results are fairly similar to those reported by Potter and Ordonez, indicating that there may be an understatement of about 12-percent in the births reported for the year preceding the census (taking the mean of the P_1/F_1 ratios for age groups 20-24 to 40-44). An adjustment of this magnitude would raise the observed total fertility rate from 4.50 to 5.04 children per woman.

3.2.3 The 1976 Colombian Fertility Survey

The 1976 CFS included two types of questionnaires: a household form, which was a general-purpose demographic survey that gathered information about all the members of a household, and an individual form, which recorded detailed maternity histories. The household form included questions on parity and date of most recent

TABLE 68 Application of the First-Birth P/F Ratio Method to the 1973 Census Sample: Colombia

Age Group	Observed Proportions of Mothers[a] $P_1(i)$	First-Birth Age-Specific Rates[a] $f_1(i)$	Estimated Proportions of Mothers $F_1(i)$	$P_1(i)/F_1(i)$
15-19	.105	.043	.097	1.09
20-24	.473	.068	.428	1.10
25-29	.726	.030	.656	1.11
30-34	.835	.011	.742	1.13
35-39	.869	.004	.771	1.13
40-44	.876	.004	.790	1.11
45-49	.869	.002	.808	1.08
Mean				1.11

Source: [a]Potter and Ordonez (1976:387).

birth that were posed to all women aged 15 and over in the household. In his detailed analysis of the CFS fertility data, Hobcraft (1980) applied the P/F ratio method and the first-births method to the data classified by education of mother. Table 69 presents the results of applying the P/F ratio method to data on all births and all women. As expected, the P/F ratios increase with age, indicating that fertility has been declining. Table 70 shows the results of applying the first-birth P/F ratio method to the same data. The results suggest that the CFS data are fairly consistent and that their reference-period error is small (since the ratios in the last column are all close to 1.0).

Given the richness of the CFS data, these are not the only consistency checks possible. For example, it is possible to compare the household survey reports about women who were subsequently interviewed at the individual level with the responses they themselves furnished in the individual survey. Furthermore, because some fertility information was gathered about every eligible woman in the household, the characteristics of those not selected for individual interviews can also be studied.

In theory, every woman aged 15 to 49 had the same probability of being selected for an individual interview, so one expects no systematic differentials between the

TABLE 69 P/F Ratio Method Applied to Data from the CFS Household Interviews: Colombia

Age Group	Observed Parity[a] P(i)	Observed Fertility[a] f(i)	Estimated Parity[a] F(i)	P(i)/F(i)
15-19	0.17	.072	0.153	1.11
20-24	1.11	.213	1.985	1.13
25-29	2.46	.203	2.041	1.21
30-34	3.92	.175	2.980	1.32
35-39	5.27	.134	3.746	1.41
40-44	6.33	.057	4.155	1.52
45-49	6.60	.020	4.347	1.52

Source: [a]Hobcraft (1980:16, 18).

eligible women who were actually interviewed and the ones who were not. However, these expectations do not hold in practice. According to the data presented in Table 71, women who were selected for individual interview had experienced, on average, slightly higher current fertility rates than those who were not selected. However, the parities of the two groups, as recorded at the household level, were not too different. Similar, but remarkable differences were noticed when the parities recorded at the household level for women who were later interviewed individually were compared with the ones derived from the individual interview. For age groups 25-29 and 30-34 the parities declared at the individual level are higher than those declared at the household level, but for the next two age groups the differential reverses itself. One can only speculate about the causes of these differences, but they are likely to stem from inconsistencies between the age reports in the two sources or from event omission in one of them.

Tables 72 and 73 present the data according to their source (household or individual) and according to whether information about a woman was obtained from the woman herself or from another respondent (proxy) at the household level. (There was no proxy reporting in the individual interviews; all women interviewed individually had to answer the questionnaire personally.) According to Table 72, self-reporting women at the household level were more likely to have experienced high current fertility rates. Women whose information was obtained from a proxy had experienced consistently lower fertility, whether measured on the basis of the proxy respondents' information or on the basis of the information supplied by the women themselves. In fact, when women reported about themselves, their current fertility levels appeared to be even lower than those reported by the proxy. Similar comments apply to the data on average parity in Table 73. These findings are of special importance because they indicate that information obtained from proxy respondents is not worse than that gathered from the women themselves and that, if anything, proxy respondents tend to exaggerate the number of events rather than omit them. Furthermore, this evidence suggests that surveys focusing on individual women may tend to overestimate fertility due to biases caused by selective nonresponse; that is, women whose information is provided by proxy respondents are probably more likely to be away from home and to have fewer children.

This brief assessment shows that even though the internal consistency of the CFS data is not perfect, the inconsistencies observed are minor. Evaluating the household data via the two variants of the P/F ratio method reinforces their credibility. Therefore, both the individual and the household data will play important roles in our overall assessment of fertility levels.

3.2.4 The 1978 National Household Survey

The NHS included a question on date of last birth, whose answers were tabulated originally by age of mother and time of occurrence, defined as years ending on May 31 (DANE, 1980). Since the NHS field work took place between June 12 and July 2, 1978, the published tabulations do

TABLE 70 First-Birth P/F Ratio Method Applied to Data from the CFS Household Interviews: Colombia

Age Group	Observed Proportions of Mothers $P_1(i)$	First-Birth Age-Specific Rates $f_1(i)$	Estimated Proportions of Mothers $F_1(i)$	$P_1(i)/F_1(i)$
15-19	.112	.050	.114	0.98
20-24	.524	.079	.504	1.04
25-29	.751	.030	.748	1.00
30-34	.873	.013	.839	1.04
35-39	.889	.006	.879	1.01
40-44	.899	.004	.905	0.99
45-49	.899	.000	.910	0.99
Mean				1.01

TABLE 71 Estimates of Current Fertility and Parity from the 1976 CFS: Colombia

	Household Survey			Individual Survey
Age Group	All Women	Women Selected For Individual Interview	Women Not Selected	f(i)
Part A. Age-Specific Fertility Rates				
15-19	.072	.070	.074	.063
20-24	.213	.208	.216	.204
25-29	.203	.208	.199	.209
30-34	.175	.186	.167	.182
35-39	.134	.149	.123	.136
40-44	.057	.075	.043	.076
45-49	.020	.013	.025	.025
Total Fertility Rate	4.370	4.545	4.235	4.475
Part B. Age-Specific Average Parity				
15-19	0.17	0.17	0.17	0.17
20-24	1.11	1.12	1.10	1.10
25-29	2.46	2.43	2.48	2.44
30-34	3.92	3.97	3.88	4.05
35-39	5.27	5.16	5.35	5.04
40-44	6.33	6.24	6.40	6.08
45-49	6.60	6.75	6.50	6.74

Source: Hobcraft (1980:16, 18).

TABLE 72 Effect of Proxy Reporting on Estimates of Current Fertility Based on Births in the Last Year from the 1976 CFS: Colombia

Age at Survey	Proportions Reporting a Birth in Year Prior to the Survey					
	Women Reported in Both Surveys (Unweighted)				All Women Reported in Household Survey (Weighted)	
	Proxy-Reported in Household Survey		Self-Reported in Household Survey			
	Household Survey Report (Proxy)	Individual Survey Report (Self)	Household Survey Report (Self)	Individual Survey Report (Self)	Reported by Proxy	Reported by Self
15-19	.025	.025	.162	.144	.030	.158
20-24	.129	.128	.257	.265	.113	.284
25-29	.126	.129	.234	.244	.128	.230
30-34	.134	.147	.194	.199	.109	.189
35-39	.153	.133	.147	.143	.098	.145
40-44	.027	.057	.085	.089	.020	.069
45-49	.000	.001	.018	.021	.015	.022
Total Fertility Rate	2.970	3.100	5.485	5.525	2.565	5.485

Source: Hobcraft (1980:17, Table 2.2).

TABLE 73 Effect of Proxy Reporting on Estimates of Current Average Parity from the 1976 CFS: Colombia

	Women Reported in Both Surveys (Unweighted)				All Women Reported in Household Survey (Weighted)	
	Proxy-Reported in Household Survey		Self-Reported in Household Survey			
Age at Survey	Household Survey Report (Proxy)	Individual Survey Report (Self)	Household Survey Report (Self)	Individual Survey Report (Self)	Reported by Proxy	Reported by Self
15-19	0.07	0.07	0.40	0.37	0.08	0.36
20-24	0.61	0.56	1.52	1.52	0.57	1.56
25-29	1.44	1.44	2.90	2.89	1.53	2.93
30-34	2.95	2.88	4.27	4.36	2.67	4.33
35-39	4.00	4.09	5.46	5.29	3.97	5.73
40-44	5.68	5.23	6.42	6.40	5.87	6.53
45-49	6.37	6.58	6.89	6.79	5.85	6.92

Source: Hobcraft (1980:18, Table 2.4).

not actually cover the year immediately preceding the survey. Fortunately, the raw survey data are available and retabulation was possible. Table 74 shows a comparison of the age-specific fertility rates obtained from the data tabulated by DANE and those obtained by considering all births occurring during the year preceding interview. Notice that the latter imply a slightly higher total fertility rate and that the difference (about 5.4 percent) can be accounted for totally by the fact that the DANE tabulations disregarded on average about 21 days of exposure to the risk of childbearing.

Because the original survey data were available, it was also possible to use nonstandard five-year age groups to explore the effects that age heaping may have on the fertility estimates (Hill et al. 1982; United Nations, 1982). Table 75 shows the results of applying the P/F ratio method both to data classified according to the usual five-year age groups and to those classified according to nonstandard age groups. Note that the differences in observed parity between the standard and the nonstandard age groups display the expected pattern except for the oldest age group. The mean parity of the

TABLE 74 Comparison of Age-Specific Fertility Rates Derived from the 1978 NHS: Colombia

Age Group	Fertility Rates for June 1977 to May 1978[a]	Fertility Rates for Year Preceding Interview
15-19	.048	.052
20-24	.176	.181
25-29	.187	.200
30-34	.149	.159
35-39	.100	.107
40-44	.063	.064
45-49	.015	.015
Total Fertility Rate	3.690	3.892

[a]Source: DANE (1980).

TABLE 75 Application of the P/F Ratio Method to NHS Data on all Births, Using Standard and Nonstandard Age Groups: Colombia

Age Group	Observed Parity P(i)	Observed Fertility f(i)	Estimated Parity F(i)	P(i)/F(i)
Standard				
15-19	0.117	.052	0.108	1.08
20-24	0.953	.181	0.774	1.23
25-29	2.157	.200	1.775	1.22
30-34	3.590	.159	2.665	1.35
35-39	4.796	.107	3.294	1.46
40-44	6.148	.064	3.708	1.65
45-49	6.690	.015	3.875	1.73
Nonstandard				
13-17	0.040	.014	--	--
18-22	0.531	.140	0.436	1.22
23-27	1.663	.205	1.393	1.19
28-32	2.993	.167	2.301	1.30
33-37	4.479	.144	3.085	1.45
38-42	5.359	.077	3.585	1.49
43-47	6.768	.031	3.845	1.76

43-47 age group is slightly higher than that of the 45-49 age group, suggesting that the latter may be somewhat understated. The P/F ratios associated with both age classifications are fairly similar, and those for the younger age groups are much higher than the corresponding ones derived from either the 1973 census or the 1976 CFS (see Tables 67 and 69). For the 20-24 age group, the difference between the P/F ratios in the latter sources and that calculated from NHS data is approximately 0.10, a difference that cannot be accounted for entirely by fertility change. Reference-period errors are probably contributing to this difference.

Table 76 shows the results of applying the first-birth P/F ratio method to the NHS data. First, although neither age grouping set produces ratios with clearly increasing or decreasing trends, those associated with the usual five-year age groups increase steadily after 25-29. The use of nonstandard age groups reveals that this trend is not genuine, since it does not persist when the age groups are modified. Once the value for 15-19 is disregarded, the internal consistency of both P_1/F_1 sets is relatively high. The mean of the last six P_1/F_1

TABLE 76 Application of the P/F Ratio Method to NHS Data on First Births, Using Standard and Nonstandard Age Groups: Colombia

Age Group	Observed Proportions of Mothers $P_1(i)$	Observed First-Birth Fertility $f_1(i)$	Estimated Proportions of Mothers $F_1(i)$	$P_1(i)/F_1(i)$
Standard				
15-19	.088	.034	.076	1.16
20-24	.471	.061	.359	1.31
25-29	.740	.033	.588	1.26
30-34	.845	.006	.662	1.28
35-39	.891	.003	.681	1.31
40-44	.907	.001	.687	1.32
45-49	.911	.000	.687	1.33
Nonstandard				
13-17	.035	.010	--	--
18-22	.309	.064	.238	1.30
23-27	.663	.042	.509	1.30
28-32	.806	.018	.643	1.25
33-37	.889	.005	.686	1.29
38-42	.886	.002	.699	1.27
43-47	.923	.000	.701	1.32

values of each set is 1.30 for the standard age groups and 1.29 for the nonstandard. These mean values are very high, especially when compared with those obtained from 1973 census or the 1976 CFS (1.11 and 1.01, respectively). Notice also that according to the NHS current first-birth fertility rates, only about 70 percent of all women would ever become mothers. This figure is clearly too low. The equivalent figure according to the 1973 census is 80 percent, while according to the 1976 CFS it is 91 percent. Since it is unlikely that fertility changes alone could cause such erratic changes in the projected proportions of mothers, one can only conclude that both the 1973 census and the 1978 NHS current fertility data are deficient.

In the case of the NHS it is almost certain that the 1.2 adjustment factor suggested by the P/F ratio method based on all births is too high; it would yield a total fertility estimate of approximately 4.67. Hence, the adjustment factor suggested by the first-birth data, being about 0.10 greater, is certainly excessive for all births. However, if it is applied only to first births, a lower bound for fertility in 1977-78 can be obtained. This bound is equal to a total fertility of approximately 4.10; however, because it is produced by a combination of adjusted first births and observed births of other orders, it is associated with a fertility schedule that is likely to be too high at younger ages. For this reason, the fertility schedule itself is not presented.

3.2.5 The 1978 Contraceptive Prevalence Survey

Table 77 shows the fertility estimates obtained from the information on parity and date of most recent birth recorded by the 1978 CPS, which was conducted with individual interviews. The estimated P/F ratio for 15-19 is too high, probably because the rounded figure for P(1) is not close enough to the observed (see note in Table 77). At ages 20-24 and 25-29, the ratios are similar to those obtained from the 1973 census sample and from the 1976 CFS, but for older ages their values are higher than those estimated from the other sources. At ages 30 and over the 1978 CPS P/F ratios are similar to those implied by the 1978 NHS data. Differences between these two sources are evident mainly at younger ages.

Since the 1978 CPS was conducted only six months after the 1978 NHS, one would expect close correspondence between the estimates yielded by the two surveys. The total fertility estimates agree fairly well, the CPS

TABLE 77 Application of the P/F Ratio Method to Data from the 1978 Contraceptive Prevalence Survey: Colombia

Age Group	Observed Parity[a] P(i)	Observed Fertility f(i)	Estimated Parity F(i)	P(i)/F(i)
15-19	0.20	.059	0.119	1.68
20-24	1.00	.207	0.903	1.11
25-29	2.30	.186	1.903	1.21
30-34	3.80	.142	2.700	1.41
35-39	5.20	.107	3.314	1.57
40-44	6.00	.045	3.651	1.64
45-49	7.50	.011	3.772	2.00

[a]Available tabulations showed data rounded to the first decimal place.

Source: CCRP (1979:38, 44).

estimate (3.785) being only slightly lower than the NHS estimate (3.892). However, a comparison of the average parities recorded by each survey shows that the CPS values are almost always higher. (Unfortunately, the rounding reflected in the CPS data introduces some uncertainties in this respect.) If, as Hobcraft's analysis of the CFS suggests, women who are selected and respond to individual interviews are more likely to have higher fertility than all women as a group, then the results presented in Table 77 are to be expected. The same phenomenon may account for the slightly higher current fertility rates observed among young women in the CPS in comparison with those recorded by the NHS.

At first sight, the overall similarity of the fertility estimates yielded by the CPS and the NHS appears to be reassuring. However, because of the deficiencies that a detailed analysis of the NHS data uncovered, congruence between its results and those of the CPS casts doubts on the accuracy of the latter. Unfortunately, in the case of the CPS, further consistency checks are not possible because the basic tabulations are lacking. Availability of the raw data on children ever born, the number of women interviewed, women of zero parity, and the number of first births occurring during the year immediately preceding the interview would be very helpful.

3.2.6 Intersurvey Estimates

Because a pair of demographic enquiries conducted during the 1970s is spaced approximately five years apart, intersurvey estimates of fertility can be calculated via the hypothetical cohort approach. This pair is the 1973 census and the 1978 NHS. (In theory the 1973 census and the 1978 CPS would constitute a second pair. Unfortunately, the unavailability of the raw CPS data precludes its use for intersurvey comparisons since parities rounded to only one decimal place are too crude an input for the type of analysis required.)

Two methods may be used in estimating intersurvey fertility (Zlotnik and Hill, 1981). The first is based exclusively on the parity increments observed from one point in time to the next. These parity increments allow the estimation of average parities for a hypothetical cohort subject to intersurvey fertility. The estimated mean parities can then be transformed to cumulated fertility, thus yielding estimates comparable to those obtained by other means. The second approach is a variation of the usual P/F ratio method, where the estimated mean parities for a hypothetical cohort subject to the intersurvey fertility experience are compared with a mean observed fertility schedule representing this experience.

The results of applying the first method are presented in Table 78. The observed parity increments are presented in the column labeled Δi. The estimated intersurvey values are labeled "synthetic" because they refer to a hypothetical or synthetic cohort. The values of F(i,s) can be interpreted as intersurvey estimates of cumulated fertility. (The letter s is used to indicate "synthetic.") Therefore, the value of F(7,s) is an estimate of intersurvey total fertility. This value, 5.95, is clearly too high; it is even greater than the total fertility values that would be obtained by adjusting the 1973 and 1978 NHS current fertility estimates by the P/F ratios associated with age group 20-24, that is, 5.13 and 4.79, respectively. The immediate cause of this inconsistent outcome is that the observed parity increments are too large, mainly because some of the parities recorded by the 1973 census are too low. This is especially noticeable in the 1973 parities for age groups 40-44 and 45-49 compared with those recorded in 1978. The latter are greater, which would not be expected unless fertility were on the rise. The possibility that parities at younger ages in 1973 might also be somewhat understated cannot be discarded, although it is less obvious. How-

TABLE 78 Estimation of Intersurvey Fertility on the Basis of Parity Increments, 1973-78: Colombia

Age Group	i	1973 Census P(i,1)	1978 NHS P(i,2)	Δi	Synthetic Values P(i,s)	Synthetic Values F(i,s)
15-19	1	0.1435	0.1166	(0.1166)	0.1166	0.4105
20-24	2	1.0503	0.9527	0.8092	0.9258	1.4629
25-29	3	2.4400	2.1566	1.1063	2.0291	2.6180
30-34	4	3.9349	3.5898	1.1498	3.1789	3.6410
35-39	5	5.1069	4.7957	0.8608	4.0397	4.5335
40-44	6	5.8659	6.1483	1.0414	5.0811	5.5665
45-49	7	6.1075	6.6897	0.8238	5.9049	5.9462

Note: See text for definition of Δi and "synthetic values."

ever, even the value of F(5,s) is already too high to be consistent with any reasonable estimate of fertility cumulated up to age 40 for the 1973-78 period. Hence, it is likely that even the mean parities at younger ages were underreported in 1973. This conclusion would be consistent with the fact that the child mortality estimates derived from census data were shown to be, in general, too low.

Table 79 shows the results obtained by applying the second method of intersurvey fertility estimation to the 1973-78 data. Notice that the equivalent of the P/F ratios, here denoted as P/π, increase with age, which would not be expected if the estimated synthetic parities really represented the intersurvey experience. However, such a behavior is consistent with the existence of underreporting of children ever born in 1973, since such a flaw in the basic data would lead to estimates of mean intersurvey parities whose positive biases increase with age.

Notice also that at ages 20-24 and 25-29 the P/π ratios are fairly similar. Therefore, just as in any application of the P/F ratio method in cases where fertility has remained constant, the values of P/π for those age groups may be used as adjustment factors for the observed mean intersurvey fertility schedule. The ratio associated with the 20-24 age group was used to adjust the observed f(i,s) values.

A second adjustment was necessary to obtain an intersurvey fertility schedule referring to the usual five-year age groups, since the one presented in Table 79 is based on a female population whose true age at the time of the births occurring during the year preceding the survey was, on average, half a year younger than that reported at the

TABLE 79 Estimation of Intersurvey Fertility Using a P/F Ratio Method for Synthetic Cohorts, 1973-78: Colombia

Age Group	i	1973 Census f(i,1)	1978 NHS f(i,2)	Synthetic Values f(i,s)	π(i,s)	P(i,s)	P/π
15-19	1	.0652	.0523	.0588	0.1224	0.1166	0.95
20-24	2	.2063	.1809	.1936	0.8491	0.9258	1.09
25-29	3	.2127	.1999	.2063	1.8892	2.0291	1.07
30-34	4	.1824	.1594	.1709	2.8244	3.1789	1.13
35-39	5	.1395	.1074	.1235	3.5339	4.0397	1.14
40-44	6	.0703	.0637	.0670	3.9755	5.0811	1.28
45-49	7	.0240	.0149	.0195	4.1754	5.9049	1.41

time of interview. The fully adjusted intersurvey fertility schedule, displayed in Table 80, shows that total fertility amounted to 4.58. Such a value implies that the total fertility estimates derived directly from the 1973 and 1978 NHS data are somewhat low (4.50 and 3.89, respectively). However, as we shall see later, the adjustments necessary to make these figures consistent with the adjusted intersurvey level are well in line with those that might be inferred from detailed analysis of each data set.

3.2.7 Summary of the P/F Ratio Estimates

The preceding sections have presented the results of applying several variants of the P/F ratio method to the available data. In all cases, except the 1969 NFS, the method confirmed the existence of a fertility decline when it was applied to data on all births. Applications made to first-birth data showed that the CFS had a high level of internal consistency, while the 1973 census and the 1978 NHS data are somewhat deficient. The same is probably true about the 1978 CPS, but lack of appropriate tabulations limited the possibilities of further assessment.

TABLE 80 Adjusted Intersurvey Fertility Schedule, 1973-78: Colombia

Age Group	Adjusted[a] f(i)
15-19	.079
20-24	.220
25-29	.223
30-34	.181
35-39	.130
40-44	.067
45-49	.017
Total Fertility Rate	4.577

[a]Adjustment factor = 1.09.

For future reference, Table 81 presents the age-specific fertility schedules produced by each of the sources analyzed in this section, all adjusted for the half-year age shift implicit in data referring to the year preceding a survey.

3.3 DATA ON OWN CHILDREN

The data on age and relationship to head of the household gathered by almost any household survey or census can be used to estimate fertility. Cho (1973) has suggested a technique that allows age-specific fertility rates to be estimated from data on enumerated children classified by single years of their own age and by single years of their mother's age. If these data are available, reverse projection of the female population to each of the 10 or 15 years preceding the survey and of the enumerated children (persons under 15) to the time of their birth makes it possible to calculate period age-specific fertility rates. In addition to the usual "own children" tabulation (children classified according to the ages of their mothers), this procedure requires as input detailed estimates of mortality for children and for adult females.

For Colombia, the appropriate estimates of mortality are available (see Chapter 2). Furthermore, adequate own-children tabulations have been produced for each of the potential sources: the 1973 census sample, the household data from the 1976 CFS, and the 1978 NHS. In the first case, the tabulation required was obtained by

TABLE 81 Current Fertility Schedules Based on Data on Births Last Year Adjusted for a Half-Year Age Displacement, Five Sources: Colombia

Age Group	1969 NFS f(i)	1973 Census f(i)	1976 CFS Household f(i)	1978 NHS f(i)	1978 CPS f(i)
15-19	.118	.080	.088	.064	.074
20-24	.280	.214	.219	.189	.213
25-29	.305	.211	.201	.198	.182
30-34	.272	.179	.171	.154	.138
35-39	.240	.134	.128	.104	.102
40-44	.114	.064	.052	.058	.040
45-49	.019	.019	.016	.011	.008
Total Fertility Rate	6.740	4.503	4.370	3.892	3.785

matching the enumerated children to their mothers on the basis of certain criteria (age, relationship to the head of the household, etc.). For the 1976 and 1978 data, however, no artificial matching was necessary because the surveys included either a coding mechanism or a question identifying the mother of each recorded child whenever she lived in the same household as the child.

Estimates obtained by applying the own-children method to the three data sources are presented in Tables 82, 83, and 84. Every set shows a fairly consistent trend of declining total fertility rates. Notice that in the CFS set (Table 83) the estimate for the 45-49 age group is not always derived directly from the data. This age group was left out in some cases because the available data on own-children were tabulated only for mother's ages ranging from 10 to 60; therefore, at earlier periods truncation was necessary. To make the estimated series comparable, fertility rates for age groups 45-49 were imputed on the basis of the rates for the five-year period immediately preceding them.

In general, each series is remarkably well behaved. Very few values are out of line with the contiguous ones, indicating that age heaping under age 15 is not severe. There are, however, some preferred ages that tend to attract respondents more than others, as Table 85 illustrates. For example, age 12 seems to be even more attractive than ages 10 or 15. Therefore, own-children estimates corresponding to a period 12 to 13 years before each survey will be too high and should be disregarded.

Unfortunately, age heaping is not the only potential source of spurious fluctuations in the fertility estimates derived from own-children information. Selective under-enumeration of young children can also seriously bias the estimates for recent periods. This phenomenon is clearly operating in the 1973 census sample, in which the recorded number of children under age 1 is obviously too low (it implies a total fertility rate for 1972-73 of only 2.54 children per woman). Although the other two data sources are not so obviously flawed by the underenumeration of young children, the fertility estimates they imply for recent periods cannot be accepted without further validation.

For the moment, we conclude by noting the three-year averages presented in Part B of Tables 82, 83, and 84. Although smoother than the series of annual fertility estimates, the three-year period estimates are not entirely free from the problems associated with heaping

TABLE 82 Estimates of Fertility Derived from the 1973 Census Sample by the Own-Children Method: Colombia

Estimated Fertility Rates by Five-Year Age Groups

Age	1972-73	1971-72	1970-71	1969-70	1968-69	1967-68	1966-67	1965-66
15-19	0.0351	0.0654	0.0804	0.0924	0.0965	0.1068	0.1164	0.1295
20-24	0.1106	0.1813	0.2116	0.2421	0.2552	0.2568	0.2666	0.2851
25-29	0.1210	0.1925	0.2281	0.2584	0.2769	0.2878	0.2950	0.3236
30-34	0.1084	0.1647	0.2060	0.2312	0.2378	0.2516	0.2485	0.2645
35-39	0.0791	0.1180	0.1355	0.1624	0.1675	0.1820	0.1848	0.2005
40-44	0.0411	0.0635	0.0737	0.0845	0.0909	0.0893	0.0884	0.0887
45-49	0.0126	0.0191	0.0209	0.0214	0.0217	0.0184	0.0233	0.0229
TFR	2.5391	4.0222	4.7808	5.4623	5.7326	5.9629	6.1144	6.5740

Age	1964-65	1963-64	1962-63	1961-62	1960-61	1959-60	1958-59
15-19	0.1322	0.1316	0.1386	0.1430	0.1538	0.1587	0.1512
20-24	0.3015	0.3006	0.3124	0.3147	0.3264	0.3442	0.3069
25-29	0.3305	0.3240	0.3292	0.3253	0.3439	0.3412	0.3338
30-34	0.2833	0.2619	0.2948	0.2844	0.3074	0.3138	0.2873
35-39	0.2191	0.1930	0.2083	0.1967	0.1998	0.2021	0.1763
40-44	0.0917	0.0837	0.0862	0.0845	0.0999	0.0916	0.0906
45-49	0.0220	0.0200	0.0259	0.0211	0.0260	0.0251	0.0219
TFR	6.9007	6.5736	6.9768	6.8486	7.2859	7.3836	6.8400

Estimated Fertility Rates for Three-Year Averages

Age	1971-73	1968-70	1965-67	1962-64	1959-61
15-19	0.0603	0.0986	0.1260	0.1377	0.1546
20-24	0.1678	0.2514	0.2844	0.3092	0.3258
25-29	0.1806	0.2744	0.3164	0.3262	0.3397
30-34	0.1597	0.2402	0.2654	0.2804	0.3028
35-39	0.1109	0.1706	0.2015	0.1993	0.1927
40-44	0.0594	0.0882	0.0896	0.0848	0.0940
45-49	0.0175	0.0205	0.0227	0.0223	0.0243
TFR	3.7807	5.7193	6.5297	6.7996	7.1698

TABLE 83 Estimates of Fertility Derived from the 1976 CFS Household Schedule by the Own-Children Method: Colombia

Estimated Fertility Rates by Five-Year Age Groups

Age	1975-76	1974-75	1973-74	1972-73	1971-72	1970-71	1969-70	1968-69
10-14	0.0008	0.0015	0.0018	0.0032	0.0024	0.0040	0.0048	0.0049
15-19	0.0906	0.0926	0.0852	0.1092	0.0977	0.1224	0.1238	0.1192
20-24	0.1979	0.2020	0.2141	0.2285	0.2419	0.2851	0.2796	0.2805
25-29	0.1913	0.1885	0.1853	0.2091	0.2736	0.2697	0.2896	0.3114
30-34	0.1693	0.1669	0.1613	0.1815	0.1894	0.2267	0.2470	0.2456
35-39	0.1163	0.1161	0.0915	0.1243	0.1335	0.1679	0.1909	0.1822
40-44	0.0343	0.0518	0.0615	0.0735	0.0752	0.0831	0.1013	0.0827
45-49	0.0193	0.0159	0.0062	0.0222	0.0159	0.0293	0.0133	0.0137
TFR	4.0988	4.1766	4.0344	4.7578	5.1479	5.9409	6.2520	6.2005

Age	1967-68	1966-67	1965-66	1964-65	1963-64	1962-63	1961-62
10-14	0.0073	0.0075	0.0108	0.0150	0.0148	0.0120	0.0116
15-19	0.1229	0.1256	0.1339	0.1420	0.1573	0.1739	0.1579
20-24	0.2971	0.3059	0.3083	0.2920	0.3455	0.3298	0.3323
25-29	0.3440	0.2934	0.3292	0.2888	0.3432	0.3584	0.3813
30-34	0.2649	0.2317	0.3086	0.2720	0.3013	0.3232	0.3107
35-39	0.2050	0.1719	0.2192	0.1951	0.2233	0.2499	0.1963
40-44	0.0905	0.0735	0.0843	0.0766	0.1002	0.1042	0.0863
45-49	0.0254	0.0077	(0.0202)	(0.0186)	(0.0215)	(0.0225)	(0.0214)
TFR	6.7861	6.0861	7.0729	6.5008	7.5357	7.8692	7.4891

Estimated Fertility Rates for Three-Year Averages

Age	1974-76	1971-73	1968-70	1965-67	1962-64
10-14	0.0014	0.0032	0.0056	0.0111	0.0128
15-19	0.0894	0.1098	0.1220	0.1339	0.1630
20-24	0.2046	0.2519	0.2857	0.3021	0.3359
25-29	0.1884	0.2508	0.3150	0.3038	0.3610
30-34	0.1658	0.1992	0.2525	0.2708	0.3117
35-39	0.1080	0.1419	0.1927	0.1954	0.2232
40-44	0.0492	0.0773	0.0915	0.0781	0.0969
45-49	0.0138	0.0225	0.0175	(0.0225)	(0.0262)
TFR	4.1033	5.2822	6.4128	6.5881	7.6532

( ): Imputed values

TABLE 84 Estimates of Fertility Derived from the 1978 NHS by the Own-Children Method: Colombia

	Estimated Fertility Rates by Five-Year Age Groups							
Age	1977-78	1976-77	1975-76	1974-75	1973-74	1972-73	1971-72	1970-71
15-19	0.0659	0.0744	0.0765	0.0968	0.0978	0.0972	0.1092	0.1217
20-24	0.1779	0.1813	0.2022	0.2147	0.2273	0.2345	0.2416	0.2837
25-29	0.1764	0.1849	0.1963	0.1829	0.2213	0.2284	0.2296	0.2716
30-34	0.1516	0.1419	0.1679	0.1728	0.1911	0.1707	0.1942	0.2340
35-39	0.0985	0.0873	0.1266	0.1147	0.1257	0.1238	0.1544	0.1543
40-44	0.0432	0.0295	0.0379	0.0609	0.0579	0.0718	0.0736	0.0864
45-49	0.0131	0.0090	0.0105	0.0105	0.0142	0.0166	0.0218	0.0139
TFR	3.6328	3.5410	4.0898	4.2671	4.6769	4.7147	5.1221	5.8276

Age	1969-70	1968-69	1967-68	1966-67	1965-66	1964-65	1963-64
15-19	0.1120	0.1156	0.1048	0.1333	0.1381	0.1543	0.1517
20-24	0.2737	0.2957	0.2851	0.2805	0.3055	0.2935	0.3313
25-29	0.2916	0.2558	0.2990	0.2816	0.3206	0.3126	0.3287
30-34	0.2321	0.2295	0.2644	0.2356	0.3033	0.2843	0.2543
35-39	0.2019	0.1749	0.1699	0.1690	0.2438	0.2205	0.2026
40-44	0.0863	0.0745	0.0694	0.0905	0.0811	0.0852	0.0888
45-49	0.0132	0.0270	0.0222	0.0204	0.0164	0.0242	0.0201
TFR	6.0544	5.8650	6.0744	6.0542	7.0440	6.8727	6.8871

	Estimated Fertility Rates for Three-Year Averages				
Age	1976-78	1973-75	1970-72	1967-69	1964-66
15-19	0.0723	0.0973	0.1143	0.1179	0.1481
20-24	0.1871	0.2255	0.2663	0.2871	0.3101
25-29	0.1859	0.2109	0.2642	0.2788	0.3206
30-34	0.1538	0.1782	0.2201	0.2431	0.2806
35-39	0.1041	0.1214	0.1702	0.1713	0.2223
40-44	0.0369	0.0635	0.0821	0.0781	0.0850
45-49	0.0109	0.0138	0.0163	0.0232	0.0202
TFR	3.7545	4.5529	5.6680	5.9978	6.9346

TABLE 85 Population Under Age 16 Classified by Single Years of Age, Selected Sources (in thousands): Colombia

Age	1973 Census Sample	1976 CFS	1978 NHS
0	466	181	670
1	503	173	616
2	587	158	641
3	615	175	661
4	609	174	677
5	616	196	668
6	608	189	701
7	644	186	761
8	631	188	740
9	568	172	701
10	631	189	715
11	542	157	680
12	617	194	802
13	561	178	700
14	510	171	722
15	505	153	699

and underenumeration. Hence, estimates incorporating the data on children aged 12 at the time of interview or those incorporating the data on children under age 1 are still likely to over- or underestimate fertility, respectively.

3.4 SUMMARY EVALUATION OF THE EVIDENCE

Preceding sections have presented sets of fertility estimates derived from different sources and by a variety of means. To extract from them a series of consistent and plausible fertility estimates for the 1964-78 period, we begin by comparing the total fertility estimates obtained on the basis of the CFS maternity histories with those derived via the own-children method applied to the 1973 census sample, the household data of the 1976 CFS, and the 1978 NHS. Figures 12, 13, and 14 display these different pairs of estimates. As Figure 12 indicates, the fertility estimates obtained from data on children

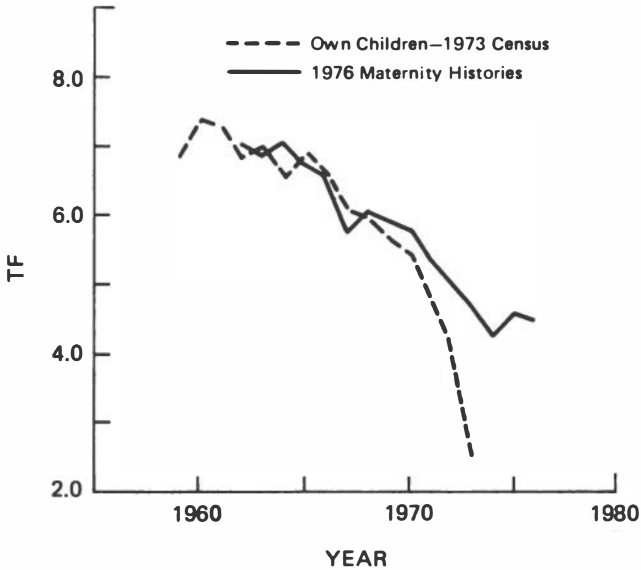


FIGURE 12 Comparison of Fertility Estimates Derived from the 1973 Census via the Own-Children Method and Those Obtained from the 1976 CFS Maternity Histories: Colombia

aged 2 or less in 1973 are too low. However, the overall consistency between the maternity history estimates and the ones obtained from the census for the 1962-68 period is reassuring, and although the census figures are affected by some age heaping--especially at ages 8, 10, 12, and 13--its impact is fairly mild.

Figure 13 compares the estimates obtained from 1976 CFS maternity histories with those obtained from the CFS own-children data. The comparison shows that the age distribution of children enumerated by the CFS is subject to a higher degree of distortion due to age heaping than that produced by the census. Furthermore, the own-children CFS estimates are higher on the whole than those implied by either the census or the maternity history estimates. However, especially for the earlier periods (1961-64), it is clear that the CFS own-children estimates are too high because they are derived from attractive age groups. The possibility that the same type of problem may produce the relatively high own-children estimates for the 1967-71 period should be kept in mind. In

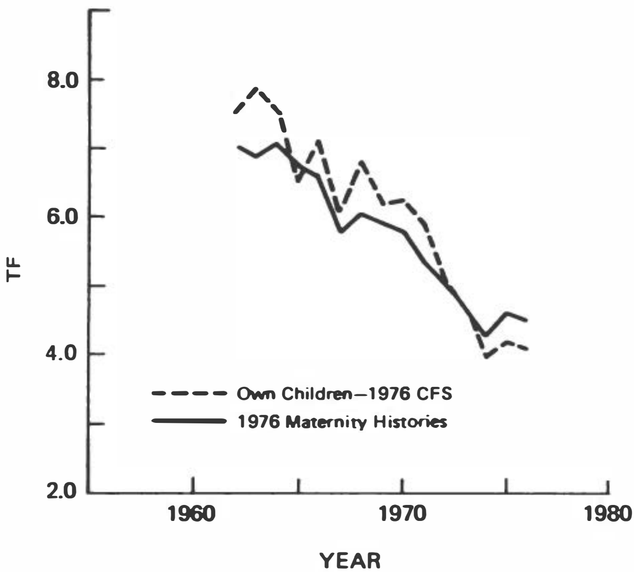


FIGURE 13 Comparison of Fertility Estimates Derived from the 1976 CFS via the Own-Children Method and Those Obtained from the 1976 CFS Maternity Histories: Colombia

addition, it must be pointed out that the total fertility estimates derived from the own-children CFS data include a fertility rate for the 10-14 age group. Although the contribution of this age group is fairly small, it certainly increases the estimated TF values.

Figure 13 also shows that maternity history data are not entirely exempt from the effects of age heaping. Notice that several of the troughs and peaks evident in the own-children estimates are also present in the ones derived from maternity history data. However, the effect of heaping is smaller on the latter.

Figure 14 compares the estimates implied by CFS maternity history data and those derived from the own-children data of the 1978 NHS. Once more, the general agreement between these two sets of estimates is high and reassuring. For most of the period covered jointly, the maternity history estimates lie below those implied by the NHS, but at some ages this outcome is clearly due to the distorting effect of age heaping. For the most recent period (1975-78) the NHS estimates are probably too low,

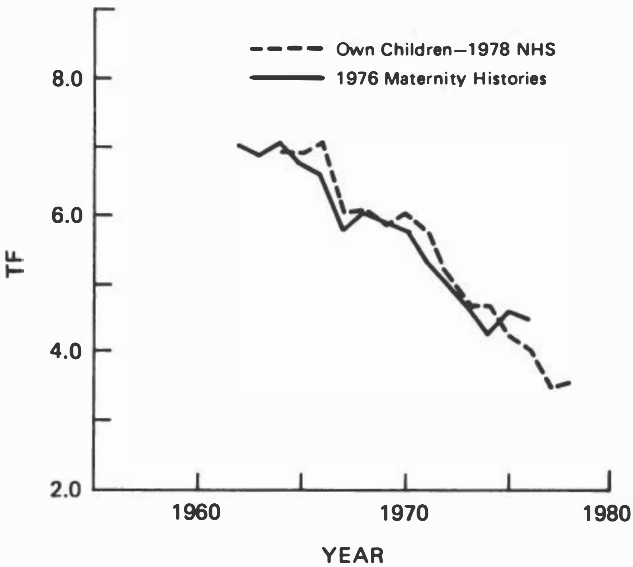


FIGURE 14 Comparison of Fertility Estimates Derived from the 1978 NHS via the Own-Children Method and Those Obtained from the 1976 CFS Maternity Histories: Colombia

although they conform fairly well to the declining trend implicit in the sets displayed.

Figure 15 displays the major estimates presented so far. With few exceptions, the various sources agree very well. Perhaps the most prominent exceptions are the 1970-73 estimates derived from the 1973 census, which are evidently too low, and the NFS estimate for 1969 (Ochoa and Ordonez, 1980), which is clearly too high, approximating closely the estimate derived from children aged 8 (an attractive age) at the time of the CFS.

The case of the 1969 NFS requires further discussion. Recall that when the P/F ratio test was applied to the data (Ochoa-Ordonez version), the estimates obtained appeared to be internally consistent. However, the fertility level they imply for 1968-69 is considerably higher than the levels estimated for previous periods on the basis of the same data (Elkins in ASCOFAME, 1973a). Moreover, there is other internal evidence suggesting that the NFS probably underestimates fertility prior to 1969. However, according to Figure 15, Elkins' estimates

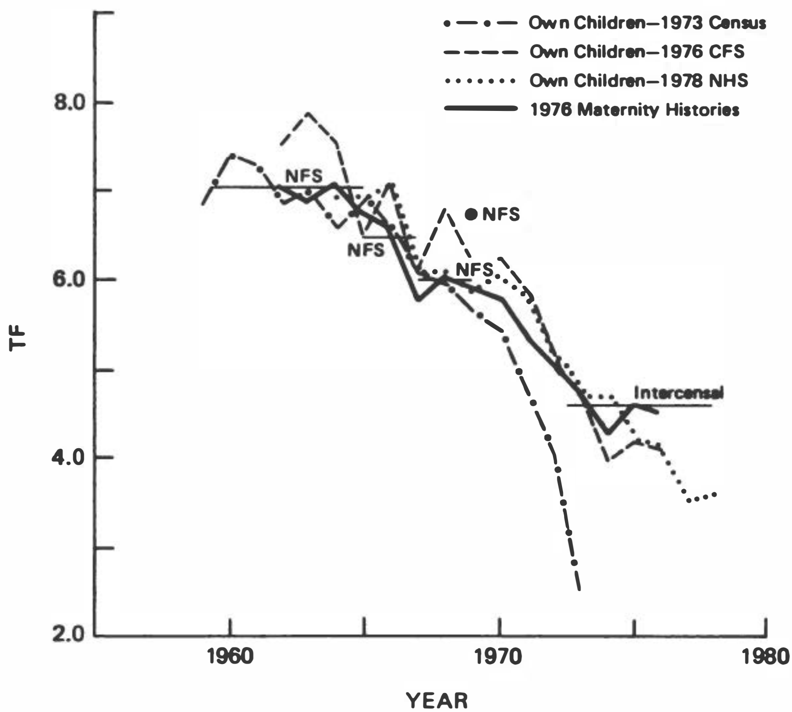


FIGURE 15 Comparison of Fertility Estimates Derived from Several Sources: Colombia

(shown as solid, horizontal lines labeled "NFS") are in good agreement with those derived from other sources, while the single-point estimate proposed by Ochoa and Ordonez is clearly out of line with all the rest. Hence, we can either conclude that most sources underestimate fertility or that the NFS is subject to some type of positive bias that balances the negative ones detected in its data. We believe that the latter is the most plausible explanation, especially because the NFS sample is not truly representative of the country as a whole (see Appendix B). An overrepresentation of the rural population in the NFS data could very well account for the results obtained. In view of these observations, the NFS estimates are omitted from the following evaluation.

Another aspect of Figure 15 that deserves comment is the relationship between the 1973-78 intersurvey or intercensal estimate and those obtained from other sources. Notice first that the intercensal estimate agrees closely with those obtained from the CFS maternity-history data, especially if one treats it as a mid-period estimate referring roughly to 1975-76. Second, its level implies that the own-children estimates derived from children aged 0-2 in 1976 and 0-3 in 1978 are too low, a fact that is not surprising given the typical problems affecting own-children estimates. In conclusion, therefore, the intersurvey estimate is not inconsistent with those obtained from other sources and although it may not be perfectly correct, it is probably the best possible estimate for the 1975-76 period.

3.5 DERIVING A YEARLY SERIES OF TOTAL FERTILITY ESTIMATES, 1964-78

Up to this point no consideration has been given to estimates obtained from data on births during the year preceding each survey (with the exception of the discredited NFS estimates). It is possible to compare single-year estimates based on births last year to own-children and maternity history estimates. However, because the former are affected by age heaping and other types of biases, such comparisons tend not to be very enlightening. Therefore, it is usually best to smooth such estimates before comparing them with others. Figure 16 displays the trend curves obtained by plotting the three year averages of the own-children estimates (from Tables 82, 83, and 84).

Although smoother than the single-year estimates, the curves in Figure 16 are not necessarily unbiased, because deficiencies in the single-year data may still affect some of their points. For example, those corresponding to the three-year period immediately preceding each survey are likely to be too low, while those corresponding to the furthest period before each survey (obtained from children aged 12-14) are likely to be too high. The solid line in Figure 16 is an estimated trend line that approximates fairly well the most reliable points of each set. The trend line was obtained by assuming that the total fertility rate in 1963 was about 7.0 and that the estimated intercensal total fertility (4.6) corresponded approximately to 1976. This line implies that total fertility in 1964 was approximately 6.8 children per woman. Such a total fertility rate, coupled with a model

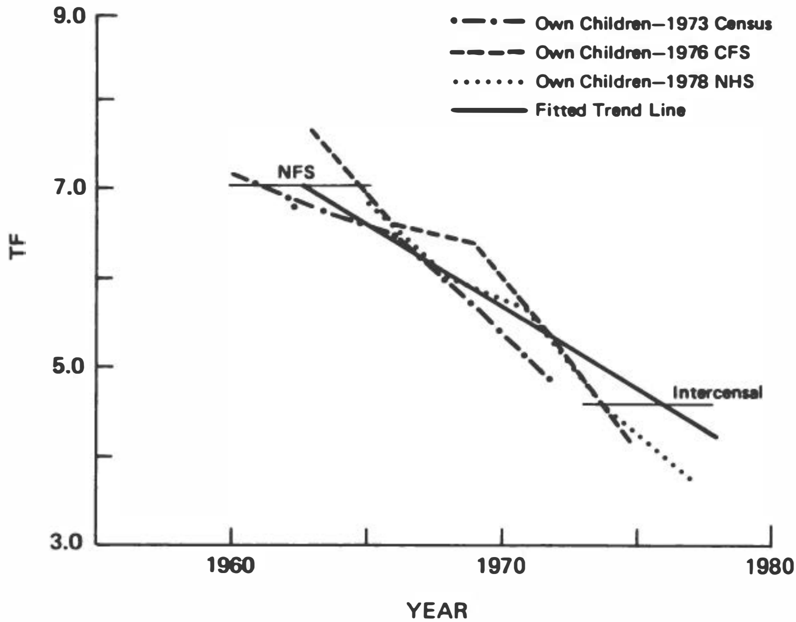


FIGURE 16 Fitted Fertility Trend Line, 1963-78, and Smoothed Fertility Estimates Derived from Own-Children Estimates: Colombia

fertility schedule fitted to the one obtained from the CFS own-children data for 1963-64 and applied to the age distribution derived via the stable and quasi-stable populations fitted in Chapter 2 to the 1951 and 1964 populations (Set 2), produces estimates of birth rates by sex that are very similar to those implied by the quasi-stable fit: the quasi-stable birth rate estimates for 1964 (Table 42) are .0476 for males and .0462 for females, while those obtained from the fitted fertility schedule in Figure 17 are .0481 and .0467, respectively (assuming that the sex ratio at birth is 1.034). Although exact coincidence is not achieved, the similarity of the two sets is reassuring. (A TF value of 6.73 in 1964 would assure coincidence, but the difference between this value and 6.8 is so small that it does not warrant selection of a different trend line.) For reference, the yearly TF estimates implied by the trend line in Figure 13 are presented in Table 3 (report summary).

3.5.1 Comparing the Yearly Series of Total Fertility Estimates (Fitted Trend Line) to Estimates Based on Births Last Year

The estimates in Table 3 can be compared with those obtained from data on the number of births during the year preceding each survey (Table 81). The limitations of the NFS estimates have already been discussed, so the first comparison to be made is with the 1973 census estimate of TF (4.50 children per woman). If the fitted-trend-line estimate in Table 3 is correct, total fertility in 1973 was 5.15, which means that the census underestimated fertility by about 14 percent. It is interesting to note that an adjustment of just that size is implied by the P/F ratio associated with age group 20-24 (see Table 67). In addition, an upward adjustment of about 12 percent is suggested by the P_1/F_1 ratios for age groups 20-24 to 40-44 in 1973 (see Table 68). The latter adjustment would produce a total fertility rate of 5.04 for 1973, a value that is very close to the 5.15 implied by the fitted trend line. It can be concluded, therefore, that the 1973 census data on births last year and children ever born do not invalidate the trend-line estimates.

The next case for comparison is the 1976 estimate obtained from the household section of the CFS. It implies a total fertility of approximately 4.4, compared to the trend-line estimate of 4.6. The trend-line estimate was derived from intersurvey comparisons, and although it is higher than the CFS household estimate and the one obtained from maternity histories (approximately 4.5), the difference is very small. Since there is no solid evidence indicating that one estimate is better than the others, we have preferred to be conservative and have chosen the highest of the three as the most acceptable. This choice is validated, in a way, by the fact that it implies a total fertility estimate of about 4.2 for 1978, while the minimum obtained in Section 3.2.4. for the same year is 4.1. Either of the lower estimates for 1976 would imply a TF value for 1978 closer to or even lower than the minimum, an outcome that does not seem satisfactory.

Probably the most uncertain estimates in Table 3 are those corresponding to the 1977-78 period, since they depend mainly on the extrapolation of those selected for previous periods and, as just noted, the one for 1978 is too close to the estimated minimum. However, in view of the available evidence, greater certainty is not possible for these most recent periods.

In conclusion, these comparisons indicate that the trend line estimates of Table 3 are reasonable and consistent with the bulk of the evidence. One cannot claim that they are exact, but they represent an acceptable compromise with respect to the overall levels observed during the period.

3.6 DERIVING A YEARLY SERIES OF AGE-SPECIFIC FERTILITY SCHEDULES, 1964-78

Given the available series of estimates of overall fertility, it would seem that a final series of age-specific fertility schedules could be derived directly from them. However, none of the available series of schedules is entirely exempt from the effects of errors. Maternity-history data are affected by errors in reporting the date of birth of each child and the age of the mother, and by truncation and censoring. Own-children data are also affected by age-reporting errors (for both children and adult females) and by matching errors. Matching errors arise when a child is erroneously assigned to a female member of the household who is not really his or her mother. Mismatches of this type often tend to assign fairly young children to relatively old mothers, artificially inflating the fertility rates at older ages.

3.6.1 Evaluation of the 1964 Estimates

To illustrate how these types of errors can affect the shape of the estimated fertility schedules, Figures 17, 18, and 19 compare fertility density functions derived from different sources for selected periods. (A fertility density function is an age-specific fertility schedule whose TF equals 1.) The first period considered is 1964 (Figure 17). The first panel of Figure 17 compares Elkins' 1969 NHS estimates with those derived from the CFS (own-children and maternity-history data). As expected, the consistency between the two sets of CFS estimates is high, although some important differences can be noticed. For example, while the mode of the own-children estimates is associated with the 25-29 age group, the modal point of the maternity-history schedule occurs at age group 20-24. It is also evident that the contribution of women aged 15-19 is higher in the maternity-history set than in the own-children set and

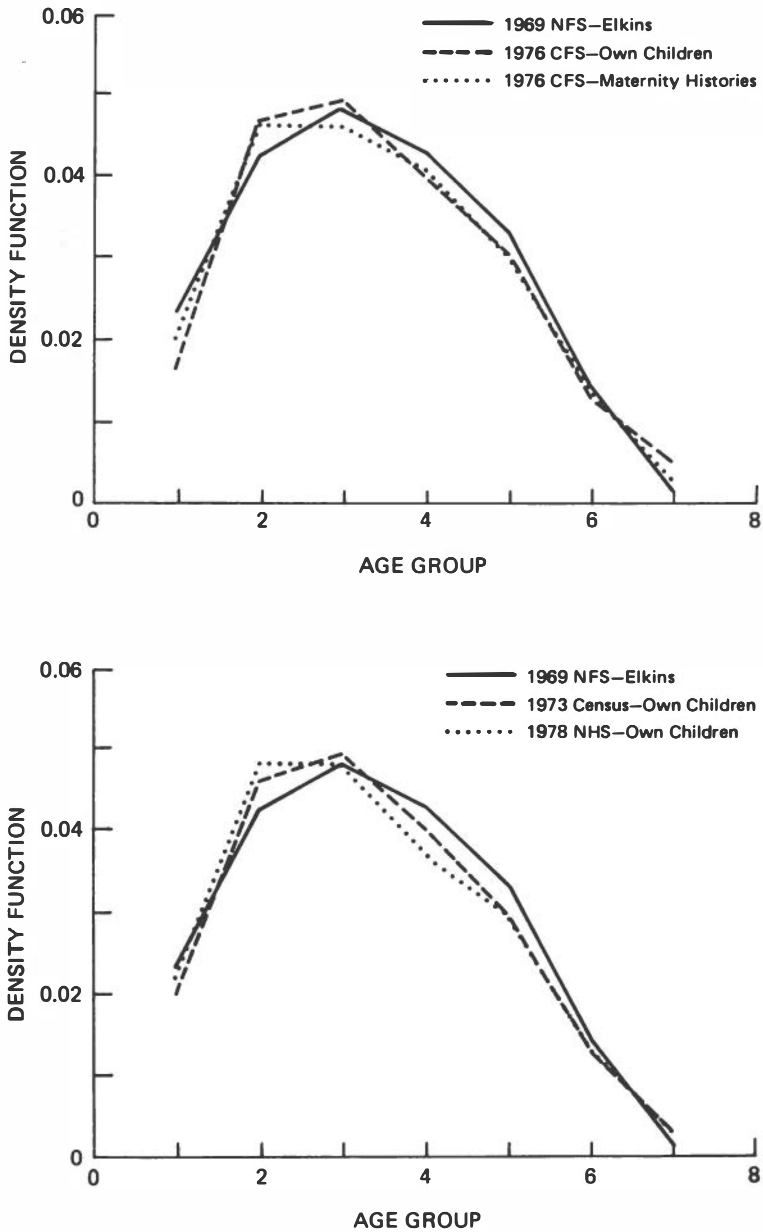


FIGURE 17 Comparison of Fertility Density Functions from Different Sources, 1964: Colombia

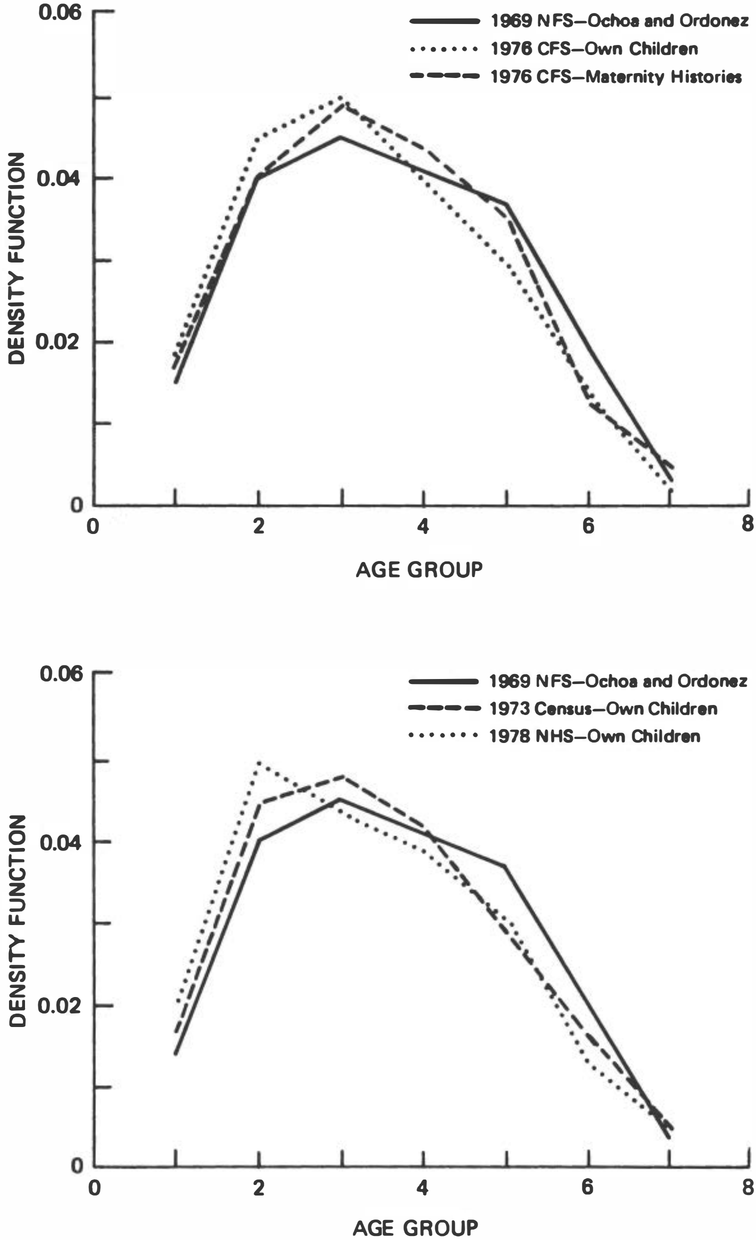
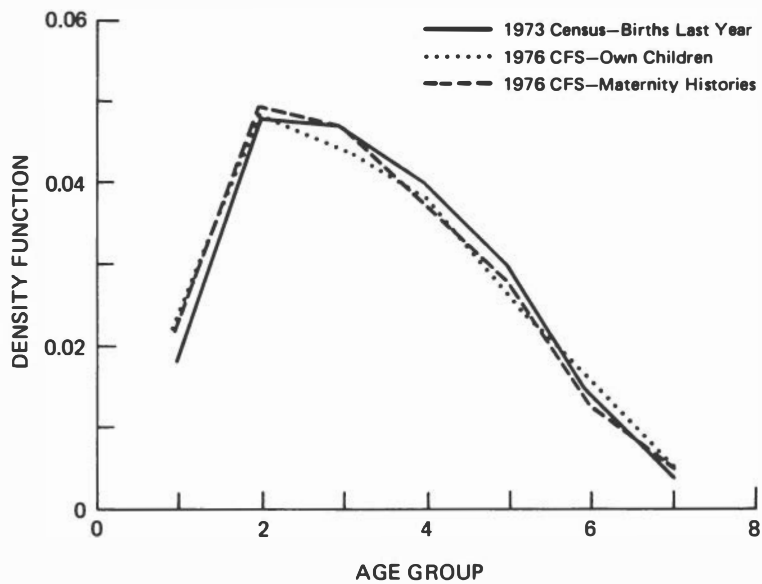


FIGURE 18 Comparison of Fertility Density Functions from Different Sources, 1969: Colombia



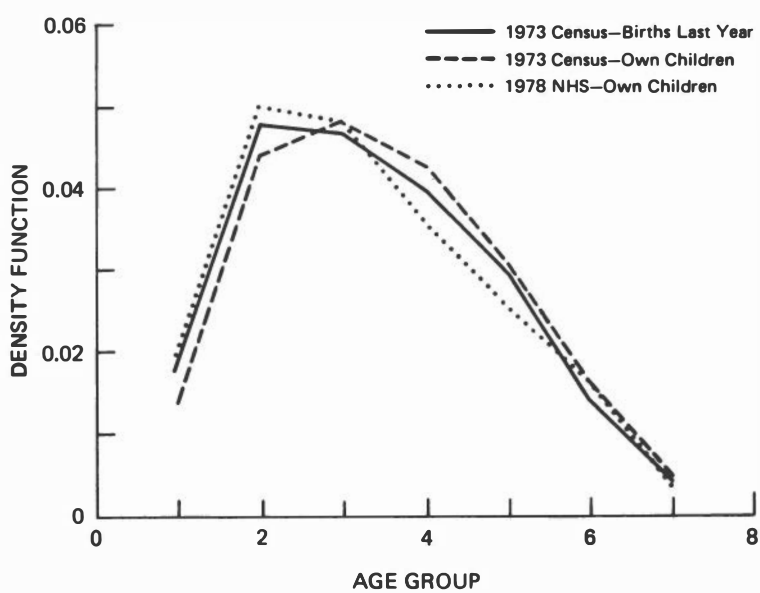


FIGURE 19 Comparison of Fertility Density Functions from Different Sources, 1973: Colombia

that women aged 45-49 have a greater impact in the own-children set than in the maternity-history set. These differences, although minor, may have nontrivial implications for the selection of a final set of consistent estimates, which is the reason for pointing them out at this stage.

Although not shown in Figure 17, the agreement between the 1973 and the 1976 own-children estimates is very good, especially over the 20-44 age range. The NHS estimates deviate more markedly from the general shape of the other two own-children sets, but the deviations are relatively small. Undoubtedly, the schedule whose shape is essentially different from all the others is the one derived from the NFS data. Being flatter and broader (i.e., having greater variance), it may be associated with a population that exercises less control over fertility and is probably subject to higher fertility levels. Once more, an overrepresentation of the rural population in the NFS sample is consistent with this outcome.

3.6.2 Evaluation of the 1969 Estimates

Figure 18 shows a similar set of comparisons for 1969. It is again evident that the NFS estimates deviate markedly from the shape of most of the others, but in 1969 the estimates derived from the CFS maternity histories agree somewhat better with the NFS estimates than with those derived from the CFS own-children, a fact that casts doubts on the accuracy of the maternity-history estimates. There is generally a good agreement between all the estimates derived from own-children data, even though the ones associated with the NHS display greater distortions than those obtained from either the census or the CFS.

The 1968-69 period helps illustrate the inconsistencies encountered in comparing fertility schedules derived from different sources. The maternity-history estimates for this period are inconsistent with those obtained for 1964 from the same source, assuming that a fertility decline usually implies greater reductions at older than at younger ages. If only the maternity-history data were available, one would have difficulties in reconciling the observed changes in the shape of the fertility schedules from 1964 to 1969 with the existence of a fertility decline. Fortunately, the availability of own-children estimates for the same period suggests that the distortions observed in the maternity-history data are probably not real.

3.6.3 Evaluation of the 1973 Estimates

In contrast with 1969, the schedules presented in Figure 19 for the 1972-73 period are in excellent agreement. Although its shape is not altogether unsatisfactory, the most deviant one is that derived from the 1973 own-children data (it is the only one whose modal point occurs at age 25-29, for example).

3.6.4 Constructing a Smooth Series of Age-Specific Fertility Schedules, 1964-78

Using model fertility schedules to smooth and reduce some of the irregularities observed in direct estimates is common. At least two such models have been used frequently during recent years: the Coale-Trussell fertility models (Coale and Trussell, 1974) and the relational Gompertz model suggested by Brass (United Nations, 1982). Fitting the Coale-Trussell models requires knowledge not only of the observed age-specific fertility schedules but also of the proportions ever married by age. In the case of Colombia, estimates of the latter are very unreliable, hence it does not seem advisable to use the Coale-Trussell models, even though their versatility is high.

Having fewer parameters than the Coale-Trussell models, the relational Gompertz model is somewhat less flexible, but it has the advantage of not requiring any estimates of nuptiality. Therefore, it was used to fit several of the age-specific fertility schedules derived so far. Using the 1976 CFS own-children estimates for 1964 and an adjusted average of the NHS and CPS 1978 schedules (based on information on births occurring during the year preceding each survey) as basic indicators of the shape of the schedule at the beginning and the end of the period, a Gompertz relational model was fitted to each of them and linear interpolation on the Gompertz parameters was used to derive a consistent yearly series of fertility densities for the 1964-78 period. Trials with other beginning and ending shapes led to inconsistencies that did not seem acceptable. However, not every possibility was explored, so the one selected, although basically satisfactory, represents simply an internally consistent representation of a plausible trend.

Once a smoothed yearly series of densities was obtained using the Gompertz model, it was coupled with the total fertility estimates presented in Table 3 to produce a series of yearly age-specific fertility schedules. A selected subset of these schedules is presented in Table 86, and three of them are displayed in Figure 3.

3.7 ESTIMATION OF A YEARLY SERIES OF BIRTH RATES, 1964-74

Comparison of the shapes of the fertility schedules displayed in Table 86 and those obtained from other sources show that the former are usually slightly higher at 15-19, lower above age 40, and that their agreement with the observed over the middle age range (20-39) is acceptable. However, notice that whereas the mode of all the fitted schedules occurs at 25-29, the observed ones are not always as consistent in this respect.

In conclusion, the estimates of Table 86 are internally consistent in the sense that they conform to a reasonable trend without being inconsistent with the available evidence. They do not reflect, however, what seem to be deviant cases, such as, for example, the 1969 maternity history schedule. Insofar as the latter are caused by errors rather than by true fluctuations in fertility, the Table 86 series should be preferred. However, because

TABLE 86 Fitted Age-Specific Fertility Schedules for Selected Years, 1965-78: Colombia

Age Group	1965	1968	1970	1973	1975	1978
15-19	.1415	.1291	.1209	.1087	.1006	.0886
20-24	.2998	.2788	.2644	.2422	.2270	.2036
25-29	.3126	.2896	.2740	.2501	.2338	.2089
30-34	.2665	.2444	.2297	.2074	.1926	.1703
35-39	.1971	.1781	.1657	.1474	.1355	.1180
40-44	.0932	.0824	.0755	.0657	.0596	.0508
45-49	.0126	.0108	.0096	.0081	.0072	.0059
Total Fertility Rate	6.6165	6.0657	5.6986	5.1479	4.7807	4.2300

the elements of this series were derived by assuming a smooth trend, the Table 86 estimates cannot reflect true fluctuations in fertility. Hence, their year-to-year accuracy should not be interpreted too strictly.

The availability of yearly age-specific fertility schedules for the 1965-78 period, of yearly estimates of mortality (from Chapter 2), and of an adjusted age distribution for 1964 (based on Set 2 of the stable and quasi-stable estimates presented in Chapter 2 and shown in Table 87), makes it possible to estimate yearly birth rates by sex for the period. These are shown in Table 4 in the report summary. Obviously, their accuracy depends on that of all the estimates involved in their derivation. In particular, the age distribution of the female population plays an important role in determining their value, as does the total estimated size of the population. Both these elements have been derived assuming that the population is closed. Inasmuch as migration reduces the denominator more than the numerator of the weights applied to the estimated age-specific fertility rates, the true birth rates in the population may be slightly higher.

3.8 SUMMARY

According to the estimates presented earlier in Tables 3 and 4, total fertility in Colombia declined by about 36 percent between 1965 and 1978. In terms of birth rates, the decline during the same period amounted to about 32 percent. Although it is not possible to pinpoint exactly the time at which the decline started, because of the paucity of data for years prior to 1964 and the spurious fluctuations inherent in the own-children estimates, the rough trend of the latter during the 1959-65 period (see Figure 15) is relatively horizontal. Hence, it seems likely that fertility remained constant up to 1964 or 1965 at a level of about 6.6 to 6.8 children per woman. The decline started thereafter, reaching a level of about 5.0 to 5.2 by 1973, and 4.4 to 4.6 in 1976. Since it is likely that the decline has continued, a level of about 4.2 for 1978 is not implausible. However, this value is subject to greater uncertainty than the rest. It is hoped that the data gathered by the surveys conducted in 1980 and early 1981 will aid in reducing this uncertainty.

NOTES

[1]Note that because the direct and indirect estimates are affected by different types of biases, such agreement is not necessary. For example, the direct estimates are affected by truncation since those corresponding to earlier periods are based on the not altogether representative experience of relatively young women. Indirect estimates, on the other hand, are dependent on the choice of model and are differentially affected by the age-of-mother effect.

[2]This is the assumption made by Lopez. It is based, however, on fairly weak evidence since the 1938-73 growth rate estimates are themselves open to question. The fairly unchanging age distribution observed during 1938-51 lends support to the premise that the growth rate started to change at a date close to 1951, but the exact timing of its turning point cannot be known accurately. In this report, the dates 1949.5 and 1950.5 will be used in different instances to derive alternative sets of demographic estimates. Although the choice of one over the other will seem somewhat arbitrary, the uncertainty surrounding the timing of the turning point does not warrant further justification for this treatment.

[3]We wish to thank Dr. Alberto Hernandez for providing us with the tabulations required to perform these recalculations.

APPENDIX A

RESULTS OF THE 1973 CENSUS

The official 1973 census date was October 24 (or, technically, midnight of October 23). According to the census plans, all populated conglomerates with at least 500 inhabitants in the departamentos were to be enumerated on that date. The inhabitants of sparsely populated areas in the departamentos, mainly in the rural areas, were enumerated during the two weeks immediately following. The intendencias of San Andres and Providencia were also enumerated within this time frame (DANE, 1975b). During this initial stage, only the population living in household dwellings, whether private or collective, was counted.

At least three other constituents of the Colombian population were counted either at different times or by different procedures. These included the population of the national territories, the population serving in the armed forces and the Indian population living in reservations. The cabeceras (municipal capitals) of the national territories were enumerated in May and June 1974. According to DANE (1974b) the reference date for this enumeration was May 29, 1974, except in Putumayo and Amazonas, where the dates were June 2 and 12, respectively. However, the final census report (DANE, 1981) suggests that some effort was made to establish whether the enumerated population was present on October 24, 1973, therefore making possible the use of a single reference date. The rural areas of the territories were canvassed only in late 1974 (from October 1974 to February 1975) and no information could be found regarding their reference dates.

The armed forces administration undertook the enumeration of its members. The date on which this enumeration was carried out could not be established, but it was probably close to the official census date. However, the final results of this enumeration were provided to DANE only late in 1980 (DANE, 1981) and they do not include a breakdown by age or sex.

Finally, the Indian population living in reservations seems to have been counted in at least two stages. The Cauca reservations were enumerated in late 1972 (DANE, 1977e) as part of a pilot census. The total population canvassed at that time in the Cauca amounted to 65,204 persons. The rest of the Indian population was enumerated by means of a special questionnaire at the same time as the rest of the rural population.

Even though part of the Colombian population had not yet been enumerated by October 1974, preliminary census results were published at that time (DANE, 1974a and 1974b). These results were based on a manual count of the data referring to the population in private and collective dwellings in the departamentos, the intendencias of San Andres and Providencia, and the cabeceras of the other national territories. The total count published in DANE 1974a differs from that published in the addendum (DANE 1974b) by 1,000; however, all the other numbers coincide. Apparently, the difference in the totals was due only to an addition error, which was corrected in the addendum.

Table A.1 presents the main results contained in the addendum (DANE, 1974b), as well as two revisions of the preliminary results, published by Potter and Ordonez (1976) and by DANE (1977b). The main difference between these two sets and the preliminary counts occurs in the figures referring to the national territories, which was to be expected, since the preliminary count published in 1974 refers mainly to the urban areas of the territories (the cabeceras). As shown by the decomposition of the 1974 count for the national territories, only the intendencias of San Andres and Providencia had been enumerated in their entirety by the time DANE published results in October, 1974. Furthermore, the count for the national territories appears to be a hybrid figure, since, at least according to the DANE (1974b) data, its components refer to different points in time.

Neither Potter and Ordonez (1976) nor the DANE (1977a) publication explain how the total figures for the national territories (371,542 and 394,261) were obtained. In both cases, however, the figures are labeled "not adjusted," so it seems probable that they also were derived from manual counts of the census returns. The large differ-

TABLE A.1 Preliminary, Interim, and Final Results of the 1973 Census: Colombia

		Preliminary Counts			
		Preliminary	Interim		Final
Area	Reference Date	DANE 1974b	Potter and Ordonez 1976	DANE 1977a	DANE 1981
Departamentos (excluding Bogota)	Oct. 24, 1973	17,719,592	17,695,304	17,695,308	17,491,160
Bogota	Oct. 24, 1973	2,855,065	2,863,994[a]	2,863,994[a]	2,571,548
National territories		139,794[b]	371,542	394,261	375,000
San Andres and Providencia (complete)	Oct. 24, 1973	22,719	--		
Amazonas cabeceras	June 2, 1974	6,285	--		
Putumayo cabeceras	June 12, 1974	22,916	--		
All other cabeceras	May 29, 1974	87,874	--		
Armed forces	c	--	--	66,629	53,111
Indian population in reservations:		--	267,596	--	294,416
Cauca reservations	Oct. 1972	--	--	65,204	
Total		20,714,451	21,198,436	21,085,396	20,785,235

[a]Incorporates an upward adjustment of 322,932 persons.
[b]Refers mostly to the cabeceras.
[c]Date not established, but probably near the official census date, October 1973.

ence between them and the 1974 figure can probably be attributed to the fact that it took several months to complete the enumeration of rural areas in the territories. There is one other discrepancy: The final census results (DANE, 1981) indicate that the total population in the national territories was 375,000. The difference between this figure and the DANE (1977a) figure may result from an adjustment for the use of different reference dates, however this is not stated clearly in any of the publications available.

No explanation could be found regarding the discrepancies between the 1974 figures for the departamentos and Bogota and those published later by Potter and Ordonez (1976) or DANE itself (1977a). However, the latter sources coincide in pointing out that their figure for Bogota already incorporates an upward adjustment of 322,932 persons. No explanation is provided for the necessity or the basis of this adjustment, however it implies that the raw census count of Bogota amounted only to 2,541,062. According to the final results, the true figure was 2,571,548.

The differences between the DANE pre-1981 totals for the departamentos and the final count can probably be attributed to the fact that the two preliminary counts included the "other" Indian population (that portion not living in the Cauca reservations or in the national territories). If this is the case, the Potter and Ordonez (1976) total count is too high, because it incorporates this Indian population twice.

Finally, none of the figures for the armed forces published before 1981 are derived from actual counts, and it is not clear whether the final figure (53,111) includes those serving in the police forces.

Table A-2 presents the actual, unadjusted census counts for different sectors of the population, as published by DANE in the final report (1981). The figures for the departamentos and for Bogota have been decomposed into private-household and collective-dwelling categories. At least one component of the total count does not refer to the official census date (the Indian population in the Cauca reservations), and those serving in the armed forces are usually not incorporated into most of the published tabulations because their classification by age is not available.

TABLE A.2 Official (Unadjusted) Results from the 1973 Census:

Type of Population	Count	Total
Departamentos		17,491,160
Private households	17,147,984	
Collective dwellings	343,176	
Bogota		2,571,548
Private households	2,530,467	
Collective dwellings	41,081	
National territories		375,000
Municipal capitals (cabeceras)	118,640	
Other areas	256,360	
Armed forces	53,111	53,111
Indian Population		
In the Cauca	65,204	294,416
Other (not in national territories)	229,212	
Total		20,785,235

Source: DANE (1981).

APPENDIX B

DESCRIPTION OF SAMPLING DESIGNS

B.1 THE 1969 NFS SAMPLE

The sample used in carrying out the 1969 NFS was a multistage probability sample of mixed type. First, four geographic regions were defined. The 1968 population of the municipios in each region was then estimated on the basis of the 1964 census count. Estimates of the population living in the cabecera (capital) of each municipio were also obtained. On the basis of these estimates, two types of primary sampling units (PSU) were defined. A Type-A PSU was constituted by the "rest" (all except the capital) of a municipio with 20,000 or more inhabitants in its capital. A Type-B PSU was constituted by each municipio whose capital had less than 20,000 inhabitants. The Type-A PSUs were classified into two subgroups and Type-B PSUs were classified into four subgroups, the subgrouping based on the estimated number of females aged 15-49 in each PSU. Applied in conjunction with the four geographic regions defined before, this division gave rise to 24 distinct strata. The anticipated 3,000 interviews were allocated proportionately to these strata on the basis of the estimated number of eligible women in each.

One municipio from each stratum was selected at random with a probability proportional to the number of eligible women living in it (estimated on the basis of the 1964 census). The selected municipios were then divided into census tracts or blocks, a certain number of which were selected systematically. The number of tracts selected depended on the number of questionnaires assigned (according to size of stratum) to each municipio and on the estimated number of eligible women in each tract. In rural areas (the "rest" of every municipio considered), all eligible women in selected census tracts were interviewed. In semi-urban areas (municipal capitals with less than 20,000 inhabitants) only a fraction of all eligible women was interviewed. Women to be interviewed were selected by means of a systematic procedure that might have reduced a woman's probability of selection whenever she belonged to a household with more than one eligible woman.

To select the urban sample, the municipal capitals with at least 20,000 inhabitants were classified in two groups: those with a population equal to or greater than 100,000 and the rest. This grouping, applied in conjunction with the same four geographic regions defined for the rural sample, created eight strata. The cities selected to represent each stratum were either those belonging to the municipios already chosen for the rural sample or those lying close to the selected rural municipios. The city of Bogota was also included. Within the cities selected, eligible women selected for individual interviews were chosen by the same procedure used in semi-urban areas.

B.2 THE COLOMBIAN MASTER SAMPLE

The Master Sample was envisioned as a general probability sample of households in Colombia that would serve as a basis for both periodic and one-time surveys. It was designed so that surveys based on the entire sample could produce reliable estimates of health characteristics for detailed subgroupings of the population at the national level or for large subgroupings of the population at the "regional" level (e.g., for cities of 1 million persons or more, for certain departamentos, or for groups of departamentos with 2 million persons or more). The design of the Master Sample also permits the selection of subsamples for surveys that aim only to produce reliable estimates for large subgroupings at the national level.

Municipios are defined as the primary sampling units (PSUs) of the Master Sample. However, municipios with fewer than 3,000 inhabitants were combined with an adjacent municipio to form a single PSU. The 854 PSUs created in this way were classified into 225 homogeneous strata. The 37 municipios having the largest number of inhabitants were considered self-representative (SR) and each constituted a separate stratum. These strata (the SR) were of roughly equal size and were all included in the Master Sample. Among the non-self-representative

PSUs, one was selected from each of the 188 strata into which they were classified. The probability of selection of each PSU was proportional to its population size within the stratum. A controlled selection procedure was used to ensure the appropriate distribution of sample PSUs to departamentos.

The non-SR 188 strata were defined so that all the PSUs belonging to a given stratum were located within one of 12 "small" geographical regions defined for the purpose of sample design. Homogeneity within strata was established with respect to the following characteristics: (1) population size according to the 1973 census, (2) proportion of the population living in the municipal capital, and (3) mean altitude (feet above sea level) of the municipal capital.

The final sample resulting from this process was constituted by 225 PSUs, covering approximately 60,000 households and 360,000 persons. These 225 PSUs were later allocated to 6 subsamples, each being a representative probability sample of the Colombian population and of its five main geographical regions (see Table 5). Each subsample consists of the 15 largest municipios and 35 others selected from 35 new strata defined according to the same criteria outlined above. In this case, only 210 PSUs in the Master Sample are classified into these strata. They constitute the non-self-representative PSUs at this stage. A controlled selection procedure was used once more to assign every non-self-representative PSU to one and only one subsample.

Segments, groups of approximately 10 households, constitute the secondary sampling units (SSU). The Master Sample comprises 6,000 segments, 2,220 of which are located within the 15 largest PSUs (this number being proportional to the population in these PSUs). The number of segments in each PSU is proportional to its population size. The urban-rural distribution of the segments is proportional to the urban-rural population in the PSUs. The other 3,780 segments are allocated among the rest of the PSUs. Each one has about 18 segments on average, a fact that reflects the equal size of their strata.

The segments in the 15 largest PSUs belonging to every subsample were allocated to the different subsamples by a controlled selection procedure based on geographic distribution. In the remaining 35 PSUs no secondary selection of segments was necessary, since they were contained in only one sample. Every subsample comprises a total of 1,000 segments.

APPENDIX C

APPLICATION OF EL-BADRY'S METHOD TO THE 1973 CENSUS SAMPLE

TABLE C.1 Proportions of Women with Zero Parity and with Not-Stated Parity, 1973 Census Sample: Colombia

Age Group	Women with Zero Parity (Proportions)	Women with Not-Stated Parity (Proportions)
Whole Country		
15-19	.5316	.3645
20-24	.3416	.1916
25-29	.1777	.1050
30-34	.1058	.0693
35-39	.0846	.0572
40-44	.0811	.0533
45-49	.0815	.0607
Cabeceras		
15-19	.5527	.3602
20-24	.3812	.1984
25-29	.2100	.1092
30-34	.1206	.0676
35-39	.0980	.0546
40-44	.0915	.0509
45-49	.0960	.0592
Rest of Country		
15-19	.4758	.3759
20-24	.2394	.1738
25-29	.1012	.0952
30-34	.0740	.0729
35-39	.0580	.0624
40-44	.0600	.0582
45-49	.0507	.0639

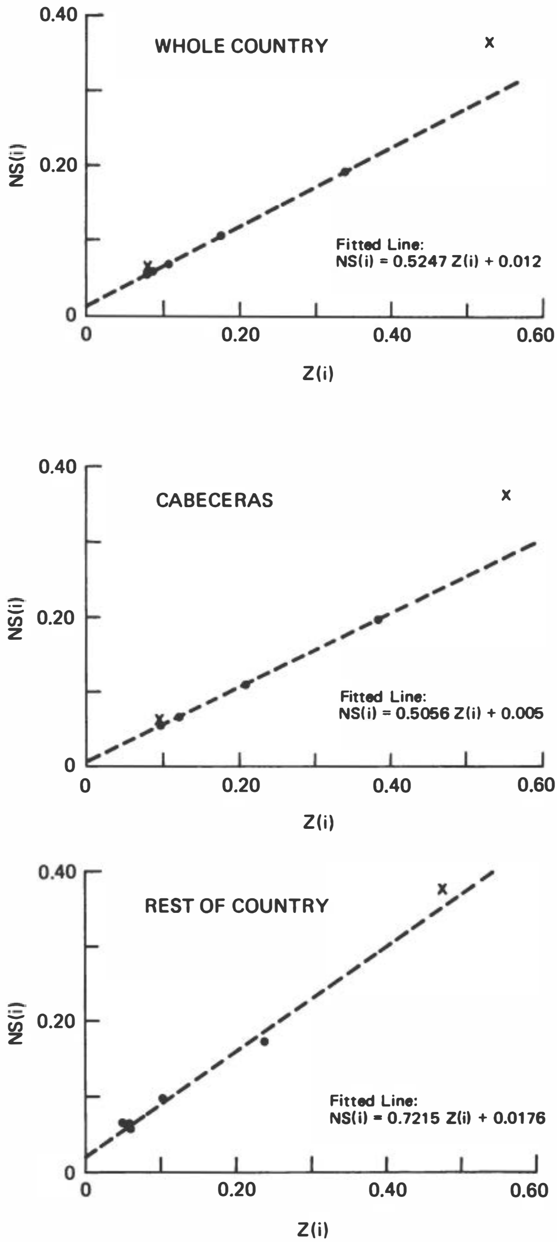


FIGURE C.1 Application of the El-Badry Adjustment for Nonresponse to the 1973 Census Sample: Colombia

APPENDIX D

DIFFERENTIAL MORTALITY ESTIMATES DERIVED FROM FERTILITY HISTORY DATA

Somoza (1980) used the detailed data from the CFS to estimate infant and child mortality over time and according to characteristics of the mother or child (region, urban or rural residence, mother's age at the birth, sex of the child, birth order, education of the mother, etc.). He investigated the plausible assumption that mortality risks vary in different subgroups of the population. To do so, separate life tables were calculated for each combination of categories of interest. Unfortunately, as in most such situations, this procedure was feasible for only a few categories, since sample sizes usually become quite small as the number of subgroups increases. In addition, it becomes increasingly difficult to summarize larger numbers of life tables.

Recently, new methods of analyzing the effects of covariates on the life table simultaneously have become available (Cox, 1972). The best-developed of these methods is the proportional hazards model, in which it is assumed that the age-specific mortality risks, for given individual characteristics, are proportional, with proportionality factors that are the same at every age (Prentice and Kalbfleisch, 1980). As in the standard life table, there is a risk of mortality at each age. In the proportional hazards model, the risk at age x is the product of two factors, one which represents the underlying age pattern of mortality and another which reflects the effect of characteristics of the individual. For example, suppose children born after 1960 have lower mortality than those born earlier and the effect is to lower the mortality risk proportionally at every age. Then let $Z_{i1} = 0$ if child i was born before 1960 and $Z_{i1} = 1$ if child i was born more recently. Then the mortality risk for this child at age x, $\mu_i(x)$, can be given by

$$\mu_i(x) = e^{\lambda(x)} e^{\beta_1 Z_{i1}}$$

where $e^{\lambda(x)}$ is the underlying age pattern of mortality and $e^{\beta_1 Z_{i1}}$ is the <u>relative risk</u> associated with being in the category given by Z_{i1}. Then children born before 1960 have mortality rates given by $e^{\lambda(x)}$, since their value of Z_{i1} is zero and children born later have their risks multiplied by e^{β_1}. If the hypothesis that children born later experience lower mortality rates is correct, then the estimated value of β_1 should be negative, so that e^{β_1} is less than 1. Procedures are available for estimating the value of β_1 and the coefficients for as many other covariates as we wish to add to the model.

As in the standard regression analysis, we need some way of assessing how well the model fits, i.e., how much variation is explained. In this case, if we are fitting a proportional hazards model, we ask how well the model with one covariate fits as compared to life tables calculated in the usual way separately for the pre-1960 and post-1960 periods. A chi-square test is available (see Menken et al., 1981). If the chi-square statistic is associated with a high p-value (i.e., the chance of a value as large as or larger than that observed is high), we accept the model as fitting the data well.

The same type of model can be applied if we want to use three time periods, births in 1941-59, 1960-67, and 1968-76. Then two covariates are necessary: $Z_{i1} = 1$ if child i was born in 1960-67 and zero otherwise and $Z_{i2} = 1$ if child i was born after 1967 and zero otherwise.

The results of fitting this model to the CFS data are given in Table D.1. Since both Z_{i1} and Z_{i2} are zero when the child was born prior to 1960, there is no β for that period. The coefficient for 1960-67 is negative, -0.33, indicating a mortality decline, and that for the most recent period has a greater negative value, -0.46. The effect on the mortality risks is given in the column labeled e^{β}. For 1960-67, it is estimated that the risks at each age were 72 percent of those in the earlier period and for 1968-1976, they were 63 percent--relative to the risks prior to 1960. The p-value of 0.68 indicates that the model fits quite well.

Table D.2 gives comparable values for single-factor models calculated for eight variables. In this table the

TABLE D.1 Time Period Proportional Hazards Model from the 1976 CFS: Colombia

Time Period of Birth	β	e^{β}
1960-67	-.3313	.72
1968-76	-.4586	.63

Note: p = .68

estimated standard error of each β coefficient is also shown. The p-values are high for the time period, region, and mother's age at birth models, moderate for birth order and urban-rural residence, and low for parent's education and sex of child. They indicate that the first three factors, or even the first five, can be assumed to be represented well as proportional hazards.

The results are not startling. Children of mothers living in the Central, Atlantic and Eastern-Bogota regions reported mortality rates that were, respectively, 76, 59 and 68 percent of those in the Pacific Region. As compared to infants of mothers under 20 at their birth, those born to older mothers have reduced mortality. Mortality drops by 23, 27 and 18 percent when mothers are 20-24, 25-29, and over 30, respectively. Other values of e^{β} can be interpreted similarly.

Of course, additional information is necessary to judge the plausibility of these estimates. Without knowledge of general conditions in the Atlantic region, it would be impossible to tell from this analysis that the estimated coefficient is highly suspect because of poorer reporting of child deaths.

It should also be noted that a low p-value is not necessarily accompanied by a small coefficient. In addition, a factor with a coefficient close to zero can have a high p-value, since the model with this variable included may fit nearly as well as the model that omits it.

The multivariate analysis was carried out by adding one factor at a time. The factor chosen was the one with the highest p-value. Therefore, at the first stage,

TABLE D.2 Single Factor Proportional Hazards Models from the 1976 CFS: Colombia

Factor[a]	β	$S.E._{\beta}$	e^{β}	P
Time period of birth:				
1960-67	-.331	.058	.72	
1968-76	-.459	.060	.63	
				.68
Region:				
Central	-.271	.065	.76	
Atlantic	-.522	.076	.59	
Eastern-Bogota	-.393	.066	.68	
				.85
Mother's age at birth:				
20-24	-.255	.065	.77	
25-29	-.321	.071	.73	
30+	-.204	.070	.82	
				.69
Birth order of child:				
2-3	.285	.070	1.33	
4+	.227	.067	1.25	
				.37
Residence:				
Rural	.292	.048	1.34	
				.43
Mother's education:				
3+ years	-.463	.049	.63	
				.01
Father's education:				
3+ years	-.332	.048	.72	
				.05
Sex of child:				
Female	-.079[b]	.048	.92	
				.01

[a]The omitted categories are: time period, prior to 1960, Pacific region, mother's age < 20 at birth, birth order 1, urban residence, education less than 3 years, and male sex.
[b]Coefficient not significantly different from zero.

region was the factor selected. At the second stage, two-factor models were fitted, e.g., region by time period, region by mother's age, etc. The fit of these models was compared to the fit using region alone. The second factor selected was that in which the p-value was highest. This procedure is analogous to a stepwise regression in which the next variable to be added is the one which increases the multiple correlation coefficient the most. Table D.3 shows the p-values at each stage. Since the region-times-mother's-age model had the highest p-value at the two-factor stage, mother's age was the next covariate to be added to the model. Successively, time period, birth order, sex, and residence were included. Table D.4 gives the coefficients and their standard errors for the best fitting models, and Table D.5 displays the relative risks.

In most cases, the coefficients change very little as additional variables are included, indicating that the effects are primarily direct ones. Notably, however, the impact of maternal age and birth order changes when both are included. In this case, very high risks are attributed to birth orders above the first and low risks to maternal ages above 20. Somoza (1980) has demonstrated a differential effect of birth order according to maternal age, which is not captured by this type of proportional hazards model. A model that includes age and birth-order interaction terms would probably be more appropriate.

At least for the first four factors (region, maternal age, time period, and birth order) the proportional hazards model appears to fit the observed data quite well and offers a reasonable way to summarize the risks associated with each category of these covariates.

Table D.6 is another demonstration of how well the proportional hazards model fits the observed data. If l_1^O is calculated for each sub-group in the usual way and also estimated from the model to produce l_1^E, the percentage error in the estimate is given by $(l_1^E - l_1^O)/l_1^E)$. For the most part, these errors are less than 5 percent.

TABLE D.3 Associated p-Values for Proportional Hazards Models from the 1976 CFS: Colombia

Factor	Single Factor	Region x	Region x Age x	Region x Age x Time Period x	Region x Age x Time Period x Birth Order x	Region x Age x Time Period x Birth Order x Sex x
Time period of birth	.68	.72	.68[a]			
Region	.85[a]					
Mother's age at birth	.69	.80[a]				
Birth order of child	.37	.14		.26[a]		
Residence	.43	.42	.32	.03	.01	.01
Mother's education	.01	.01	.00	.00	--	
Father's education	.05	.15	.15	.00	--	
Sex of child	.01	.03	.05	.06	.04[a]	

[a]Factor added next.

TABLE D.4 Coefficients and Their Standard Errors for the Single-Factor and Best-Fitting Two-to-Six Factor Proportional Hazards Models from the 1976 CFS: Colombia

	Number of Factors											
	β						$S.E._{β}$					
Factor	1	2	3	4	5	6	1	2	3	4	5	6
Time period of birth:												
1960-67	-.331		-.336	-.348	-.346	-.349	.058		.061	.061	.061	.060
1968-76	-.459		-.464	-.464	-.463	-.482	.060		.063	.063	.063	.063
Region:												
Central	-.271	-.260	-.266	-.269	-.270	-.274	.065	.065	.065	.065	.065	.065
Atlantic	-.522	-.539	-.518	-.534	-.536	-.549	.076	.076	.076	.076	.076	.076
Eastern-Bogota	-.393	-.385	-.397	-.387	-.388	-.358	.066	.066	.067	.066	.067	.067
Mother's age at birth:												
20-24	-.255	-.266	-.238	-.406	-.407	-.386	.065	.065	.065	.069	.069	.070
25-29	-.321	-.336	-.270	-.533	-.535	-.509	.071	.071	.071	.083	.083	.083
30+	-.204	-.233	-.073	-.382	-.383	-.361	.070	.070	.074	.092	.092	.092
Birth order of child:												
2-3	.285			.435	.434	.423	.070			.072	.072	.072
4+	.227			.549	.550	.515	.067			.083	.083	.084
Residence:												
Rural	.292					.284	.048					.049
Mother's education:												
3+ years	-.463						.049					
Father's education:												
3+ years	-.332						.048					
Sex of child:												
Female	-.079				-.083	-.081	.048				.048	.048

TABLE D.5 Relative Risks (e^{β}) for the Single Factor and Best-Fitting Two-to-Six-Factor Proportional Hazards Models from the 1976 CFS: Colombia

	Number of Factors					
Factor	1	2	3	4	5	6
Time period of birth:						
1960-67	.72		.72	.71	.71	.71
1968-76	.63		.63	.63	.63	.62
Region:						
Central	.76	.77	.77	.76	.76	.76
Atlantic	.59	.58	.60	.59	.59	.58
Eastern-Bogota	.68	.68	.67	.68	.68	.70
Mother's age at birth:						
20-24	.77	.77	.79	.67	.67	.68
25-29	.73	.71	.76	.59	.59	.60
30+	.82	.79	.93	.68	.68	.70
Birth order of child:						
2-3	1.33			1.54	1.54	1.53
4+	1.25			1.73	1.73	1.67
Residence:						
Rural	1.34					1.33
Mother's education:						
3+ years	.63					
Father's education:						
3+ years	.72					
Sex of child:						
Female	.92				.92	.92

TABLE D.6 Percentage Error[a] in Survival to Age 1 Estimated from the Four-Factor Proportional Hazards Model from the 1976 CFS: Colombia

		Pacific			Central			Atlantic			Eastern-Bogota		
Mother's Age	Birth Order	Before 1960	1960-1967	1968-1976	Before 1960	1960-1967	1968-1976	Before 1960	1960-1967	1968-1976	Before 1960	1960-1967	1968-1976
Less than 20	1	0.1	6.8	3.7	-0.0	-4.1	1.2	-4.6	1.0	2.3	3.5	-3.0	-0.2
	2-3	-4.9	-1.0	3.6	3.7	4.2	-3.3	3.5	0.6	1.8	-0.9	-0.4	-5.1
	4+	--	--	--	10.7	--	--	6.8	--	--	0.5	--	--
20-24	1	0.6	0.9	2.7	2.6	1.8	-0.2	0.5	-1.8	-0.2	-0.7	0.3	-2.6
	2-3	2.7	6.8	-1.5	-2.4	-1.9	-0.7	-9.1	-2.5	1.9	-1.1	1.8	-0.5
	4+	-3.4	-2.3	-3.7	1.6	-2.1	-0.4	-2.7	-1.5	-0.5	6.7	4.4	-0.4
25-29	1	1.1	10.0	4.6	-3.3	2.4	1.4	5.7	--	8.0	-5.6	5.1	2.0
	2-3	12.2	-5.0	0.3	5.4	-0.3	-0.1	-4.2	0.4	-0.2	-1.0	-0.5	-0.2
	4+	-4.6	1.0	-1.4	0.1	0.7	-3.4	-2.7	-0.7	1.3	0.7	-0.3	0.4
30+	1	--	-6.7	6.0	--	-5.2	8.8	--	--	-3.6	--	32.4	1.3
	2-3	--	-4.5	-4.5	-2.0	--	-7.0	--	22.9	9.7	8.5	3.7	-0.2
	4+	-8.3	-6.4	1.8	-1.3	-0.2	1.1	-0.4	-1.2	-1.3	2.8	2.0	-0.3

[a]Cells containing fewer than 10 infants are omitted.

APPENDIX E

POPULATION ESTIMATES AND AGE DISTRIBUTION OF THE POPULATION

Table E.1 presents the census counts consistent with the growth rates of Sets 1 and 2 described in Chapter 2, and with the adjusted population sex ratios, 1938-64. Table E.2 shows population estimates based on stable and quasi-stable estimates, 1951-64.

As a by-product of the fertility and mortality estimation undertaken in this report, adjusted estimates of the population's age distribution in 1964 and in 1973 were obtained. When these are coupled with the estimates of census counts derived in conjunction with the stable and quasi-stable estimates (Table E.1, Set 2), the completeness of enumeration of the last three censuses can be estimated. Table E.3 shows the adjusted age distributions for 1964 and 1973, and Table E.4 shows the observed and estimated census counts of 1951, 1964, and 1973. It is important to note that these estimated counts do not make any allowance for the existence of a net out-migrant flow. If, as suggested by Arbalaez (1977), about 557,000 persons left Colombia during the 1964-73 period, then the completeness of the 1973 census count would be 0.913, very close to that estimated by the post-enumeration survey.

TABLE E.1 Census Counts Consistent with the Growth Rates of Sets 1 and 2, and with Adjusted Population Sex Ratios, 1938-64: Colombia

Census Date	Estimated Count		Sex Ratio[a]	Estimates of Completeness	
	Male	Female		Male	Female
Set 1					
1938	4,411,999	4,389,313	1.0052(1)	0.9774	1.0000
1951	5,998,815	5,967,969	1.0052(1)	0.9301	0.9466
1964	8,910,782	8,869,856	1.0046(2)	0.9668	1.0000
Set 2					
1938	4,410,382	4,389,313	1.0048(1)	0.9778	1.0000
1951	6,027,708	5,998,913	1.0048(1)	0.9256	0.9417
1964	8,901,787	8,869,856	1.0036(3)	0.9678	1.0000

[a]The population sex ratios have been adjusted to be consistent with the estimated birth rates and the following sex ratios at birth: (1) 1.050, (2) 1.044, (3) 1.034.

TABLE E.2 Population Estimates Based on Stable and Quasi-Stable Estimates, 1951-64: Colombia

Case	Estimated Population in 1951	Estimated Population Aged 13 and Over in 1964	Estimated Intercensal Deaths
Set 1			
Male	5,998,815	5,209,504	789,311
Female	5,967,969	5,243,789	724,180
Set 2			
Male	6,027,708	5,230,886	796,822
Female	5,998,913	5,260,047	738,866

TABLE E.3 Adjusted Age Distributions by Sex, 1964 and 1973: Colombia

Age Group	1964		1973	
	Male	Female	Male	Female
0-1	388,765	378,733	395,912	385,474
1-2	357,138	349,579	385,434	376,007
2-3	335,977	328,818	379,986	370,664
3-4	317,246	311,688	376,446	367,792
4-5	299,780	295,535	373,133	364,826
5-9	1,295,298	1,278,723	1,816,195	1,792,542
10-14	1,037,385	1,021,349	1,529,340	1,516,218
15-19	873,462	858,528	1,213,573	1,202,079
20-24	753,218	741,356	973,539	963,760
25-29	644,421	636,053	821,010	813,264
30-34	547,486	542,132	701,822	697,458
35-39	462,545	459,549	595,248	594,194
40-44	388,530	387,829	501,113	502,999
45-49	323,535	325,815	419,418	423,478
50-54	264,033	269,860	346,620	352,588
55-59	209,114	218,677	279,259	288,136
60-64	158,613	170,936	216,006	228,468
65-69	112,471	126,260	156,902	172,273
70-74	71,724	85,305	103,534	119,539
75-79	38,904	50,094	58,604	72,419
80+	22,149	33,047	35,356	49,485
Total	8,901,787	8,869,856	11,678,446	11,653,654

TABLE E.4 Estimates of Completeness of Census Enumeration, 1951, 1964, and 1973: Colombia

	Actual Count		Estimated Population[a]		Completeness
Year	Male	Female	Male	Female	Both Sexes
1951	5,579,259	5,649,250	6,027,708	5,998,913	.934
1964	8,614,652	8,869,856	8,901,787	8,869,856	.984
1973	10,210,256[b]	10,574,979	11,678,446	11,653,654	.891

[a]These estimates are obtained from the series of estimated fertility and mortality schedules presented in the main body of this report. The 1951 estimates are consistent with the Set 2 stable parameters of Table 43. In all cases, net migration is assumed to be nil.
[b]Includes armed forces.

APPENDIX F

ESTIMATED LIFE TABLES BY SEX, 1950, 1955, 1960, 1965, 1970, AND 1975

TABLE F.1 Estimated Life Tables by Sex, 1950: Colombia

MALES

AGE X	1(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.891547	43.70874	43.709	0.0
1	0.838130	0.819940	42.81720	51.087	0.161870
2	0.801750	0.793545	41.99727	52.382	0.198250
3	0.785340	0.779955	41.20374	52.466	0.214660
4	0.774570	0.770440	40.42378	52.189	0.225430
5	0.766310	3.779058	39.65335	51.746	0.233690
10	0.746690	3.704607	35.87430	48.044	0.253310
15	0.733790	3.620343	32.16969	43.840	0.266210
20	0.713480	3.505048	28.54936	40.014	0.286520
25	0.687960	3.372508	25.04433	36.404	0.312040
30	0.660220	3.227592	21.67183	32.825	0.339780
35	0.630490	3.073503	18.44424	29.254	0.369510
40	0.598600	2.901258	15.37075	25.678	0.401400
45	0.561580	2.688134	12.46949	22.204	0.438420
50	0.515030	2.449463	9.78136	18.992	0.484970
55	0.463200	2.163803	7.33189	15.829	0.536800
60	0.400350	1.818683	5.16809	12.909	0.599650
65	0.325240	1.416864	3.34941	10.298	0.674760
70	0.240470	0.985655	1.93254	8.037	0.759530
75	0.154560	0.580560	0.94689	6.126	0.845440
80	0.080680	0.366330	0.36633	4.541	0.919320

FEMALES

AGE X	1(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.910644	46.73459	46.735	0.0
1	0.862530	0.844270	45.82396	53.127	0.137470
2	0.826010	0.817585	44.97969	54.454	0.173990
3	0.809160	0.803570	44.16211	54.578	0.190840
4	0.797980	0.793660	43.35855	54.335	0.202020
5	0.789340	3.887464	42.56490	53.925	0.210660
10	0.767790	3.808013	38.67744	50.375	0.232210
15	0.754660	3.726298	34.86945	46.205	0.245340
20	0.735000	3.614388	31.14316	42.372	0.265000
25	0.710160	3.484982	27.52878	38.764	0.289840
30	0.682990	3.342544	24.04381	35.204	0.317010
35	0.653680	3.190063	20.70128	31.669	0.346320
40	0.622010	3.034122	17.51123	28.153	0.377990
45	0.590420	2.871008	14.47711	24.520	0.409580
50	0.555080	2.665318	11.60610	20.909	0.444920
55	0.509560	2.411833	8.94078	17.546	0.490440
60	0.453170	2.097044	6.52895	14.407	0.546830
65	0.383420	1.714213	4.43191	11.559	0.616580
70	0.300370	1.275455	2.71769	9.040	0.699630
75	0.209240	0.822890	1.44224	6.893	0.790760
80	0.121700	0.619350	0.61935	5.089	0.878300

TABLE F.2 Estimated Life Tables by Sex, 1955: Colombia

MALES

AGE X	l(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.909617	46.81645	46.817	0.0
1	0.865100	0.848305	45.90704	53.066	0.134900
2	0.831510	0.823805	45.05875	54.189	0.168490
3	0.816100	0.811005	44.23495	54.203	0.183900
4	0.805910	0.801975	43.42395	53.882	0.194090
5	0.798040	3.935182	42.62198	53.408	0.201960
10	0.777970	3.857763	38.68680	49.728	0.222030
15	0.764820	3.778769	34.82904	45.539	0.235180
20	0.745860	3.670757	31.05028	41.630	0.254140
25	0.721860	3.545550	27.37953	37.929	0.278140
30	0.695540	3.407424	23.83398	34.267	0.304460
35	0.667070	3.259058	20.42657	30.621	0.332930
40	0.636210	3.094778	17.16753	26.984	0.363790
45	0.601270	2.899137	14.07275	23.405	0.398730
50	0.558650	2.673493	11.17362	20.001	0.441350
55	0.509120	2.397658	8.50012	16.696	0.490880
60	0.447780	2.056034	6.10247	13.628	0.552220
65	0.372330	1.644693	4.04643	10.868	0.627670
70	0.283840	1.183669	2.40174	8.462	0.716160
75	0.189640	0.726820	1.21807	6.423	0.810360
80	0.103720	0.491250	0.49125	4.736	0.896280

FEMALES

AGE X	l(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.923600	50.01714	50.017	0.0
1	0.885550	0.869100	49.09154	55.436	0.114450
2	0.852650	0.844935	48.22244	56.556	0.147350
3	0.837220	0.832065	47.37752	56.589	0.162780
4	0.826910	0.822905	46.54546	56.288	0.173090
5	0.818900	4.035792	45.72256	55.834	0.181100
10	0.797910	3.958263	41.68678	52.245	0.202090
15	0.785360	3.884618	37.72853	48.040	0.214640
20	0.767700	3.783773	33.84392	44.085	0.232300
25	0.745250	3.666323	30.06015	40.336	0.254750
30	0.720480	3.535960	26.39383	36.634	0.279520
35	0.693540	3.395093	22.85786	32.958	0.306460
40	0.664130	3.249168	19.46278	29.306	0.335870
45	0.634410	3.095348	16.21362	25.557	0.365590
50	0.600990	2.899822	13.11827	21.828	0.399010
55	0.557400	2.654818	10.21845	18.332	0.442600
60	0.502380	2.343758	7.56363	15.056	0.497620
65	0.432580	1.954319	5.21988	12.067	0.567420
70	0.346680	1.491134	3.26556	9.420	0.653320
75	0.248430	0.991485	1.77442	7.143	0.751570
80	0.149360	0.782940	0.78294	5.242	0.850640

TABLE F.3 Estimated Life Tables by Sex, 1960: Colombia

MALES

AGE X	1(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.926648	50.27802	50.278	0.0
1	0.890520	0.875400	49.35138	55.419	0.109480
2	0.860280	0.853215	48.47598	56.349	0.139720
3	0.846150	0.841435	47.62277	56.282	0.153850
4	0.836720	0.833055	46.78134	55.910	0.163280
5	0.829390	4.090909	45.94829	55.400	0.170610
10	0.809370	4.012444	41.85739	51.716	0.190630
15	0.796240	3.939778	37.84496	47.530	0.203760
20	0.778900	3.840549	33.90518	43.530	0.221100
25	0.756760	3.724498	30.06464	39.728	0.243240
30	0.732240	3.595198	26.34015	35.972	0.267760
35	0.705460	3.454873	22.74496	32.241	0.294540
40	0.676110	3.301163	19.29010	28.531	0.323890
45	0.643840	3.126847	15.98894	24.834	0.356160
50	0.606040	2.919064	12.86209	21.223	0.393960
55	0.559930	2.659502	9.94303	17.758	0.440070
60	0.501580	2.329659	7.28353	14.521	0.498420
65	0.427620	1.918098	4.95387	11.585	0.572380
70	0.337180	1.433994	3.03577	9.003	0.662820
75	0.235410	0.923835	1.60177	6.804	0.764590
80	0.135980	0.677940	0.67794	4.986	0.864020

FEMALES

AGE X	1(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.937817	53.60393	53.604	0.0
1	0.907560	0.893035	52.66612	58.030	0.092440
2	0.878510	0.871455	51.77310	58.933	0.121490
3	0.864400	0.859755	50.90166	58.887	0.135600
4	0.855110	0.851480	50.04192	58.521	0.144890
5	0.847850	4.182384	49.19044	58.018	0.152150
10	0.827840	4.108278	45.00807	54.368	0.172160
15	0.816080	4.043472	40.89980	50.117	0.183920
20	0.800610	3.954823	36.85632	46.035	0.199390
25	0.780800	3.850858	32.90150	42.138	0.219200
30	0.758800	3.734533	29.05066	38.285	0.241200
35	0.734650	3.607662	25.31613	34.460	0.265350
40	0.708040	3.474488	21.70848	30.660	0.291960
45	0.680760	3.333098	18.23399	26.785	0.319240
50	0.649960	3.152043	14.90091	22.926	0.350040
55	0.609310	2.921253	11.74887	19.282	0.390690
60	0.556960	2.621344	8.82761	15.850	0.443040
65	0.488750	2.233933	6.20627	12.698	0.511250
70	0.401740	1.753609	3.97233	9.888	0.598260
75	0.297400	1.207794	2.21873	7.460	0.702600
80	0.185950	1.010932	1.01093	5.437	0.814050

TABLE F.4 Estimated Life Tables by Sex, 1965: Colombia

MALES

AGE X	l(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.936240	53.40178	53.402	0.0
1	0.908010	0.896700	52.46555	57.781	0.091990
2	0.885390	0.880255	51.56885	58.244	0.114610
3	0.875120	0.870655	50.68860	57.922	0.124880
4	0.866190	0.862675	49.81795	57.514	0.133810
5	0.859160	4.217843	48.95528	56.980	0.140840
10	0.834610	4.137664	44.73744	53.603	0.165390
15	0.821760	4.070948	40.59979	49.406	0.178240
20	0.805900	3.979898	36.52885	45.327	0.194100
25	0.785520	3.872653	32.54897	41.436	0.214480
30	0.762770	3.752143	28.67632	37.595	0.237230
35	0.737700	3.620183	24.92418	33.786	0.262300
40	0.709970	3.477183	21.30400	30.007	0.290030
45	0.680320	3.322868	17.82683	26.204	0.319680
50	0.647080	3.133348	14.50397	22.414	0.352920
55	0.604640	2.892398	11.37062	18.806	0.395360
60	0.550000	2.579753	8.47822	15.415	0.450000
65	0.479010	2.177773	5.89847	12.314	0.520990
70	0.389060	1.684479	3.72070	9.563	0.610940
75	0.282700	1.134464	2.03622	7.203	0.717300
80	0.171870	0.901755	0.90175	5.247	0.828130

FEMALES

AGE X	l(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.943374	56.74768	56.748	0.0
1	0.920370	0.907930	55.80432	60.632	0.079630
2	0.895490	0.890490	54.89639	61.303	0.104510
3	0.885490	0.881305	54.00591	60.990	0.114510
4	0.877120	0.873830	53.12460	60.567	0.122880
5	0.870540	4.298433	52.25078	60.021	0.129460
10	0.851670	4.228333	47.95235	56.304	0.148330
15	0.840720	4.171147	43.72401	52.008	0.159280
20	0.827120	4.093042	39.55287	47.820	0.172880
25	0.809630	4.000978	35.45984	43.798	0.190370
30	0.790090	3.897327	31.45886	39.817	0.209910
35	0.348490	3.783453	27.56154	35.865	0.231510
40	0.744580	3.662614	23.77809	31.937	0.255420
45	0.719650	3.533652	20.11548	27.952	0.280350
50	0.691520	3.367642	16.58183	23.979	0.308480
55	0.654030	3.153088	13.21420	20.204	0.345970
60	0.604970	2.868872	10.06111	16.631	0.395030
65	0.539600	2.491732	7.19224	13.329	0.460400
70	0.453550	2.006639	4.70050	10.364	0.546450
75	0.345890	1.428219	2.69387	7.788	0.654110
80	0.224490	1.263447	1.26345	5.638	0.775510

TABLE F.5 Estimated Life Tables by Sex, 1970: Colombia

MALES

AGE X	1(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.942140	56.26334	56.263	0.0
1	0.920680	0.911240	55.32120	60.087	0.079320
2	0.901800	0.897530	54.40996	60.335	0.098200
3	0.893260	0.889515	53.51244	59.907	0.106740
4	0.885770	0.882820	52.62292	59.409	0.114230
5	0.879870	4.339998	51.74011	58.804	0.120130
10	0.860550	4.270013	47.40012	55.081	0.139450
15	0.848840	4.210423	43.13011	50.811	0.151160
20	0.834670	4.128763	38.91969	46.629	0.165330
25	0.816320	4.031738	34.79094	42.619	0.183680
30	0.795640	3.921662	30.75920	38.660	0.204360
35	0.772630	3.799863	26.83754	34.735	0.227370
40	0.746900	3.664924	23.03769	30.844	0.253100
45	0.718690	3.517814	19.37277	26.956	0.281310
50	0.687040	3.338113	15.85496	23.077	0.312960
55	0.646570	3.106338	12.51685	19.359	0.353430
60	0.593550	2.799527	9.41051	15.855	0.406450
65	0.523110	2.394848	6.61099	12.638	0.476890
70	0.431270	1.882354	4.21614	9.776	0.568730
75	0.318860	1.289914	2.33378	7.319	0.681140
80	0.197230	1.043870	1.04387	5.293	0.802770

FEMALES

AGE X	1(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.948685	59.78659	59.787	0.0
1	0.930910	0.920250	58.83791	63.205	0.069090
2	0.909590	0.906710	57.91766	63.674	0.090410
3	0.903830	0.900250	57.01096	63.077	0.096170
4	0.896670	0.893840	56.11072	62.577	0.103330
5	0.891010	4.420393	55.21689	61.971	0.108990
10	0.877880	4.360668	50.79651	57.863	0.122120
15	0.867800	4.310868	46.43585	53.510	0.132200
20	0.856000	4.242904	42.12498	49.211	0.144000
25	0.840730	4.162188	37.88210	45.059	0.159270
30	0.823530	4.070514	33.71991	40.946	0.176470
35	0.804340	3.968843	29.64940	36.862	0.195660
40	0.782830	3.858303	25.68056	32.805	0.217170
45	0.759800	3.737078	21.82227	28.721	0.240200
50	0.733260	3.582023	18.08519	24.664	0.266740
55	0.698050	3.378678	14.50317	20.777	0.301950
60	0.651130	3.103683	11.12449	17.085	0.348870
65	0.587160	2.728969	8.02081	13.660	0.412840
70	0.500400	2.230728	5.29184	10.575	0.499600
75	0.387820	1.613258	3.06111	7.893	0.612180
80	0.255640	1.447853	1.44785	5.664	0.744360

TABLE F.6 Estimated Life Tables by Sex, 1975: Colombia

MALES

AGE X	l(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.947637	58.74170	58.742	0.0
1	0.931030	0.922610	57.79407	62.075	0.068970
2	0.914190	0.910410	56.87146	62.210	0.085810
3	0.906630	0.903230	55.96106	61.724	0.093370
4	0.899830	0.897140	55.05783	61.187	0.100170
5	0.894450	4.433878	54.16071	60.552	0.105550
10	0.881130	4.375504	49.72484	56.433	0.118870
15	0.870480	4.322264	45.34933	52.097	0.129520
20	0.857810	4.248968	41.02708	47.828	0.142190
25	0.841290	4.161287	36.77812	43.716	0.158710
30	0.822530	4.061013	32.61684	39.654	0.177470
35	0.801480	3.949048	28.55583	35.629	0.198520
40	0.777720	3.822584	24.60680	31.640	0.222280
45	0.751090	3.683474	20.78423	27.672	0.248910
50	0.721200	3.514344	17.10075	23.712	0.278800
55	0.682910	3.293433	13.58641	19.895	0.317090
60	0.632000	2.995823	10.29298	16.286	0.368000
65	0.562990	2.594088	7.29715	12.961	0.437010
70	0.470630	2.070128	4.70307	9.993	0.529370
75	0.353830	1.442999	2.63294	7.441	0.646170
80	0.222710	1.189939	1.18994	5.343	0.777290

FEMALES

AGE X	l(X)	L(X)	T(X)	E(X)	Q(X)
0	1.000000	0.953653	62.30685	62.307	0.0
1	0.939750	0.929665	61.35321	65.287	0.060250
2	0.919580	0.916610	60.42355	65.708	0.080420
3	0.913640	0.910040	59.50696	65.132	0.086360
4	0.906440	0.903565	58.59692	64.645	0.093560
5	0.900690	4.484623	57.69336	64.055	0.099310
10	0.893160	4.448419	53.20874	59.574	0.106840
15	0.885960	4.411717	48.76033	55.037	0.114040
20	0.878720	4.361167	44.34862	50.470	0.121280
25	0.865360	4.290342	39.98746	46.209	0.134640
30	0.850210	4.209332	35.69713	41.986	0.149790
35	0.833200	4.118798	31.48781	37.791	0.166800
40	0.813960	4.018269	27.36902	33.625	0.186040
45	0.792800	3.906365	23.35075	29.454	0.207200
50	0.768000	3.761743	19.44539	25.320	0.232000
55	0.735230	3.571012	15.68365	21.332	0.264770
60	0.690880	3.308309	12.11263	17.532	0.309120
65	0.629140	2.941639	8.80433	13.994	0.370860
70	0.543100	2.438787	5.86269	10.795	0.456900
75	0.427540	1.792058	3.42390	8.008	0.572460
80	0.286380	1.631841	1.63184	5.698	0.713620

GLOSSARY

AGE HEAPING A tendency for enumerators or respondents to report certain ages instead of others; also called age preference or digit preference. Preference for ages ending in 0 or 5 is widespread.

AGE PATTERN OF FERTILITY The relative distribution of a set of age-specific fertility rates. It expresses the relative contribution of each age group to total fertility.

AGE RATIO The ratio of the population in a given age group to the average of the populations in the two neighboring age groups, times 100.

AGE-SPECIFIC FERTILITY RATE The number of births occurring during a specified period to women of a specified age or age group, divided by the number of person-years-lived during that period by women of that age or age group. When an age-specific fertility rate is calculated for a calendar year, the number of births to women of the specified age is usually divided by the midyear population of women of that age.

AGE-SPECIFIC MORTALITY RATE The number of deaths occurring during a specified period to persons (usually specified by sex) of a specified age or age group, divided by the number of person-years-lived during that period by the persons of that age or age group. When an age-specific mortality rate is calculated for a calendar year, the number of deaths to persons of the specified age is usually divided by the midyear population of persons of that age. Age-specific mortality rates are generally denoted by ${}_nM_x$, the annual death rate to persons aged x to x + n.

AGE STANDARDIZATION A procedure of adjustment of crude rates (birth, death, or other rates) designed to reduce the effect of differences in age structure when comparing rates for different populations.

BIRTH HISTORY A report of the number and dates of all live births experienced by a particular woman; see also pregnancy history. The sex of each child, the survival of each child to the date of the interview, and, where pertinent, the date of death are also generally recorded.

BIRTH ORDER The ordinal number of a given live birth in relation to all previous live births of the same woman (e.g., 5 is the birth order of the fifth live birth occurring to the same woman).

BIRTH RATE See crude birth rate.

CHANDRASEKARAN-DEMING TECHNIQUE A procedure to estimate the coverage of two independent systems collecting information about demographic or other events, based on the assumption that the probability of an event being recorded by one system is the same whether or not the event is recorded by the other system. The events from both systems are matched to establish M, the number of events recorded by both systems; U_1, the number recorded only by system 1; and U_2, the number recorded only by system 2. The Chandrasekaran-Deming formula then estimates total events, N, as

$$\hat{N} = M + U_1 + U_2 + \frac{U_1 U_2}{M}.$$

CHILDBEARING AGES The span within which women are capable of bearing children, generally taken to be from age 15 to age 49 or, sometimes, to age 44.

CHILDREN EVER BORN(E) The number of children ever borne alive by a particular woman; synonymous with parity. In demographic usage, stillbirths are specifically excluded.

COHORT A group of individuals who experienced the same class of events in the same period. Thus an age cohort is a group of people born during a particular period, and a marriage cohort is a group of people who married during a particular period. The effects of a given set of mortality or fertility rates are often illustrated by applying them to hypothetical cohorts.

COHORT FERTILITY The fertility experienced over time by a group of women or men who form a birth or a marriage cohort. The analysis of cohort fertility is contrasted with that of period fertility.

CRUDE BIRTH RATE The number of births in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as births per 1,000 population. The crude birth rate for a single year is usually calculated as the number of births during the year divided by the midyear population.

CRUDE DEATH RATE The number of deaths in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as deaths per 1,000 population. The crude death rate for a single year is usually calculated as the number of deaths during the year divided by the midyear population.

CUMULATED FERTILITY An estimate of the average number of children ever borne by women of some age x, obtained by cumulating age-specific fertility rates up to age x; also often calculated for age groups.

DEATH RATE See crude death rate.

DE FACTO POPULATION A population enumerated on the basis of those present at a particular time, including temporary visitors and excluding residents temporarily absent. See de jure population.

DE JURE POPULATION A population enumerated on the basis of normal residence, excluding temporary visitors and including residents temporarily absent. See de facto population.

DIGITAL PREFERENCE See age heaping.

DUAL RECORD SYSTEM See Chandrasekaran-Deming Technique

EXPECTATION OF LIFE AT BIRTH The average number of years that a member of a cohort of births would be expected to live if the cohort were subject to the mortality conditions expressed by a particular set of age-specific mortality rates. Denoted by the symbol e(o) in life table notation.

FERTILITY HISTORY Either a birth history or a pregnancy history.

FORWARD SURVIVAL A procedure for estimating the age distribution at some later date by projecting forward an observed age distribution. The procedure uses survival ratios, often obtained from model life tables. The procedure is basically a form of population projection without the introduction of new entrants (births) to the population.

GENERAL FERTILITY RATE The ratio of the number of live births in a period to the number of person-years-lived by women of childbearing ages during the period. The general fertility rate for a year is usually calculated as the number of births divided by the number of women of childbearing ages at midyear.

GROSS REPRODUCTION RATE The average number of female children a woman would have if she survived to the end of her childbearing years and if, throughout, she were subject to a given set of age-specific fertility rates and a given sex ratio at birth. This number provides a measure of replacement fertility in the absence of mortality.

GROWTH RATE The increase or decrease of a population in a period divided by the number of person-years-lived by the population during the same period. The increase in a population is the result of a surplus (or deficit) of births over deaths and a surplus (or deficit) of immigrants over emigrants. (The annual increase is often expressed as a fraction of the total population at the beginning of the year, but this convention has the inconvenient characteristic of not being readily defined for a five-year interval and of being unequal to the difference between the birth rate and the death rate even in the absence of migration.) See also rate of natural increase.

INFANT MORTALITY RATE The number of deaths of children under 1 year of age occurring in the same year; also used in a more rigorous sense to mean the number of deaths that would occur under 1 year of age in a life table with a radix of 1,000, in which sense it is denoted by the symbol ${}_1q_0$.

LIFE TABLE A listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort subject from birth to a particular set of age-specific mortality rates. The rates are usually those observed in a given population during a particular period of time. The survivors of the radix to age x are generally denoted by l(x). The tabulations commonly accompanying a life table include other features of the cohort's experience: its expectation of life at each age x, denoted by e(x); the probability of surviving from each age x to age x + n, denoted by ${}_nq_x$; the person-years-lived by the hypothetical cohort as it ages from age x to age x + n, denoted by ${}_nL_x$ (also equivalent to the population aged x, x + n in a stationary population experiencing a number of births each year equal to the radix of the life table); and the person-years-lived by the hypothetical cohort from age x onward, denoted by T(x).

LOGIT The logit of a proportion p is 1/2 ln[p/(1 - p)]. As a linearizing transformation, the logit has been proposed as the basis of a model life table system in which the logit of a probability of dying by age x ($_xq_o$) is related linearly to the logit of a standard probability of dying by age x ($_xq_o^s$) so that

$$\text{logit}\ (_xq_o) = \alpha + \beta\ [\text{logit}\ (_xq_o^s)],$$

where α is a measure of mortality level relative to the standard and β is a parameter that alters the shape of the standard mortality function.

MARITAL FERTILITY Any measure of fertility in which the births (in the numerator) are births to married women and in which the number of person-years-lived (in the denominator) also pertains to married women. In some instances, the designation "married" includes persons in consensual unions.

MEDIAN The value associated with the central member of a set that is ordered by size or some other characteristic expressed in numbers.

MEAN AGE OF CHILDBEARING The average age at which a mortality-free cohort of women bear their children according to a set of age-specific fertility rates.

MEAN AGE OF CHILDBEARING IN THE POPULATION The average age of the mothers of the children born in a population during a year. This measure incorporates the effects of both mortality and the age distribution.

MIGRATION RATE Number of migrants during a specified period divided by the person-years-lived of the population exposed to migration. Also see population change due to migration.

MODEL LIFE TABLE An expression of typical mortality experience derived from a group of observed life tables.

MOVING AVERAGES The successive averaging of two or more adjacent values of a series in order to remove sharp fluctuations.

MYERS INDEX An index of digit preference that essentially sums in turn the population ending in each digit over some age range, often 10-89, expressing the total as a percentage of the total population, and which avoids the bias introduced by the fact that the population is not evenly distributed among all ages by repeating the calculations 10 times, once for each starting digit, and averaging the results. The difference between the average percentage for each digit and the expected value of 10 percent provides a measure of the preference for or avoidance of the digit over the age range considered.

NATURAL FERTILITY The age pattern of marital fertility observed in non-contraceptive populations where reproductive behavior is not affected by the number of children already born.

NET MIGRATION The difference between gross immigration and gross emigration.

NET REPRODUCTION RATE The average number of female children born per woman in a cohort subject to a given set of age-specific fertility rates, a given set of age-specific mortality rates, and a given sex ratio at birth. This rate measures replacement fertility under given conditions of fertility and mortality: it is the ratio of daughters to mothers assuming continuation of the specified conditions of fertility and mortality.

OWN-CHILDREN METHOD A refinement of the reverse-survival procedure for fertility estimation, whereby estimates of age-specific fertility rates for the recent past are obtained by relating mothers to their own children, using information on relationship and other characteristics available from a census or survey.

PARITY See children ever born.

PARTIAL BIRTH RATE The proportion of the population that enters (that is, is "born" into) a given age category in a year. The age categories used are normally open-ended, thus the partial birth rate x+ designates the proportion of the population becoming x years and older.

PARTIAL DEATH RATE The proportion of the population that leaves (that is, "dies" out of) a given age category in a year. See partial birth rate.

PERIOD FERTILITY The fertility experienced during a particular period of time by women from all relevant birth or marriage cohorts; see also cohort fertility.

P/F RATIO METHOD A consistency check for survey information on fertility. Information on recent fertility is cumulated to obtain measures that are equivalent to average parities. Lifetime fertility in the form of reported average parities by age group (P) can then be compared for consistency with the parity-equivalents (F) by calculating the ratio P/F for successive age groups. If certain assumptions about error patterns are met, an improved estimate of fertility can sometimes be obtained by correcting the age pattern of current fertility to agree with the level of lifetime fertility reported by younger women.

POPULATION CHANGE DUE TO MIGRATION The sum of in-migrants minus out-migrants during a specified period of time. The change may also be expressed as a rate by dividing the change by person-years-lived in the population during the same period.

PREGNANCY HISTORY A report of the number and the dates of occurrence of all the pregnancies experienced by a particular woman. The outcome of the pregnancy--live birth, stillbirth, fetal death--is also recorded.

RADIX The hypothetical birth cohort of a life table. Common values are 1, 1,000, and 100,000.

RATE OF NATURAL INCREASE The difference between the births and deaths occurring during a given period divided by the number of person-years-lived by the population during the same period. This rate, which specifically excludes changes resulting from migration, is the difference between the crude birth rate and the crude death rate.

RETROSPECTIVE SURVEY A survey that obtains information about demographic events that occurred in a given past period, generally terminating at the time of the survey.

REVERSE PROJECTION See reverse survival.

REVERSE SURVIVAL A technique to estimate an earlier population from an observed population, allowing for those members of the population who would have died according to observed or assumed mortality conditions. It is used as a method of estimating fertility by calculating from the observed number of survivors of a given age x the expected number of births that occurred x years earlier. (In situations for which both fertility and mortality are known or can be reliably estimated, reverse survival can be used to estimate migration.)

ROBUSTNESS A characteristic of estimates that are not greatly affected by deviations from the assumptions on which the estimation procedure is based.

SEX RATIO AT BIRTH The number of male births for each female birth, or male births per 100 female births.

SINGULATE MEAN AGE AT MARRIAGE (SMAM) A measure of the mean age at first marriage, derived from a set of proportions of people single at different ages or in different age groups, usually calculated separately for males and females.

STABLE POPULATION A population exposed for a long time to constant fertility and mortality rates, and closed to migration, establishes a fixed age distribution and constant growth rate characteristic of the vital rates. Such a population, with a constant age structure and constant rate of growth, is called a stable population.

STATIONARY POPULATION A stable population that has a zero growth rate, with constant numbers of births and deaths per year. Its age structure is determined by the mortality rates and is equivalent to the person-years-lived ($_nL_x$) column of a conventional life table.

SURVIVAL RATIO The probability of surviving between one age and another; often computed for age groups, in which case the ratios correspond to those of the person-years-lived function, $_nL_x$, of a life table. Also called survivorship probabilities.

SURVIVORSHIP PROBABILITIES See survival ratio.

SYNTHETIC PARITY The average parity calculated for a hypothetical cohort exposed indefinitely to a set of period age-specific fertility rates.

TOTAL FERTILITY RATE (TFR) The average number of children that would be born per woman if all women lived to the end of their childbearing years and bore children according to a given set of age-specific fertility rates; also referred to as total fertility. It is frequently used to compute the consequence of childbearing at the rates currently observed.

UNITED NATIONS AGE-SEX ACCURACY INDEX An index of age reporting accuracy that is based on deviations from the expected regularity of population size and sex ratio, age group by age group. The index is calculated as the sum of (1) the mean absolute deviation from 100 of the age ratios for males, (2) the mean absolute deviation from 100 of the age ratios for females, and (3) three times the mean of the absolute difference in reported sex ratios from one age group to the next. The United Nations defines age-sex data as "accurate," "inaccurate," or "highly inaccurate" depending on whether the index is less than 20, 20 to 40, or greater than 40.

WHIPPLE'S INDEX A measure of the quality of age reporting based on the extent of preference for a particular target digit or digits. The index essentially compares the reported population at ages ending in the target digit or digits with the population expected on the assumption that population is a linear function of age. For a particular age range, often 23 to 62, the population with ages ending in the target digits is divided by one-tenth of the total population, the result then being multiplied by 100 and divided by the number of different target digits. A value of 100 indicates no preference for those digits, whereas values over 100 indicate positive preference for them.

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