# Scientific Reports

NUMBER 72 JULY 1985

M. RIZGALLA

## Evaluation of the Sudan Fertility Survey 1978–79

INTERNATIONAL STATISTICAL INSTITUTE
Permanent Office. Director: E. Lunenberg

Mailing Address
428 Prinses Beatrixlaan, PO Box 950
2270 AZ Voorburg
Netherlands

WORLD FERTILITY SURVEY
Project Director: Halvor Gille

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

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

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

# Scientific Reports

## Evaluation of the Sudan Fertility Survey 1978–79

M. RIZGALLA

The recommended citation for this publication is:

Rizgalla, M. (1985). Evaluation of the Sudan Fertility Survey 1978–79. *WFS Scientific Reports* no 72. Voorburg, Netherlands: International Statistical Institute.

Typeset and printed in Great Britain
by H Charlesworth & Co Ltd, Huddersfield.

# Contents

FIGURES

# Preface

One of the major objectives of the World Fertility Survey programme was to assist the participating countries in obtaining high quality data through national fertility surveys. The high standards set by the WFS were expected to yield better quality data than typically obtained in the past, but this expectation in no way obviated the need for a detailed assessment of the quality of the data. It is recognized that such an evaluation will not only alert the analysts by identifying defects, if any, in the data, but also throw light on the shortcomings of the WFS approach, which can be taken into account in the design of future fertility surveys.

It is in this context that, as part of its analysis policy, the WFS conducted a systematic programme for a scientific assessment of the quality of the data from each survey. A series of data evaluation workshops was organized at the WFS London headquarters with the dual objective of expediting this part of the work and of providing training in techniques of analysis to researchers from the participating countries. Working in close collaboration with WFS staff and consultants, participants from a number of countries evaluated the data from their respective surveys after receiving formal training in the relevant demographic and data processing techniques.

The seventh such workshop, involving six countries – Benin, Ivory Coast, Mauritania, Morocco, Sudan and Yemen Arab Republic – was held between September and December 1983. The present document reports on the results of the evaluation of the data of the Sudan Fertility Survey of 1978–9 and was prepared by M. Rizgalla who participated on behalf of Sudan.

Dr Shea Oscar Rutstein, as the co-ordinator of the workshop, assumed a major responsibility in the successful completion of the work. Edmonde Naulleau and Andrew Westlake provided much valuable assistance, and many other staff members also made significant contributions.

We are indebted to Neil Thomas of the University Population Centre, University College, Cardiff, who reviewed the manuscript and made many helpful suggestions.

HALVOR GILLE
Project Director

# 1 Introduction

This chapter outlines certain aspects of the country and the people, and the sources of demographic data. It describes the survey briefly and explains why we need to evaluate the data.

## 1.1 THE COUNTRY AND PEOPLE

Sudan is a large country, extending from 23°N to 35°N latitude and from 21.75°E to 38.50°E longitude. It is the largest country in Africa and has extensive borders with eight other African countries: Egypt and Libya to the north, Chad, Central African Republic and Zaïre to the west, Uganda and Kenya to the south and Ethiopia to the east. The country is sparsely populated. In an area of about 2.5 million square kilometres, there is a population of 21.5 million, a figure ascertained by the latest census in February 1983. The current population density is about 8 persons per square kilometre. Preliminary results from the 1983 census show that the majority of the population live in rural areas. Of the total population, about 20 per cent live in urban areas, 71 per cent in rural settled areas, while the nomads who are dispersed mainly in the northern regions constitute the remaining 9 per cent.

### Physical features

The Sudan consists essentially of an extensive plain rising gradually to mountains in the north-east near the Red Sea coast, and plateau and low mountains near the southern and western borders. Three geographical areas are distinguished:

- Northern zone: the area from the Egyptian border to Khartoum is flat and arid. The Nubian desert stretches east to the Red Sea mountains, and the Libyan desert in the west merges with the Sahara.
- Central zone: this zone is intersected by many rivers and streams. In the west, mountains rise to over 10 000 feet, and the east is bordered by the massif of the Abyssinian plateau.
- Southern zone: this zone consists of vast swamps, savanna and tropical forests.

### Climate and vegetation

The climate in the Sudan ranges from tropical in the extreme south to a climate of arid desert in the north. The vegetation is determined by the physical features and climate. Bare sand, rock and gravel in the dry north give way to grass and savanna in the central plains. The tropical south is covered with extensive swamps in the east and south, and high wood savanna and tropical rainforests to the west.

### People

The people of Sudan are very diverse. Information on ethnicity is available only from the first census in 1955/6. According to that census, there are 597 tribes speaking some 115 languages. There are three main racial groups in the country:

- The negro group including the Nilotic, Nilo-Hamitic and Sudanic tribes.
- The Brown and Mediterranean races, mainly the Beja.
- The Arab elements: through contact and intermarriage between the Arab nomadic migrants and the indigenous population, the Islamic faith and the Arabic language are the common heritage of the majority of the people in the North. The other groups – the Nuba, the Nubiyin, the Beja and Westerners – still retain their own original languages and cultural patterns, but superimposed on these are Islam and the Arabic language, so much so that there is cultural homogeneity among the peoples of the North.

### Historical background

Sudan became independent in 1956. During the long period of the British rule, some ordinances were introduced by which certain areas in the south and north of the country were declared inaccessible to certain groups of the people. Gradually the country became divided into 'two Sudans', the North and the South, with no cultural, social, economic or political contacts between the peoples of the two regions. Further, resources for social and economic development were unequally allocated between the two regions. This has preserved and perpetuated cultural, institutional and economic differences between the two parts of the country. Independent Sudan inherited this situation which was to become a severe obstacle to the process of national integration and development. A mutiny broke out in the South which turned into civil war. Successive governments, however, failed to find a solution to the problem and the situation in the South continued to deteriorate. In May 1969, the present regime was established and worked towards a peaceful solution to the problem of the South. This was achieved by the 1972 Addis Ababa Accord. During the skirmishes (1956–72), most of the government institutions were not functioning properly. This affected the data collection system. In fact, up until very recently little was known about the statistical situation in the region, and a complete frame for sampling purposes was unavailable.

### Administrative set-up

For the Sudan Fertility Survey (SUDFS), the country was divided into 18 provinces, 12 covering the Northern part and six the Southern part. The Northern provinces

include the Northern, Nile, Red Sea, Kassala, Khartoum, Gezeira, White Nile, Blue Nile, North Kordofan, South Kordofan, North Dar Fur and South Dar Fur provinces. The South comprises Bahr Elghazal (later on divided into West Bahr Elghazal and East Bahr Elghazal), Lakes, Upper Nile, Jongeli, East Equatoria and West Equatoria provinces. Each of the provinces is divided into a number of area councils, which in turn are divided into town and rural councils. The towns are divided into 'quarter' and the rural areas into 'village' councils.

As a further step towards decentralization, the country has recently been divided into 8 regions, with Khartoum province left as the national capital. Each region comprises 2–3 provinces which are more or less similar in their socio-economic characteristics.

At this juncture, it is important to mention that the SUDFS was conducted only in the Northern provinces. For operational reasons, it was not possible to extend the programme to the South. The Northern regions are:

1 Khartoum province, the national capital
2 Northern (Northern and Nile provinces)
3 Eastern (Red Sea and Kassala provinces)
4 Central (Gezeira, White Nile and Blue Nile provinces)
5 Kordofan (South Kordofan and North Kordofan)
6 Dar Fur (South Dar Fur and North Dar Fur).

These are the divisions which were used in the tabulation of the SUDFS data.

Khartoum is the capital city and major urban area in the country. It consists of the three city areas of Khartoum, Omdurman and Khartoum North. It is also the main centre for economic, commercial and industrial activities in the country. During the last few years, Khartoum has been subject to a heavy influx of migrants from rural areas.

The Northern region is flat and almost arid, and the population is concentrated along the Nile banks. Emigration from this region is known to be high.

The Eastern region comprises the fertile Elgash delta and the Gedarif clay plain, which is a mechanized agricultural area. Port Sudan, the country's only sea outlet and the second largest city in the country, falls within this region.

The Central region is the most densely populated area in the Sudan. The region includes the famous Gezeira Scheme, the largest organized farm in Africa. It also includes other highly developed agricultural schemes. This region and Khartoum enjoy relatively more favourable socio-economic conditions than the rest of the country. Immigration to the Central region from other parts of the country is also known to be very high.

The northern parts of the Kordofan and Dar Fur regions are arid and thinly populated by nomadic tribes. The southern areas, however, are characterized by highly fertile land and populated mainly by farmers, with mechanized farming schemes in the Nuba hills of South Kordofan. The two regions are also rich in animal resources.

## 1.2 DEMOGRAPHIC DATA SOURCES

The major sources of demographic data are vital registration, population censuses and sample surveys. In Sudan, the vital registration system is incomplete. Apart from in major towns, registration is very poor. According to the latest estimates, only about two out of five births are registered, perhaps less, and about the same proportion of deaths. Furthermore the events which are registered are not tabulated.

The first national census was carried out on a *de jure* sample basis, with enumeration spread over a period of 14 months during 1955/6. Resulting population estimates are taken to apply to 1 January 1956. Data on age were collected for broad age groups. Fertility questions were asked about births within the last 12 months and the number of children ever born to women who had completed their reproductive span. However, the usefulness of the data was extremely limited.

In 1964–6, a series of population and housing surveys were carried out on a sample basis in the urban areas of the Northern provinces only. The population was enumerated according to the age groups 0–2, 3–7, ..., 53–67, 68+, and births and deaths during the last 12 months were recorded. Directly estimated crude birth and death rates were subject to the same kind of error as occurred in the census.

The first complete national census was carried out on a *de facto* basis in April 1973. Single-year age data were collected from all the settled population. Questions asked on fertility and mortality were such as to lend themselves to the application of indirect estimation techniques, namely Brass-type questions. The census report (Department of Statistics 1980) noted errors in age reporting mainly due to mis-statement of age and the shifting of ages, especially among females, either downwards or upwards. Examination of the intercensal rate of growth by province suggested that the population was underenumerated in the South. The report has critically examined the reliability of most of the data collected in the census.

Recently, a third census was conducted in February 1983. Unfortunately, results from this census are not yet available for any exercise in comparability in the different stages of the data evaluation in the following chapters.

## 1.3 THE SURVEY

The Sudan Fertility Survey was undertaken by the Department of Statistics (DOS) of the Government of Sudan as part of the World Fertility Survey (WFS) programme.

The WFS was an international programme of fertility research undertaken by the International Statistical Institute (ISI) with the collaboration of the United Nations and in co-operation with the International Union for the Scientific Study of Population. The main objectives of the WFS programme were to assist developing countries in carrying out well-planned and scientifically designed sample surveys in order to provide high quality data on fertility levels, trends and differentials.

The SUDFS was designed to obtain data on fertility, nuptiality, mortality and other related factors, with the aim of enhancing understanding of the changing dynamics of the population of the Sudan.

The SUDFS was originally designed as a two-phase survey, covering the North and the South. But as we have already noted, it was carried out only in the North of the Sudan, for operational reasons. The SUDFS was conducted during the period December 1978–April 1979. The survey was a single-round survey of households, selected so as to provide a sample capable of yielding accurate national and regional estimates.

The sample was designed as a three-stage stratified sample of households, each of which was interviewed by means of an expanded household schedule designed to ascertain certain characteristics of the household members together with information on nuptiality, fertility and mortality. The target for achieved sample size was 12 000 completed household schedules. One-third of these households was systematically selected for a more detailed, individual interview with the women residing there. Within these households, all ever-married women under the age of 51 were eligible for interview by means of an individual questionnaire.

In addition, a community questionnaire was used in the SUDFS in the rural areas to collect information on community-level variables likely to affect reproductive behaviour.

For more details of the survey's methodology and design, the reader is referred to the First Country Report (Department of Statistics 1982). It explains the survey's background, methodology and sample design, and gives the tabulations and the basic findings on different aspects of the survey. It was presented at the Second National Population Conference in Khartoum in April 1982.

## 1.4 THE NEED FOR EVALUATION

The data collected in the survey enable us to obtain more refined estimates of various aspects of population dynamics. However, the quality of the estimates will depend on the accuracy of the data supplied by the respondents. Experience has shown that the information collected in surveys may be subject to response errors which bias any estimates. Response errors arise mainly from the misreporting of age and the omission and displacement of vital events. The usefulness of the survey data in providing reliable estimates of the demographic parameters depends on how far they are affected by response errors, and how far possible sources of bias have been detected.

Therefore, before using the data for more detailed analyses, it is important to examine their reliability and to determine the direction of bias. The primary focus of this report is to evaluate the SUDFS data, especially age reporting as related to other vital events. This will enable us to assess the quality of the data and the possible range of variation of the estimates; it will also remind us of any pitfalls in the data collection system and the shortcomings of the actual data collected. This information may be of use in the running of future surveys.

# 2 Age Reporting

Information on age is a basic variable in constructing many demographic parameters. Errors in reported age distribution affect the estimation of fertility and mortality rates, especially in developing countries. The reliability of the derived estimates for these countries depends to a large extent on the degree of error and bias inherent in the age reporting of their populations. The quality of age reporting, therefore, has merited more intensive study than any other type of data.

In Sudan, as in most African countries, many people do not know their exact age. In the household survey, the problem is aggravated because only one respondent reported on behalf of the other household members. In some cases, interviewers had to estimate ages with the aid of different procedures or guess age merely by the physical appearance of the respondent. Only a very small percentage (0.04 of males and 0.02 of females) were reported as not stated, but this does not imply that the ages are correctly reported.

Two types of error that affect age reporting may be identified: preference for certain terminal digits, known as heaping, and age transference, when ages are shifted either upwards or downwards from their true group. In the following sections, we examine the data on age available from the two surveys and try to quantify any errors by means of certain indices. In some cases, comparisons between the survey and the 1973 population census results for the North are also carried out.

## 2.1 AGE IN THE HOUSEHOLD SURVEY

The household survey provided data on age by single year and five-year age groups by sex, both on a *de jure* and *de facto* basis. Since the tabulation was based on the *de facto* population, the present analysis is restricted to that distribution.

The single-year age distribution (not shown) reveals that there is a concentration of respondents at ages ending with certain digits; equally, other digits are avoided. In normal conditions, the curve should gradually slope downwards, implying the loss of persons as a result of death as age increases. The curves both for males and females show that large numbers of individuals were reported as having ages ending in certain preferred digits. In most developing countries, the digits 0 and 5 are preferred and so are the digits 2 and 8. The Sudan also conforms to this pattern of digit preference, with the terminal digits 1, 3, 4, 7 and 9 being unpopular; this is not surprising in view of the strong attraction exerted by figures terminating in 0 and 5. The heaping is, however, more excessive among older age groups (above 20), where both curves depict very similar patterns. The female distribution seems to be more affected by digit preference at younger ages, even though the difference between the two sexes is not large. Similar observations were made in the 1973 census (Department of Statistics 1980).

For comparative purposes, age accuracy may be measured by means of an index, which can be used to determine whether the age distribution under study is more accurate than the age distribution of, say, a previous census or another country. Whipple's index, a common measure of age heaping (or preference) was calculated. This index was derived by comparing the sum of the population at ages ending in 0 and 5 in the range 23–62 years and one fifth of the total population in the range. The index is compared with observed values in the 1973 census and is presented in table 1 for some African and Arab countries.

From the table it may be observed that the index for the household data was one of the highest, slightly higher even than that for the 1973 census. The table also shows that the urban population seem to have reported their ages more accurately than the rural population. This is to be expected since the percentage of literate persons who are more aware of their ages is higher in the urban areas than in the rural ones. On the whole, age reporting in the Sudan household survey is less accurate than the selected African and Arab countries where similar surveys have been carried out. The main drawback of the method is that it measures the preference for only two digits, namely 0 and 5. In that sense, it is rather a crude measure of the accuracy of age reporting.

Because of the limitations inherent in the above method, another procedure was adopted. Myers' index (United Nations 1967) reflects preferences or dislikes for each of the ten digits from 0 to 9. It is obtained by computation of a blended population in which ordinarily almost equal sums are to be expected for each digit. The deviations of each sum from 10 per cent of the grand total are added together, irrespective of sign, to form the index.

**Table 1** Whipple's index in the household survey compared to the 1973 census and in selected countries

| Source | Male | Female |
|---|---|---|
| *Household survey 1978* | 2.90 | 2.94 |
| Urban | 2.48 | 2.56 |
| Rural | 3.11 | 3.08 |
| Population census 1973 | 2.72 | 2.97 |
| Morocco, HH survey | 1.79 | 2.09 |
| Ivory Coast, HH survey | 1.33 | 1.27 |
| Mauritania, HH survey | 2.30 | 2.50 |

*Source:* Department of Statistics 1980; unpublished WFS data evaluation reports for the respective countries

**Table 2** Deviations of percentages of blended sums at the ten terminal digits, and Myers' index in household survey, by urban–rural residence, and in the census

| Terminal digit | Deviations from 10% | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Household survey | | | | | | Census | |
| | Total | | Urban | | Rural | | North | |
| | Male | Female | Male | Female | Male | Female | Male | Female |
| 0 | +14.3 | +12.3 | +10.2 | +9.1 | +16.4 | +13.6 | +13.6 | +16.9 |
| 1 | −5.5 | −5.9 | −4.4 | −4.7 | −6.1 | −6.4 | −5.1 | −5.9 |
| 2 | −1.7 | −1.6 | −0.5 | −1.0 | −2.4 | −1.8 | −1.5 | −2.3 |
| 3 | −4.1 | −4.1 | −3.1 | −3.3 | −4.7 | −4.5 | −3.4 | −4.5 |
| 4 | −5.1 | −5.0 | −4.4 | −4.6 | −5.5 | −5.1 | −5.0 | −5.4 |
| 5 | +14.5 | +17.2 | +10.8 | −13.1 | −16.4 | +18.9 | +12.8 | +14.7 |
| 6 | −4.4 | −4.7 | −3.5 | −3.3 | −4.8 | −5.3 | −4.0 | −4.7 |
| 7 | −2.4 | −2.7 | −2.2 | −2.1 | −2.4 | −2.9 | −1.5 | −2.3 |
| 8 | −0.6 | −0.7 | −0.7 | −0.2 | −1.3 | −0.8 | −1.2 | −1.3 |
| 9 | −4.9 | −4.9 | −3.6 | −3.0 | −5.6 | −5.7 | −4.8 | −4.9 |
| Myers' index | 57.5 | 59.1 | 43.4 | 44.4 | 65.6 | 65.0 | 52.9 | 62.9 |

Table 2 presents the results of this exercise for both the household survey, disaggregated by sex and type of place of residence, and the census, by sex. From the table it can be seen that the heaping is mainly on digits 0 and 5 and to a lesser degree on 2 and 8. The heaping on ages ending in 0 is more marked for males than for females, whereas digits ending with 5 seem to be more preferred by females. Compared with the results from the census, females seem to have achieved a slight improvement in accurate age reporting. On the other hand, reporting for males in the census seems to be better than in the survey. Again, urban dwellers show more accurate age reporting than their counterparts in the rural areas. Comparing the index arrived at for the household survey with the values observed in the selected countries shown in table 3, we see that the index values are considerably higher in the Sudan. Evidently the quality of age reporting in the Sudan was very poor compared with some of these countries.

### Five-year age and sex distribution

In the preceding sections, we have seen that the single-year age distribution is erratic in the household data. Grouping data would reduce these errors and the resulting age structure would be more reliable than the single-year age structure, but the broader the grouping, the less the sensitivity of the rates, etc computed. Conventionally, five-year age grouping is utilized.

**Table 3** Myers' index for selected countries

| Country | Myers' index | |
|---|---|---|
| | Male | Female |
| Sudan HH survey | 57.5 | 59.1 |
| Morocco HH survey | 26.9 | 35.7 |
| Mauritania HH survey | 41.6 | 49.5 |
| Ivory Coast HH survey | 13.5 | 14.2 |

Table 4 shows the five-year percentage distribution by sex and the sex ratios (the number of men per 100 women) in the household survey and the 1973 census.

The two distributions show that the Sudanese population is a young one, with about 49 per cent aged under 15 years and only about 5 per cent above 60. The two distributions show similar patterns, although the results of the household survey appear to be more plausible. It seems that the age grouping is better reported in the household survey than in the census. However, in the household data there appears to be an exaggeration of numbers in the age group 5–9 and a deficit in the two adjacent ones. In other words, some individuals in the adjacent groups had their ages misreported and were shifted to the age group 5–9. Numbers in the age group 25–29 for females also seem to be exaggerated, as also happens for both sexes at ages 35–39.

The sex ratios by age show an inconsistent, zigzag pattern. This is clearly seen in table 4. Sex ratios are very low in both the census and the survey at ages 15–39. From age 40 onwards, except for the age group 55–59 in the household survey, there seem to be severe deficits in the reported female population. In the absence of any known migration which might have age-selective effects, this pattern can only be attributed to overstatement and understatement of ages for males and females respectively.

One way of detecting and measuring the overall extent of age misreporting is to examine the age and sex ratios of the population under study and to calculate an index of age accuracy from the regularity of these ratios. The index is three times the mean difference in sex ratios plus the mean of the male and female age ratios. The detailed

**Table 4** Five-year percentage distribution by sex and sex ratios in the household survey and 1973 census

| Age group | Household | | | Census | | |
|---|---|---|---|---|---|---|
| | % male | % Female | Sex ratio | % Male | % Female | Sex ratio |
| 0–4 | 16.6 | 15.3 | 105 | 18.2 | 17.9 | 103 |
| 5–9 | 17.4 | 17.4 | 97 | 18.1 | 17.6 | 106 |
| 10–14 | 14.7 | 13.9 | 102 | 11.9 | 10.9 | 111 |
| 15–19 | 10.1 | 10.7 | 92 | 8.1 | 8.5 | 98 |
| 20–24 | 6.1 | 7.4 | 80 | 6.1 | 7.3 | 85 |
| 25–29 | 6.0 | 8.4 | 69 | 7.3 | 9.1 | 82 |
| 30–34 | 4.6 | 5.0 | 88 | 5.7 | 6.2 | 92 |
| 35–39 | 5.8 | 5.9 | 95 | 6.4 | 6.2 | 104 |
| 40–44 | 4.0 | 3.4 | 114 | 4.5 | 4.3 | 107 |
| 45–49 | 3.7 | 3.1 | 116 | 3.6 | 3.0 | 119 |
| 50–54 | 3.0 | 2.5 | 119 | 2.9 | 2.7 | 113 |
| 55–59 | 2.0 | 2.3 | 84 | 1.7 | 1.3 | 129 |
| 60–64 | 2.0 | 1.6 | 120 | 2.0 | 1.8 | 118 |
| 65–69 | 1.4 | 1.1 | 119 | 1.1 | 0.9 | 128 |
| 70+ | 2.6 | 2.0 | 127 | 2.3 | 2.1 | 110 |
| Total | 100.0 | 100.0 | | | | |

*Source:* Census data from Department of Statistics 1980

**Table 5** Computation of age accuracy index by the United Nations Secretariat method (household survey)

| Age group | Reported numbers | | Analysis of sex ratios | | Analysis of age ratios | | | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Ratio | Successive differences | Male | | Female | |
| | | | | | Ratio | Deviation from 100 | Ratio | Deviation from 100 |
| 0–4 | 5175 | 4910 | 105 | – | | | | |
| 5–9 | 5420 | 5582 | 97 | −8 | 111 | +11 | 119 | +19 |
| 10–14 | 4571 | 4467 | 102 | +5 | 107 | +7 | 99 | −1 |
| 15–19 | 3152 | 3427 | 92 | −10 | 98 | −2 | 100 | 0 |
| 20–24 | 1892 | 2371 | 80 | −12 | 76 | −24 | 77 | −23 |
| 25–29 | 1854 | 2692 | 69 | −11 | 112 | +12 | 135 | +35 |
| 30–34 | 1428 | 1619 | 88 | +19 | 78 | −22 | 70 | −30 |
| 35–39 | 1812 | 1905 | 95 | +7 | 136 | +36 | 141 | +41 |
| 40–44 | 1241 | 1088 | 114 | +19 | 84 | −16 | 75 | −25 |
| 45–49 | 1158 | 998 | 116 | +2 | 106 | +6 | 106 | +6 |
| 50–54 | 938 | 789 | 119 | +3 | 107 | +7 | 91 | −9 |
| 55–59 | 617 | 731 | 84 | −35 | 80 | −20 | 113 | +13 |
| 60–64 | 609 | 507 | 120 | +36 | 117 | +17 | 93 | −7 |
| 65–69 | 422 | 354 | 119 | −1 | 86 | −14 | 89 | −11 |
| 70–74 | 369 | 287 | | | | | | |
| Total (irrespective of sign) | | | | 168 | | 194 | | 220 |
| Mean | | | | 12.9 | | 14.9 | | 16.9 |
| Index (3 times mean difference sex ratio plus mean deviations of male and female age ratios) | | | | | | 70.5 | | |

calculation of this index is presented in table 5 for the population in the household survey.

The index calculated is 70.5. It is almost the same as the value of 70.6 calculated from the 1973 census (Department of Statistics 1980). Compared with other African and Arab countries, the index is relatively high for Sudan. This can be seen in table 6.

## 2.2 AGE IN THE INDIVIDUAL SURVEY

Two questions relating to age were included in the individual questionnaire. The respondent was first asked to give her current age. She was then asked to give the month and year of her birth. The two surveys were carried out at the same time, and the interviewer usually completed the two questionnaires in a single visit to the selected household. In this situation, there was a likelihood that the interviewer might transfer the answer on age from the report recorded in the household schedule; however, during training interviewers were instructed not to do so, nor should they infer the answer for one of the two questions from the answer obtained for the other. The interviewers were specially trained to probe in detail where necessary (for example by referring to other events in the respondent's life) and also to consult any documentary evidence available. Next, the interviewer plotted the respondent's birth date on an events' chart so that this date could subsequently be compared with dates of other events. Finally, the interviewer recorded her comments regarding age reporting: whether age was reported without further probing, whether it was obtained from some document, whether extensive probing was necessary and whether the reporting was believed to be an estimate (Department of Statistics 1982).

Out of a total of 3114 women interviewed in the survey, only 22 per cent gave their exact ages; for the remaining 78 per cent, ages had to be estimated using different sources. The single-year distributions for the two categories have similar patterns of heaping even though it is less marked for women who reported their exact ages. Evidently age reporting is more accurate for these women who reported their own ages than for women whose age was estimated. In fact Myers' index for the former group is 41.7, whereas it is as high as 63.9 for the latter group. Unfortunately, the number of women who reported their ages exactly is too small to enable cross-tabulations to be made in order to find other characteristics that will identify these women.

The age distribution of ever-married women has a heavy concentration or heaping at ages ending in 0 or 5 and slightly on 8 and 2. Age reporting in the household and individual surveys has a similar pattern, though the heaping is perhaps slightly less pronounced for women in the individual survey. Further comparison of reported ages in the two surveys reveals that for about 93 per cent of the women the same age is reported; however, the percentage does not show any distinct pattern or trend for the different groups. This may be due to sampling variability. Only about 4 per cent reported an age one or more years older than the one recorded in the household questionnaire and 3 per cent reported younger ages. If we compare the age groups in the two surveys, we see that the inconsistency is considerably reduced; we find that 96 per cent were reported in the same age groups. This close similarity might indicate that the interviewers did not comply with the instructions in most cases where they inferred the age in the individual survey from the household returns.

There are some differentials in the quality of age reporting between various subgroups of women: literate women reported their ages better, even though the two distributions show similar patterns. With less pronounced heapings at preferred digits, literate women seem to be more aware of their ages than non-literate women. Urban women reported their ages better than their counterparts in the rural areas. This, however, is partly because a higher proportion of women are literate in the urban than in the rural areas. In fact, Myers' index was 60.8 for women in rural areas compared with only 38.7 in urban areas. For literate women, the index was 30.8 while it was as high as 66.2 among illiterate women. Even among regions of residence, there are wide variations in the quality of age reporting as expressed by Myers' index. This is shown in table 7.

This regional pattern of variations in the index reflects more or less the variations in the level of socio-economic development in which Khartoum province and the Central region are most favoured. In fact, Khartoum is the main urban area in the country, with the lowest illiteracy rate.

One simple way to measure digit preference is to compare the age distribution with a rectangular distribution, ie one where there are equal numbers at adjacent ages. For example an index of heaping at age 20 is the ratio of the number of persons reported at that age to one-third of the numbers reported in the three-year range centred at age 20. A value of the index greater than unity represents heaping. The results of such an exercise applied to data from the individual and household surveys are shown in table 8.

**Table 6** Comparison of the United Nations age/sex accuracy index for the Sudan with selected countries

| Country | UN index |
|---|---|
| Sudan HH survey | 70.5 |
| Morocco HH survey | 49.3 |
| Mauritania HH survey | 50.6 |
| Ivory Coast HH survey | 61.6 |
| Benin HH survey | 72.0 |
| Yemen HH survey | 82.4 |

**Table 7** Myers' index by region for the SUDFS (individual survey)

| Region of residence | Myers' index |
|---|---|
| Khartoum | 38.4 |
| Northern | 72.0 |
| Eastern | 65.7 |
| Central | 46.9 |
| Kordofan | 62.5 |
| Dar Fur | 74.8 |

**Table 8** Digit preference index at certain selected ages for ever-married women in the household and individual surveys

| Age | Index | |
|---|---|---|
| | Individual | Household |
| 20 | 1.8 | 1.8 |
| 25 | 2.0 | 2.1 |
| 30 | 2.2 | 2.4 |
| 35 | 2.5 | 2.6 |
| 40 | 2.1 | 2.4 |
| 45 | 2.6 | 2.7 |

**Table 9** Percentage distribution of ever-married women aged 15–49 in the individual and household surveys and in the 1973 census

| Age group | Individual survey | Household survey | Census |
|---|---|---|---|
| 15–19 | 7.5 | 7.2 | 9.0 |
| 20–24 | 16.5 | 14.5 | 16.8 |
| 25–29 | 23.0 | 23.0 | 23.3 |
| 30–34 | 16.1 | 14.9 | 16.2 |
| 35–39 | 18.9 | 17.9 | 15.8 |
| 40–44 | 9.7 | 10.3 | 10.6 |
| 45–49 | 7.3 | 9.5 | 7.8 |
| Total | 100.0 | 100.0 | 100.0 |

The five-year percentage distribution is also examined and compared to equivalent values for ever-married women in the household survey and the 1973 census. This exercise is shown in table 9. The three distributions depict very similar patterns of age transfers, especially into age groups 25–29 and 35–39 in which the excess is more pronounced for the individual survey. At older ages, the percentage are lower for the individual survey.

With an index of more than one, heaping is clearly present in all selected ages in the two surveys. The scores for the individual survey are consistently lower, even though the difference is only slight. Evidently age reporting is slightly better in the individual survey than in the household survey.

## 2.3 CONCLUSION

The critical appraisal of the age data carried out in this chapter reveals some irregularities in reporting. The single-year data reveal the preference of respondents for certain digits, resulting in a zigzag pattern of distribution. Preferences are for ages ending in digits 5, 0, 8 and 2 in that order. Although errors are reduced in the five-year age data, irregularities still persist. The inflation and deflation of certain age groups indicate age transference. This is most pronounced among females in the child-bearing ages.

On the whole, there is a slight improvement in the quality of age reporting in the SUDFS compared with the 1973 census. The heaping of ages, as measured by Myers' index, for females in the Sudan is 63 and 59 in the census and SUDFS respectively. Comparing the different indices computed for some selected African and Arab countries where similar surveys were carried out, we see that the quality of age reporting in SUDFS is relatively poor.

Apparently level of education and place of residence have some influence on the quality of age reporting. The heaping is less pronounced among literate than illiterate women. Urban women have reported their ages more accurately than their counterparts in rural areas. Some regional variations are also noted in the quality of age reporting. Myers' index calculated for the different regions is highest in Dar Fur (75), while in Khartoum it is only 38. When comparing the ages reported in the household schedule with the individual questionnaire, we find that about 93 per cent of respondents reported the same age in both surveys.

# 3 Nuptiality

The study of nuptiality involves the analysis of the demographic events that shape the marital composition of the population, which in turn affects most aspects of population growth. Age at marriage, the proportion who ever married and the pattern of onset and dissolution of marital unions all influence the overall level of fertility.

In the Sudan marriage is almost universal. It is the only union through which stable cohabitation of couples takes place. The incidence of children born outside marriage is extremely rare and for this reason only ever-married females were interviewed in the individual survey. In the North, the Islamic 'Sharia' marriage which is legalized by the 'Quaseima' (the marriage contract) is predominant. The First Country Report states the following:

a distinction is made between formal or legal marriage as witnessed by the marriage contract – known as 'writing the book' – and the social marriage which marks the consummation of marriage, 'zifat'. The difference between these two events varies and can even extend to some years... (Department of Statistics 1982)

Therefore women who had been legally married but whose marriage had not been consummated were not considered eligible for the individual interview. Even though Islam permits men to marry up to four wives, the incidence of polygamy is relatively low. In the SUDFS, out of 2859 currently married women, only 16.8 per cent reported having one or more co-wives. Divorce is relatively common but the incidence of remarriage, especially among widows, is also high.

Questions pertaining to nuptiality were included in both the expanded household schedule and the individual questionnaire. The marital status section in the household schedule consisted of four questions administered to members of the household aged 12 and over:

(1) Has (he/she) ever been married? If the answer is 'yes'
(2) Is (he/she) now married, divorced or separated?
(3) Has (he/she) been married more than once?
(4) If 'yes': Is his/her first spouse still alive?

The first two questions provide an opportunity for carrying out analyses of nuptiality, whereas the last two yield the information required for the application of some indirect techniques to estimate adult mortality.

As well as ascertaining current marital status, the individual questionnaire also included a section intended to obtain the complete marital history of the respondent. Dates of the onset and termination of each marriage were obtained. For each terminated marriage, the nature of the dissolution was also obtained. It should be recalled that the information on the date of marriage refers to the date when marriage was consummated and not the date when it was contracted. Special attention was paid to the dating of such events. The respondent was first asked to provide the year and month. If the calendar year could not be obtained, she was then asked to give her age at the event.

It is of interest to study the events related to the formation of marriage, particularly age at the onset of such unions and the proportions with different marital status. In the following sections, an attempt is made to detect and analyse possible errors and biases that may have affected the quality of these data.

## 3.1 FORMAT OF DATE OF FIRST MARRIAGE

About 1231 women, constituting approximately 40 per cent of the total number of women interviewed in the individual survey, gave the year and month (exact date) of the onset of their marriages; 33.5 per cent gave the year only and 26.5 per cent gave their ages at the event. The overwhelming majority of those women, mostly younger women, who married a few years before the survey reported the exact date of the marriage. This might be because the nearer the event is the present, the more likely women are to report its exact date, though heaping occurs at years 1974, 1970, 1965, 1962 and 1950 which is hard to explain. Women who gave the year only and those who gave their age at the event show similar irregularities. There is very little evidence of regular heaping of any kind, least of all on years ending in 0 and 5. The only heaping which does occur is on years which end in the digits 3 and 8. In the case of women who gave information on the duration in years since marriage, this heaping would result from stating the number of years as multiples of 5 because the survey was conducted between December 1978 and April 1979.

## 3.2 HEAPING IN NUPTIALITY DATA

The distribution of the interval between date of first marriage and the date of the survey is marked by a distinct preference for intervals ending in 0, but none for those ending in 5. This applies to both rural and urban areas. To some extent heaping is also observed at digits ending in 8 and 9 among women in urban and rural areas respectively. This might be the result of the way in which the date of marriage was obtained. Preferred years ending in 0 or 5 would be converted into number of years before the survey ending in 8 or 3. Urban women who were mainly in Greater Khartoum were interviewed in

**Table 10** Five-year percentage distribution of women aged 15–49 in the individual and household surveys according to marital status

| Current marital status | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
| Single | 78.3 | 36.7 | 13.4 | 4.3 | 2.2 | 1.6 | 0.9 |
| Married | 21.0 | 60.0 | 81.4 | 89.6 | 87.4 | 83.0 | 86.3 |
| Widowed | 0.1 | 0.6 | 0.9 | 2.7 | 5.9 | 8.0 | 7.2 |
| Divorced | 0.4 | 2.7 | 4.0 | 3.1 | 4.3 | 6.6 | 5.0 |
| Separated | 0.2 | – | 0.3 | 0.2 | 0.2 | 0.8 | 0.6 |
| *Total* | | | | | | | |
| Number | 218 | 515 | 714 | 500 | 584 | 303 | 225 |
| Per cent | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

1978. There is also considerable heaping on durations which are multiples of ten years. Again, this is so for both literate and illiterate women. High concentrations occur on years close to the time of the survey, especially at 0, 2, 6 and 10. Both groups show substantial irregularities in their distribution and it seems likely that sampling variations have added to the variation of these results; literate women who are mainly in the young age groups constitute only 18 per cent of the total women. Unfortunately, the small number of cases makes it impossible to carry out similar comparisons among other subgroups of the population to identify factors influencing the quality of reporting of the date of first union.

## 3.3 PROPORTIONS EVER MARRIED

The data on the proportions ever married by single years among females in the household survey show some irregularities. There is a sudden rise in the curve at ages 20 and 25 and depressions at ages 21 and 23. Apart from being due to usual preference for digits 0 and 5, this could be attributed to young married females overstating their ages. Married women in their teens might look older, especially if they had ever had children, and interviewers may have tended to increase their ages. This will increase the proportions at the older ages and conversely decrease the proportions at the younger ages. Slight patterns of irregularity are also observed at ages 28–30 and 43–45.

## 3.4 MARITAL STATUS

Table 10 shows the percentage distribution of females in the individual survey by five-year age groups and according to marital status. Since the individual survey was based on an ever-married sample, the proportion single reported in the household survey was used in this distribution. The implied assumption is that the marital distributions among the population in the two surveys are identical.

As expected, the proportions ever married show a smooth pattern, increasing with age. However there are slight irregularities observed in the proportions of women currently married and divorced women.

The proportion currently married rises with age, but then falls between ages 30–34 and 40–44. In itself, this is not surprising, as the proportion of women widowed and divorced increases. There appears to be an anomaly in that the proportion married is higher for women in the age group 45–49 than 40–44, with a correspondingly lower proportion divorced and widowed. It is conceivable that the fall in the proportion divorced is a cohort effect, but the proportion widowed is implausible. This cannot be explained by women of 40–44 overstating their age, since this could only lead to a smaller increment, as opposed to an actual decline in the proportion widowed. Overstatement of age by women aged 45–49, especially among those who have been widowed, may be the explanation. If this were so, then the lower proportion divorced would also be explained.

## 3.5 COMPARISON BETWEEN THE TWO SURVEYS

In the household survey, the marital status of women was not usually reported by the women themselves. To check on the reliability of these data, a comparison was made with the individual survey. The objective was to detect or pinpoint the differences, if any, between the answers in the two surveys and to try to determine the magnitude of any errors. The comparison of marital status in the two surveys is shown in table 11.

Out of all the women interviewed in the individual survey, about 3065, constituting 98.4 per cent of the total, reported the same status in both surveys. In cases where there was no time gap between the two surveys, a high percentage of consistency between the two answers is always expected. Such agreement, however, will be more significant if the respondent provided the answers in both surveys, but in the SUDFS, the household schedule was usually completed by the head of the household. For this reason, we would expect differences in the two answers to be more common. The close agreement between the two answers suggests that the

**Table 11** Comparison of marital status in the individual and household surveys, numbers and percentages

| Marital status in the individual survey | Marital status in the household survey | | | | |
|---|---|---|---|---|---|
| | Married | Widowed | Divorced | Separated | Total |
| *Married* | | | | | |
| Number | 2845 | 7 | 1 | – | 2853 |
| Per cent | (99.6) | (0.2) | – | – | (100.0) |
| *Widowed* | | | | | |
| Number | 6 | 100 | 3 | – | 109 |
| Per cent | (5.2) | (91.9) | (2.9) | – | (100.0) |
| *Divorced* | | | | | |
| Number | 7 | 10 | 113 | 3 | 133 |
| Per cent | (5.2) | (7.1) | (84.8) | (1.9) | (100.0) |
| *Separated* | | | | | |
| Number | 4 | – | 1 | 7 | 12 |
| Per cent | (33.3) | – | (5.6) | (61.1) | (100.0) |

interviewers in the individual survey might have copied down the answer recorded in the household schedule. This is all the more likely in that the two questionnaires were, in most cases, completed in a single visit to the selected household.

## 3.6 COMPARISON WITH THE 1973 CENSUS

Another way of examining the quality of data on marital status collected in the SUDFS is to compare it with a different set of information. As stated earlier, a complete marriage history was obtained in the individual survey. This made it possible to reconstruct marital distributions for several years prior to the survey. The derived values for 1973 were then compared with the values obtained in the 1973 census. The results are shown in tables 12 and 13.

Table 12 shows the percentage ever married in the 1973 census and the percentage ever married as reconstructed from the SUDFS. The latter values were obtained using dates of first marriage reported by women in the individual survey and proportions single in the household survey. Since the highest age at which women were eligible for the individual interview was 50, estimates were made up only to age 40–44. This is because women who were 45–49 in the survey were five years younger during the census in 1973. With the exception of the age group 15–19, all the values in the matching age groups were very close to each other, an indication of good reporting on marital status. The percentage ever married at 15–19 is about 8 per cent higher in the SUDFS than in the census. Possibly young married women were recorded as single. Sometimes the interviewers in the census may not have complied with the instructions. Young married women, especially if they had no children, were not asked their marital status and would automatically have been treated as single. At the same time, very young women with children might have been shifted upwards in age. These two tendencies may explain the deficit in the proportion ever married in the 15–19 age group according to the census.

**Table 12** Percentage distribution of women ever married by five-year age group according to the 1973 census and as reconstructed from the SUDFS

| Age in 1973 | Percentage distribution | |
|---|---|---|
| | 1973 census | SUDFS |
| 15–19 | 43.1 | 50.8 |
| 20–24 | 84.9 | 83.7 |
| 25–29 | 95.4 | 94.7 |
| 30–34 | 97.3 | 97.3 |
| 35–39 | 98.2 | 98.7 |
| 40–44 | 98.2 | 97.5 |

*Source:* Census data from Department of Statistics 1977

Using the data obtained from the marriage history on the dates of onset and termination of marriage, as well as the nature of dissolution of terminated unions, it was possible to reconstruct in some detail the marital composition of the women at the 1973 census. This is compared with the actual figures observed in the census (table 13).

Taking married women, we find that apart from age group 25–29 estimates from the survey are consistently higher. This suggests that the census missed some of the married women. This becomes evident if we look at the two distributions. The survey percentages, unlike those exhibited by the census, show a very smooth pattern, the magnitude of which is positively correlated with age. Reconstructed percentages for the divorced women were very close to those observed in the census, but sharp differences are witnessed in the case of widowed women. Considering ages above 30, we find that estimates from the survey are much lower. This suggests that the survey has missed some marriages which were dissolved by the death of the spouse. Widows who remarried might have deliberately omitted their former marriages which ended with the death of their previous husbands. This is more probable among older women with marriages terminated long in the past. It seems likely that the proportion widowed in the survey may have been underestimated at older ages because of selective overstatement of age by widows.

**Table 13** Percentage distribution of women according to marital status by five-year age group according to the 1973 census and as reconstructed from the SUDFS

| Marital status | Percentage in age groups | | | | | |
|---|---|---|---|---|---|---|
| | 15–19 | | 20–24 | | 25–29 | |
| | Census | SUDFS | Census | SUDFS | Census | SUDFS |
| Single | 57 | 49 | 15.0 | 16 | 4.6 | 5.3 |
| Married | 41.0 | 49 | 80 | 81 | 89.6 | 88.0 |
| Widowed | | | 1 | 0 | 2.6 | 2.0 |
| Divorced | 2 | 1.1 | 3 | 2 | 3.2 | 4.7 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | 30–34 | | 35–39 | | 40–44 | |
| | Census | SUDFS | Census | SUDFS | Census | SUDFS |
| Single | 2.7 | 2.7 | 1.8 | 1.3 | 1.8 | 2.5 |
| Married | 88.6 | 90.7 | 85.8 | 89.5 | 77.1 | 85.1 |
| Widowed | 4.8 | 2.4 | 8.1 | 6.8 | 15.1 | 5.4 |
| Divorced | 3.8 | 4.1 | 4.3 | 2.4 | 5.9 | 6.9 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Source:* Census data from Department of Statistics 1977

## 3.7 TRENDS IN AGE AT FIRST MARRIAGE

### By birth cohort

It is also of some interest to study the age patterns and trends in nuptiality. To evaluate these aspects of nuptiality, combined data from the individual and household surveys were used. From dates of first marriage in the individual survey and proportions ever married in the household survey, the percentages ever married as at successive ages by cohorts were obtained. This is shown in table 14.

It can be seen that the proportions ever married at age 15–19 among women currently aged 30–34 and 40–44 are higher than those among women aged 35–39 and 45–49 respectively. This does not fit in with the idea of a gradually increasing age at marriage, or even a constant age at marriage. By the age of 25–29, this young marriage pattern is still evident among women currently aged 40–44, though no longer among 30–34 year old women. If it were the case that marriage had been occurring at a later age over the period 15–30 years before the survey, then it would appear that there has been considerable movement of ages into adjacent age groups, in particular the overstating of the age of 30–34 year old women.

On the whole, all cohorts exhibit the pattern of a young age at marriage. For example, by age 19 more than 50 per cent are married in all cohorts. This can easily be seen in table 14. Experience has shown that there is a tendency towards later marriage among younger cohorts. To some extent this can be seen in table 14 where we find a systematic decrease in the proportions married at exact ages by successive birth cohorts over the last 15 years.

As a further step towards inspecting the kind of data shown in table 14, we have also examined the trend in age at first marriage, as shown by exact ages by which a certain proportion of women were married. The result of this exercise is shown in table 15. It shows the ages at which 10, 25, 50 and 75 per cent of women of successive birth cohorts had been married for the first time. The last column presents the interquartile range which shows the difference between ages by which 25 and 75 per cent of women are married. This gives an indication of the spread of ages over which women in each cohort were married for the first time.

However, for some of the older cohorts, there are some puzzling irregularities. The table suggests that women in age groups 30–34 and 40–44 married earlier than those in the respective older adjacent cohorts. This would seem to be unlikely. As it is hard to imagine that these particular women would misplace marriages to a greater extent than women in the 35–39 and 45–49 age groups, it may be that age misreporting is the explanation. Unfortunately, no single pattern of age misreporting can explain these anomalies. The transference of women aged 45–49, especially those who married earlier, into older age groups (who would therefore not be included in the survey) would help to explain the apparent later marriage of these women. This would accord with earlier observations in chapter 2. In addition, the reporting of 30–34 year old women as 35–39 would cause reported age at marriage to fall for women aged 35–39. This would also help to account for the relatively small number of ever-married women in the age group 30–34 (500) as compared with the age group 25–29 (715).

Ages by which 10 and 25 per cent of the women are married are rising, indicating a tendency towards later

**Table 14** Cumulative proportions of women ever married by age (exact years), individual and household surveys

| Age (exact years) | Current age | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
| 11 | 0.006 | 0.034 | 0.032 | 0.038 | 0.047 | 0.049 | 0.030 |
| 12 | 0.011 | 0.070 | 0.062 | 0.100 | 0.106 | 0.121 | 0.073 |
| 13 | 0.021 | 0.124 | 0.138 | 0.181 | 0.176 | 0.213 | 0.124 |
| 14 | 0.046 | 0.174 | 0.220 | 0.261 | 0.257 | 0.308 | 0.205 |
| 15 | 0.079 | 0.254 | 0.308 | 0.421 | 0.373 | 0.419 | 0.359 |
| 16 | | 0.320 | 0.426 | 0.531 | 0.478 | 0.508 | 0.483 |
| 17 | | 0.390 | 0.504 | 0.607 | 0.566 | 0.613 | 0.569 |
| 18 | | 0.460 | 0.584 | 0.686 | 0.646 | 0.665 | 0.654 |
| 19 | | 0.528 | 0.668 | 0.746 | 0.715 | 0.718 | 0.710 |
| 20 | | 0.565 | 0.737 | 0.788 | 0.770 | 0.763 | 0.748 |
| 21 | | | 0.770 | 0.845 | 0.809 | 0.816 | 0.808 |
| 22 | | | 0.804 | 0.879 | 0.829 | 0.849 | 0.830 |
| 23 | | | 0.833 | 0.903 | 0.866 | 0.868 | 0.872 |
| 24 | | | 0.852 | 0.913 | 0.889 | 0.901 | 0.885 |
| 25 | | | 0.866 | 0.924 | 0.915 | 0.934 | 0.898 |
| 26 | | | | 0.932 | 0.931 | 0.947 | 0.928 |
| 27 | | | | 0.937 | 0.936 | 0.953 | 0.945 |
| 28 | | | | 0.943 | 0.948 | 0.963 | 0.945 |
| 29 | | | | 0.943 | 0.957 | 0.967 | 0.949 |
| 30 | | | | 0.951 | 0.958 | 0.970 | 0.966 |
| 31 | | | | | 0.965 | 0.973 | 0.971 |
| 32 | | | | | 0.972 | 0.980 | 0.975 |
| 33 | | | | | 0.973 | 0.980 | 0.975 |
| 34 | | | | | 0.977 | 0.983 | 0.975 |
| 35 | | | | | 0.978 | 0.983 | 0.979 |
| No of ever-married women | 218 | 515 | 715 | 500 | 589 | 303 | 225 |

*Source:* Department of Statistics 1982

**Table 15** Ages by which 10, 25, 50 and 75 per cent of women were ever married, by current age

| Current age | Per cent ever married | | | | Interquartile range |
|---|---|---|---|---|---|
| | 10 | 25 | 50 | 75 | |
| 15–19 | 15.5 | 17.9 | | | |
| 20–24 | 12.6 | 14.9 | 18.6 | | |
| 25–29 | 12.5 | 14.3 | 17.0 | 20.4 | 6.1 |
| 30–34 | 12.0 | 13.9 | 15.7 | 19.1 | 5.2 |
| 35–39 | 11.9 | 13.9 | 16.2 | 19.6 | 5.7 |
| 40–44 | 11.7 | 13.4 | 15.9 | 19.7 | 6.3 |
| 45–49 | 12.5 | 14.3 | 16.2 | 20.0 | 5.7 |

*Source:* See table 14

marriage among successive birth cohorts. The main deviation from this pattern is the value for the age group 45–49, which shows a pattern of relatively late marriage. This may suggest, in addition to earlier comments, that as a result of memory lapse these older women might have misstated their age at first marriage or some might have omitted their former marriages. A clearer picture of the quality of these data is portrayed by the median age by which 50 per cent of women were married. The figures do not show a regular pattern of increase with successive birth cohorts, so it is very hard to be sure whether or not there is any change in pattern of age at first marriage. The irregularities arising at ages above 30 can only be explained by age errors and misdating of first marriages. In fact, the wide interquartile range exhibited by age groups 30–34 and 40–44 may suggest some age misreporting.

### By period cohort

For the last 15 years or so there has been a systematic change in age at first marriage which is indicated by a decrease in the proportions ever married among the different age groups at successive periods preceding the survey (tabulation not shown). For example, if we take age group 15–19, we find that the percentage of ever-married women dropped from as high as 56 fifteen years before the survey to only 22 at the time of the survey. Similar observations can be made for the other age groups. For longer periods prior to the survey the situation is different, with substantial irregularities.

## 3.8 CONCLUSION

From the preceding sections, it is possible to conclude that though about 40 per cent of women were able to give exact dates for the onset of their first unions, heaping is still present. This is clearly seen from the reporting of the calendar year of the event and the interval between the date when the union started and the time of the survey. Heaping patterns are complicated by the fact that the data on date of marriage were obtained by means of three different formats. Slight irregularities in the proportions ever married by age are also noted and attributed to age misstatement.

The smooth and fairly plausible pattern of marital status by age indicates some reliability in these reports. This is supported by the close consistency of the reconstructed values from the SUDFS with the observed values from the 1973 population census. In fact, the former set of figures suggests that some young married women were recorded as single in the census.

The examination of the trends in age at first marriage by birth cohort suggests a systematic increase in that value. This is contradicted, however, by the reports of women in their late forties. It seems likely that this is due to erroneous data, mainly as a result of age shifting.

# 4 Fertility

## 4.1 INTRODUCTION

In the SUDFS, much detailed information pertaining to fertility was collected. The household schedule included simple census-type questions on number of children ever born which were asked of all ever-married females in the household who were aged 12 years or older. To improve the quality of data, the questions were separated to cover children living in the household, those living elsewhere and those now dead, by sex. For the most recent birth, women were asked to provide additional information on particulars such as date of birth, sex of the child, his/her survival status and the date of death if the child was not alive at the time of the survey. The individual questionnaire incorporated a whole section devoted to the maternity (or birth) history of the respondent which was divided into two tables.

In the first table where all live births were listed in chronological order, information was collected on the name, sex, date of birth and survival status of the child. If the child was not alive, the respondent was asked to specify for how long he/she had actually lived. To obtain the date of birth of the child, she was first asked to give the year and month in which the child was born. If the woman failed to give the year in which the event took place, then the interval since marriage or since the birth of the previous child, depending on his/her birth order, was obtained.

In the other table, all the other pregnancies which resulted in non-live births were recorded. Non-live births were asked for each birth interval. The woman was then asked to specify whether the child had shown any sign of life when delivered. If the answer was affirmative, that child was treated as a live birth. Among other things, this exercise was meant to minimize as far as possible omission of live births arising from failure to distinguish between a still and a live birth.

## 4.2 POSSIBLE ERRORS AND BIASES

Fertility data collected in the SUDFS, as in most demographic surveys, is subject to error and bias which might vitiate the results of later analysis carried out on the data. Age misstatement can either increase or decrease the average parity of the women in the different age groups, depending on the direction of the age shifting. Problems can also arise from the data collection itself, or they may be a result of other errors. In the following sections an attempt is made to summarize some of these errors and see to what extent they affect our findings.

### Eligible women

In the SUDFS, as we have seen earlier, only ever-married women were eligible for the individual questionnaire with its fertility questions. As a result of this procedure, the fertility of single women, though it may be very low, will be completely omitted. A more serious problem arises when an ever-married woman is reported as single. In the household survey, the information on the marital status of women was reported by proxy in most cases, and there is a high chance of misstatements being made.

### Omission

In demographic surveys, there is a tendency for some women, especially in the older age groups, to fail to report some of their children. This could either be done deliberately or could be due to memory lapse, which is prevalent among these women. The children most likely to be omitted are those who have subsequently died; again, this is more likely for those who died a long time before the survey. In societies where it is taboo to talk about a deceased person, such children are always ignored. Children living elsewhere, especially if they are grown up and have formed their own families, are also likely to be omitted. In the Sudan, where some people still believe in what is called 'Ein', the evil eye whereby children can be bewitched by a stranger, living children resident in the household may also be omitted. Some people may hide their children and refrain from reporting their exact number to the interviewer. Omission might also result from the confusion of a live birth with a still birth. The SUDFS adopted the WHO definition of a live birth and this may not always have been explained adequately by the interviewer. Other children who are likely to be omitted are children from former marriages, illegimate children and children newly born, especially if they have not yet been named.

It follows that omission affects not only the average parity of women in the various age groups but also period and cohort rates. When omissions relate to remote periods in the past, understatement of the rates in those periods gives a false impression of an increase in fertility as time goes by. On the other hand, omission of young children results in an underestimation of the levels in the most recent periods, and gives a false impression of a decline in the last few years before the survey.

### Displacement of date of birth

In most cases, respondents are not aware of the dates when they gave birth to their children. The dates are usually estimated by the interviewer, either with the aid

of a list of historical events or by the mere physical appearance of the child. A date is usually estimated for the first birth, which is then used to work out dates for the subsequent births simply by adding intervals between the successive events. Generally this results in heaping either at certain years of birth or at certain lengths of birth interval. The misdating of births, which has been investigated by many researchers, is especially problematic in the study of fertility. The explanation of timing errors proposed by Brass (Brass 1968) is that respondents distort the time scale. Some of the births that have taken place in the last five-year period before the survey are shifted into the previous period. Some of the events belonging to that period are shifted to the earlier one, and so on. Based on the idea of same kind of misconception of time, a simulation model was developed by Potter (1977), whereby the effect of misstatement on the overall levels and trends of fertility could be detected. His main hypothesis in developing the model is that the time scale perceived by the women is different from the actual one. Women tend to shorten the two periods closest to the survey and lengthen those further away. This will bias estimates of change in fertility in such a way that declines in fertility will be exaggerated. An application of this model to data obtained from surveys in Bangladesh and El Salvador showed that this kind of bias was present.

## 4.3 EVALUATION OF THE FERTILITY DATA

Having identified some of the errors and biases that may distort fertility estimates, we now look into the quality of the fertility data collected in the SUDFS. This is done by carrying out different kinds of check in order to find out to what extent the data are reliable as a basis for further analysis. The evaluation exercise carried out in the following sections is divided into three parts. The first of these deals with omission of births; the second with misdating or heaping, both for the numerator (children ever born) and the denominator (mothers). The third part deals with comparisons between the two surveys (internal checks) as well as with data from the 1973 census (external checks, described in section 4.4). Finally, in section 4.5, checks for period and cohort rates are made, in order to assess the data on fertility trends.

### Tests for omission

We have seen earlier how omission of children can distort the data on fertility. In order to test for such errors, we first inspected the mean number of children ever born to women in the individual survey according to single years of age. The normal pattern of this mean distribution should increase with the age of the mother. This is simply because the older the woman, the longer she has been exposed to the risk of childbearing. As can be seen from figure 1 the data show a deviation from this simple pattern. Instead of rising gradually and smoothly with age, the curve shows a zigzag pattern with heaping at certain ages and troughs at others. Here the usual preferred digits observed in age reporting are not obvious. Instead, heaping is on digits not usually

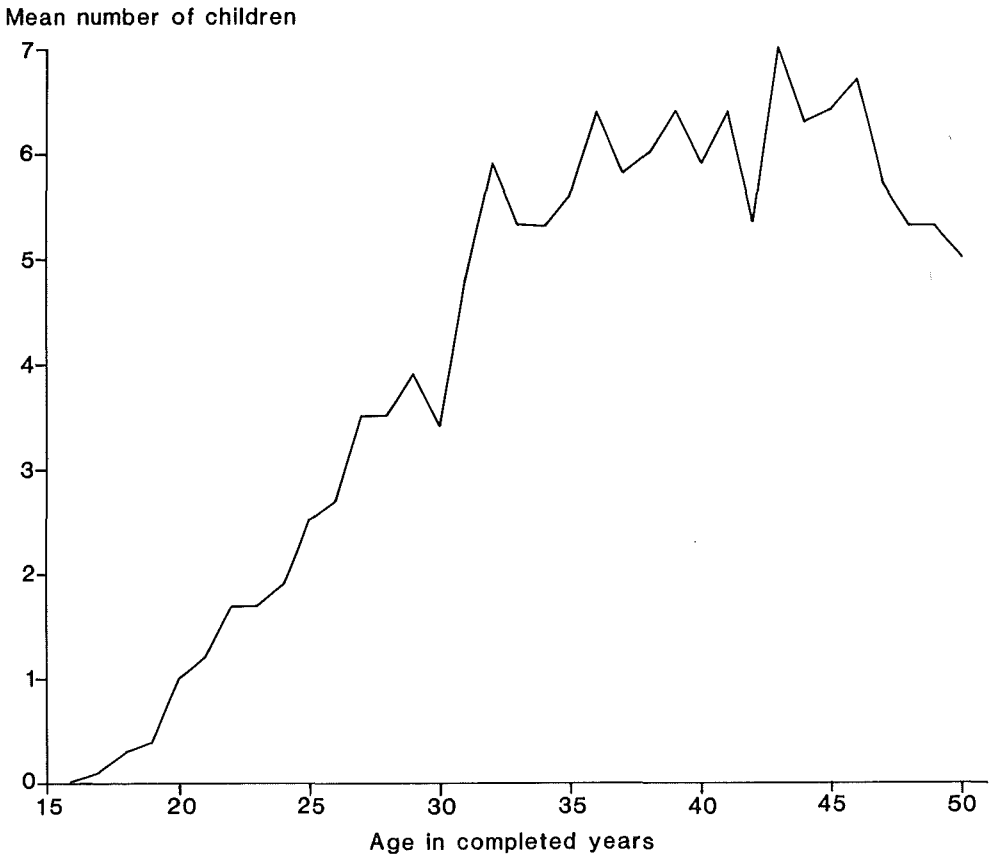


**Figure 1** Mean number of children ever born by single years of age to women in the individual survey

preferred. It is most pronounced at ages 32, 36, 39, 41, 43 and 46. In the absence of any evidence for changes in fertility behaviour which might have been age selective, such irregularities can only be explained by errors of one kind or another in the data. The heaping at those ages can be attributed to age misstatements. Women with low fertility are in most cases shifted downwards to the usual preferred digits of 0 and 5. Apart from distorting the quality of age reporting, this has a two-way effect on the estimation of fertility levels. For example, let us take women who are actually 43 years old. The ages of some of these women may have been underestimated, perhaps because they had only a few children, and shifted downwards to younger ages with preferred digits, say 40 or 35.

Equally, ages of older women with high fertility may have been overstated. This could have been done deliberately by the interviewers in order to avoid interviewing them, since women were eligible for the individual interview only up until age 50. This kind of error can partly explain the sharp decline in the mean number of children ever born after age 46. It could also be explained by omission due to memory lapse among these women, especially if any of the children being investigated had died long before the survey.

Since the study of fertility is usually carried out on the basis of conventional five-year age groups, let us see what the rates look like when grouping the data. These are shown in table 16. As we can see, by grouping the data the apparent errors are reduced. The values increase steadily with age, though the tempo of increase at older ages is very low. While the value for the age group 30–34 is 60 per cent higher than the value observed for age group 25–29, it drops to only 5 per cent when comparing values for the last two groups. This appears implausible. The increase is more substantial for urban than rural women, indicating a more plausible pattern of reporting for the former.

In the Sudan where a preference for sons over daughters is prevalent, there is a high chance that some female children have been omitted. In order to find out whether this kind of error is present, we examined the sex ratios of reported births. In most African countries, the rate, expressed as number of males per hundred females, is around 102. Looking at the sex ratio of births by age group of mother, shown in table 17, we see that the values vary widely. Due to the small number of children born to women aged 15–19, the low value for the age group should be interpreted with much care. The ratios are very high for age groups 20–24 and 35–39. This is difficult to explain. The high ratio for the last age group is likely to be due to omission of daughters in particular by these older women.

If we examine the rates by subgroup (not shown), we see that more female children were omitted by rural women and by illiterate women. Again, more daughters were omitted in the Dar Fur, Central and Eastern regions where the overall sex ratios were reported as 112, 110 and 107 respectively.

Another way of detecting the omission of children is to examine the proportions surviving and dead by age group of mother. We would expect that the proportions living would decrease with the age of the mother. The proportion dead should rise correspondingly. These proportions are shown in table 18 which indicates that the proportion of children dead does not fall regularly with age of mother, as we would expect it to. This suggests that the proportion of dead children reported by women in the age groups 25–29 and 30–34 are too low, possibly due to omission of dead children. This is rather surprising, as such omission is usually associated with older women.

Comparison of inferred proportions of children dead by different ages with model life tables suggests that if the results for women in their twenties are correct, then there is considerable omission of dead children reported by older women, but least omission among women aged 45–49.

### Retrospective information

The reliability of the fertility measures depends to a large extent on the quality of data collected on the numerator

**Table 16** Mean number of children ever born by five-year age group of mothers and according to type of place of residence

| Place of residence | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
| Urban | 0.2 | 1.5 | 3.0 | 4.8 | 5.7 | 6.0 | 6.7 |
| Rural | 0.2 | 1.4 | 3.0 | 4.8 | 5.8 | 5.9 | 5.9 |
| Total | 0.2 | 1.4 | 3.0 | 4.8 | 5.8 | 5.9 | 6.2 |

**Table 17** Sex ratios of births by five-year age group of mothers

| Age group | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
|---|---|---|---|---|---|---|---|
| Sex ratio | 74 | 114 | 106 | 101 | 110 | 104 | 114 |

**Table 18** Proportions of children living and children dead by five-year age group of mothers

| Status of child | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
| Living | 0.85 | 0.84 | 0.88 | 0.86 | 0.85 | 0.83 | 0.82 |
| Dead | 0.15 | 0.16 | 0.12 | 0.14 | 0.15 | 0.17 | 0.18 |

(births) and the denominator (women), which are mainly derived from the maternity history. With this in mind, we look now into the data obtained from this source. At this juncture, it is important to point out that there is an element of bias inherent in these data, ie that only surviving women, of course, could be interviewed. We have to assume, in analysing fertility, that the fertility experience of dead women is the same as the experience of surviving women, although in fact nothing is known about the fertility of women who have died.

### Format of date of birth of children

First we examined the format of the date of birth of children. As we saw earlier the date of birth of each child was either exactly reported, ie year and month were recorded, or the interval since the previous birth or marriage, in the case of a first child, was obtained. Information relating to the first, next to last and last births was examined in the present exercise, and results are shown in table 19.

Out of a total of 2768 women who have had at least one birth, 65.3 per cent reported the exact year and month as dates for their first births and only 0.2 per cent gave the length of interval since their first marriage. Since most women are not aware of exact dates and since their first birth had usually occurred in the distant past, a lower value was to be expected. This information might have been supplied by the interviewers, obtaining the age of the child or the interval since marriage first, and then using their own conversion procedures to estimate the date of birth. If we examine the women's age pattern of reporting, we see clearly that younger women whose births might have occurred in recent years reported exact dates more than older women. For example, while 90 per cent of women aged 15–19 reported exact dates for the birth of their first children, the proportion drops to only 45.4 per cent among women aged 45–49 (not shown). For their most recent births, women reported exact ages more than for earlier births (table 19). For the last birth the percentage of women reporting the exact date increased to 85.5 per cent; the percentages were only 65.3 and 67.6 for the first and next to last respectively. Examining the data according to the different subgroups we see that literate women reported exact dates of their births more than illiterate women. Equally, urban women and women who had more years of schooling gave the exact dates of birth of their children more frequently.

**Table 19** Percentage distribution of format of reported date of birth of first, next to last and last birth

| Format of date of birth | Birth order | | |
|---|---|---|---|
| | First | Next to last | Last |
| *Year and month* | | | |
| Number | 1808 | 1648 | 2366 |
| Per cent | 65.3 | 67.6 | 85.5 |
| *Year only* | | | |
| Number | 955 | 789 | 402 |
| Per cent | 34.5 | 32.4 | 14.5 |
| *Interval* | | | |
| Number | 5 | 1 | – |
| Per cent | 0.2 | 0.0 | – |
| *Total* | | | |
| Number | 2768 | 2438 | 2768 |
| Per cent | 100.0 | 100.0 | 100.0 |

### Years since birth

From the data derived from the maternity history, the date of birth of each child was used to calculate the years since that event took place. It represents the age of the child if he is still living. The aim is to find out whether heaping, which is a common error in age reporting, is also present in reporting dates of birth of children. A clear picture is portrayed in figure 2 which shows the percentage distribution of children according to years since birth.

The curve depicts an uneven distribution of births over the last 30 years, for all births as well as for the urban and rural subgroups. Perhaps surprisingly, heaping is not on the usually preferred digits of 0 and 5; 6 and 7 are often preferred because that is the age when children are enrolled in school. Heaping is relatively more pronounced for rural births, though the urban curve does not show a plausible pattern either. The concentration of urban births is at 12. This age is preferred because at 12 children usually enter the intermediate level of schooling. For the events that took place before 1969, the curves follow a systematic pattern of heaping which occurs at successive periods of two years. This might suggest that birth intervals of two years were added, probably by the interviewers, in order to estimate the date of birth of the children.

We have already suggested that some errors found in the reported dates of birth of children could have been caused by the addition of systematic birth intervals. Let us try to determine whether this is true by looking at the birth intervals more closely.

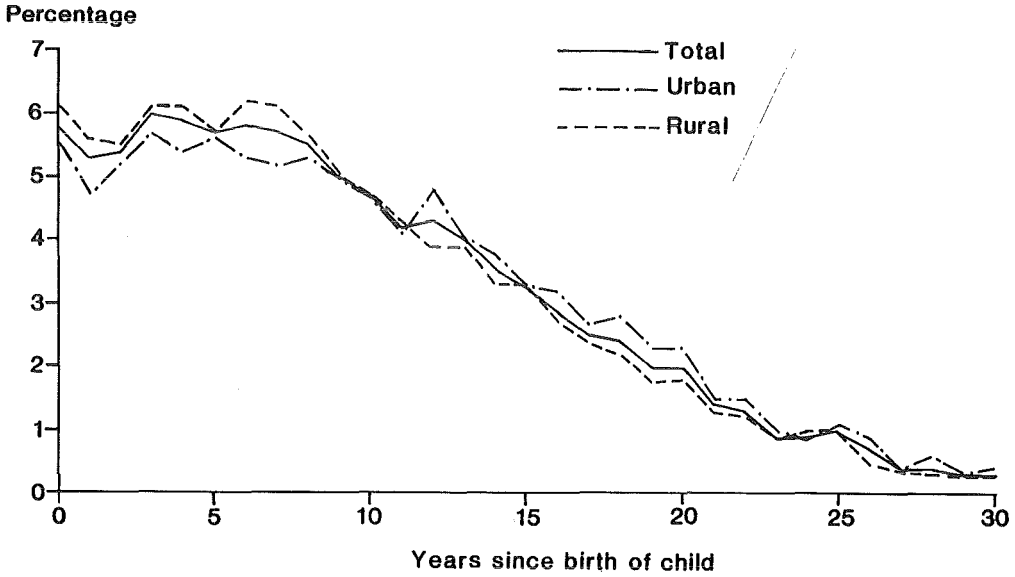


**Figure 2** Percentage distribution of children ever born by years since birth, total and according to type of place of residence

**Birth intervals**

From dates of birth of successive children, the interval was imputed, in months. The percentage distribution of the lengths of these intervals is presented in figure 3. In societies where birthspacing is not widely practised, the length of the interval usually ranges from 12 to 30 months. From the figure, we can see that most of the intervals are within that range. For all women, heaping is mainly on 12, 18, 24, 36, 39 and 48 months, which are multiples of years and fractions of a year. The greatest heaping is at 24 months, or two years, where it is more pronounced in the case of urban births. The urban distribution shows a similar pattern to that of the total population. For rural births, the curve shows a slightly different pattern of heaping, particularly at two points, 13 and 23, which are not multiples of years or fractions of a year. Perhaps this is due to the imputation procedure, since most rural women were interviewed a month after the beginning of the survey.

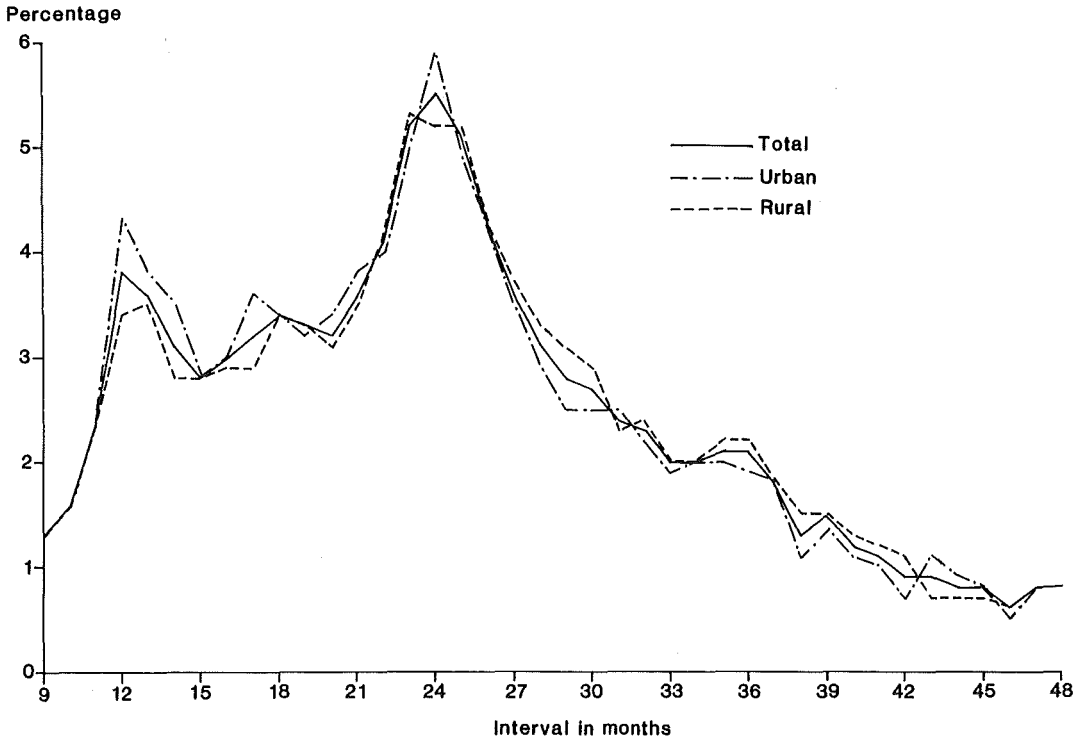


**Figure 3** Percentage distribution of intervals between births by length in months (9–48), total and according to type of place of residence

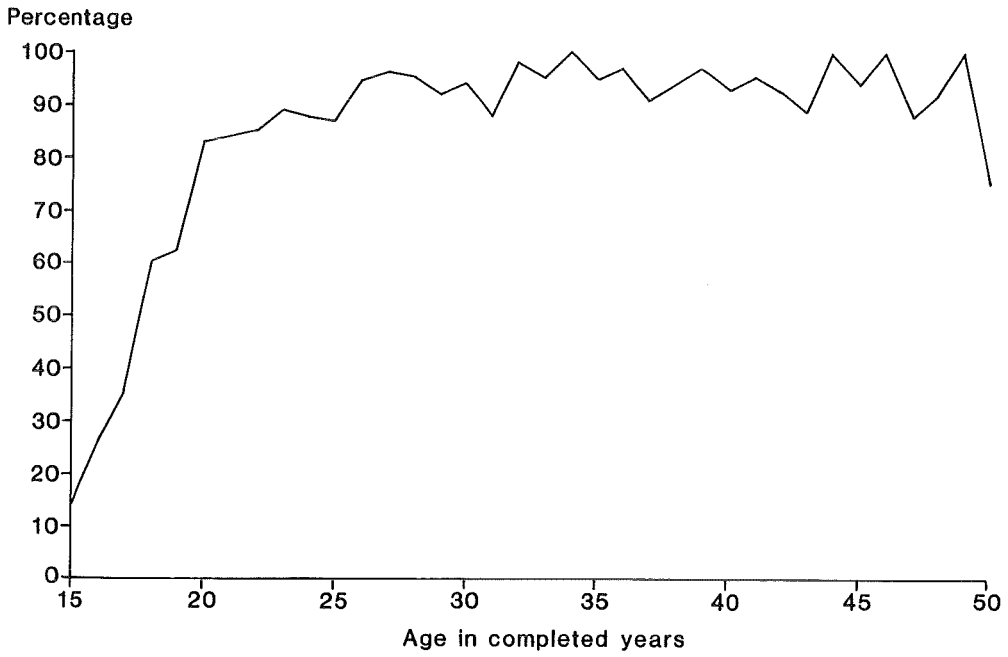


**Figure 4** Proportions of mothers by single years of age

Having pointed out some of the errors that might distort the data on the numerator (births), we now assess the quality of data on the denominator (mothers).

### Proportion of mothers

Proportions of mothers (all women who have had at least one birth) by single years are presented in figure 4. We would expect the curve to increase smoothly with age. This is not so; instead the curve shows a zigzag pattern. Heaping is more pronounced at ages ending with what are usually non-preferred digits, ie 9, 6 and 4. This may be attributed to age misstatement. Women who have not had any children might have had their ages underestimated and been transferred to adjacent age groups with numbers ending in digits 0 or 5, and therefore the number of childless women at those ages would increase. This kind of error would account for the low proportions at ages which end in 0 or 5.

### Age at birth

This information was obtained from reports on respondents' date of birth and that of her child. It is simply the difference between these two events. The age of the woman was obtained at each of her births. In other words, in this exercise, if a woman had given birth to three children, then that woman is represented three times in this distribution at different ages. The objective is to find out whether these women prefer certain ages when reporting their births. The results of the exercise are shown in figure 5 where we can see an irregular

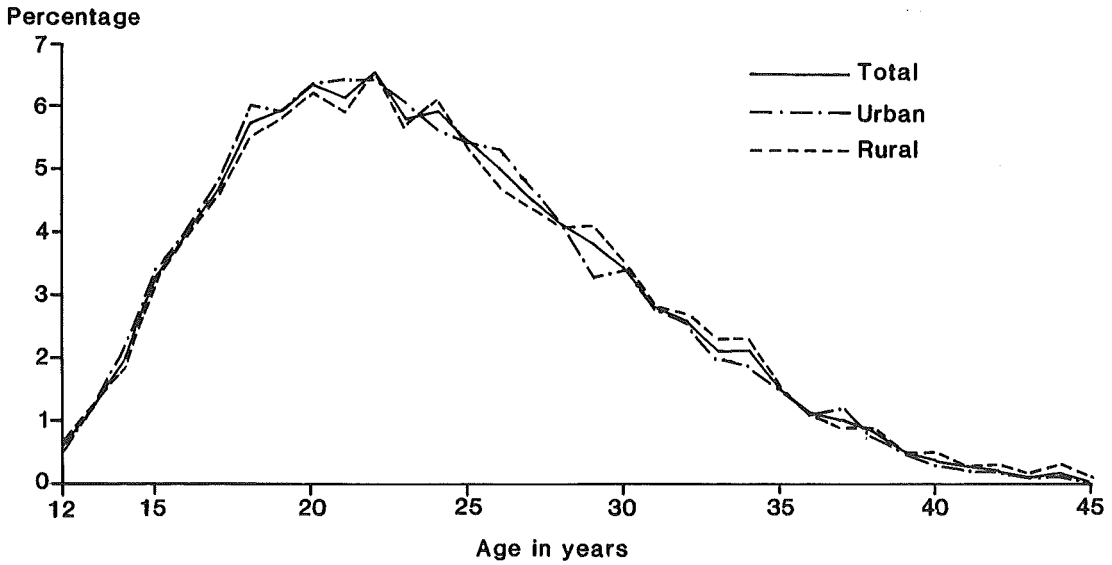


**Figure 5** Percentage distribution of mothers by age at birth of children, total and according to type of place of residence

pattern of ages at the events. Similar patterns with slight variations are depicted by the three curves. Again, unlike in age reporting, heaping is not on numbers ending in digits 0 or 5. The systematic heaping probably results from the fact that two-years intervals were added to the date of birth of the previous child in order to estimate the birth date of the subsequent one. Urban women do not show any better or more plausible pattern than rural women.

### Comparison between the two surveys

A simple way of measuring fertility levels is by means of the average number of live births women of different ages have had throughout their reproductive life up to the time of the survey. As we explained earlier, whereas the household schedule included direct questions on the number of children ever born, the individual survey probed thoroughly the maternity history of each woman. Results obtained from the two surveys are shown in table 20.

The values from the two surveys show very close agreement. It is surprising that the figures obtained from the individual survey are either lower or exactly the same as those from the household survey. The exceptions are at ages 20–24 and 35–39, though the difference is minimal. Higher values were expected from the individual survey, since more detailed questions probing the number of children ever born were incorporated. This may be partly explained by sampling errors, since the number of women interviewed in the individual survey was only one-third of those covered by the household survey. If this is the case, then women in the oldest and youngest age groups are more affected by this kind of error than the rest, because there are fewer of them.

In the household survey, since the fertility questions were in most cases reported by proxy, there is a high chance of some of the children ever born to the same women in the two surveys being omitted. Reports on the number of children ever born to the same women in the individual and household surveys were compared. This is shown in table 21, which indicates that about 96 per cent of women reported the same number of children in both surveys. About 2 per cent reported in the individual survey one or more children more than in the household survey and about the same number reported lower values. Since both surveys were conducted at the same time, we would expect an exact agreement between the two values. Generally the discrepancy is very low for the younger women, and increases with age, reaching 8.5 per cent unmatched cases at age 45–49. The individual survey, with its more probing questions and better interviewing techniques, might have led to more births being recalled. The table, however, shows that in some cases higher numbers of births were reported in the household survey. This is probably due to mistakes resulting from proxy reporting in the household survey. Some children who are not actually the respondent's own children may have been reported as such during the household survey. This is more likely to happen among rural women than urban women.

The comparison of children by sex does not show any selectivity towards omitting daughters, as we might have supposed.

## 4.4 COMPARISON WITH THE 1973 CENSUS

One way of checking the quality of data in the survey is to compare it with data from a different source. In this case, a comparison was carried out with the 1973 census. From dates of births in the SUDFS maternity history and ages of mothers, the number of children ever born can be reconstructed as at the survey date. This was compared with values obtained from the census. These are shown in table 22. Since the maximum age of women interviewed in the survey was 50, it was possible to reconstruct values only up to age 40–44. The SUDFS shows systematically higher numbers of births in all age groups; in some cases, it is almost 40 per cent higher. This suggests that more children were omitted in the census. This is to be expected as censuses are not usually

**Table 20** Children ever born to ever-married women by five-year age group, according to the individual and household surveys

| Source of data | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
| Household | 0.8 | 2.1 | 3.5 | 5.0 | 5.8 | 6.3 | 6.3 |
| Individual | 0.7 | 2.2 | 3.4 | 5.0 | 5.9 | 6.0 | 6.0 |

**Table 21** Comparison of number of children ever born reported by women in the individual and household surveys

| Difference between two surveys | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
| 1 or more higher | 0.8 | 2.0 | 0.8 | 2.2 | 2.2 | 3.0 | 4.3 |
| Same | 97.7 | 97.2 | 97.0 | 95.3 | 94.2 | 95.3 | 93.5 |
| 1 or more lower | 1.5 | 0.8 | 2.2 | 2.4 | 3.6 | 2.6 | 4.2 |

**Table 22** Mean number of children ever born by five-year age group of women in 1973 according to the census and as reconstructed from the SUDFS

| Source of data | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 |
| Census | 0.3 | 1.5 | 2.7 | 3.5 | 4.2 | 4.0 |
| SUDFS | 0.6 | 2.0 | 3.8 | 5.0 | 5.5 | 5.2 |

*Source:* Census data from Department of Statistics 1977

a good source of data for the number of children ever born. In the SUDFS, with its better interviewing techniques and detailed probing questions, more births were recalled.

Women were also asked how many of their children had died. Table 23 shows the data gathered in the census and the data reconstructed from the SUDFS. This provides a further check on the quality of reporting in the survey.

The table shows that the data from the two sources are in very close agreement. For the last age group the SUDFS shows a slightly lower value than the census. This might be due to the sampling variations or age misstatements whereby women with more children and possibly more deaths were moved upwards beyond that age limit. Although this exercise does not reveal an improvement in the quality of the data collected in the SUDFS compared with the census, the previous analysis, expressed in table 23, suggested a considerable improvement.

## 4.5 FERTILITY LEVELS AND TRENDS

As a further step towards the analysis of the birth history data, an attempt is made to examine the levels and trends in the reported fertility rates. In the following sections, an examination is made, first to check the maternity age pattern and the proportions who are mothers at different ages, as shown by the different birth cohorts. Secondly, the fertility rates of different cohorts through different time periods is examined, and finally an analysis is made of the different cohort–period rates.

### Proportions of mothers

One way of studying fertility trends is to examine age at first birth of the cohorts over time. It is also revealing to inspect the proportions who are mothers at each age for the different cohorts. Table 24 and figure 6 show the cumulative proportions who are mothers by exact ages. Using information on the date of birth of the woman and the date of birth of her child, the proportions of women who are mothers were obtained for each cohort. Since the individual survey was based on an ever-married sample, the proportions ever married from the household survey were used to adjust the results for all the women. From the table it can be seen that the cohort aged 30–34 shows the earliest fertility. The proportions who are mothers among these women are the highest of all the cohorts. By age 18, more than 50 per cent of women in that age group were mothers. The same value, however, was found for cohorts aged 40–44 and 45–49 at ages 19.5 and 20.5 respectively. The cohort aged 35–39 also shows a pattern of very early motherhood. In the absence of any evidence for an increase in fertility in that cohort, such irregularities can only be explained by some misstatements. As observed in the last chapter, it seems due to memory lapse and ignorance of the dates of events. Again, the selective overstatement of age of 45–49 year old women and the reporting of some 30–34 year old women as 35–39 would help to explain these irregularities.

### Age-specific fertility rates

One way of studying levels of fertility is by means of age-specific fertility rates (ASFR). These are obtained by dividing the number of births in a year by the number of woman-years lived by women in a specific age group in that year. Analysis of such rates attained by the different age groups over time enables us to depict changes, if any, in the levels of fertility. Table 25 shows the ASFRs by calendar year (1949–77). The original values (figure 7) show great fluctuations among the different adjacent years. In order to smooth these irregularities,

**Table 23** Mean number of children dead by five-year age group of women in 1973 according to the census and as reconstructed from the SUDFS

| Source of data | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 |
| Census | – | 0.3 | 0.5 | 0.7 | 0.9 | 1.0 |
| SUDFS | 0.1 | 0.3 | 0.5 | 0.7 | 0.9 | 0.9 |

*Source:* Census data from Department of Statistics 1977

**Table 24** Cumulative proportions who are mothers by exact ages

| Age (exact years) | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
| 12 | 0.4 | 3.1 | 2.1 | 3.7 | 3.4 | 4.2 | 1.3 |
| 13 | 0.9 | 6.6 | 5.3 | 7.5 | 7.8 | 7.8 | 3.9 |
| 14 | 2.0 | 10.6 | 10.6 | 15.3 | 11.8 | 13.7 | 7.8 |
| 15 | 3.2 | 17.1 | 18.7 | 26.3 | 19.6 | 21.9 | 15.5 |
| 16 | | 24.8 | 26.6 | 35.0 | 28.8 | 31.3 | 22.7 |
| 17 | | 30.9 | 36.0 | 43.9 | 35.8 | 38.8 | 31.2 |
| 18 | | 37.6 | 45.4 | 52.0 | 45.0 | 45.0 | 36.7 |
| 19 | | 44.3 | 53.5 | 59.9 | 51.8 | 49.2 | 42.2 |
| 20 | | 48.5 | 59.1 | 67.5 | 59.5 | 56.4 | 49.4 |
| 21 | | | 65.6 | 73.5 | 65.7 | 62.3 | 54.9 |
| 22 | | | 69.4 | 78.4 | 69.7 | 66.9 | 61.3 |
| 23 | | | 72.8 | 81.5 | 73.2 | 72.1 | 67.7 |
| 24 | | | 76.2 | 84.4 | 76.5 | 75.1 | 71.6 |
| 25 | | | 77.7 | 86.3 | 80.0 | 78.4 | 74.6 |
| 26 | | | | 87.3 | 82.5 | 81.4 | 79.8 |
| 27 | | | | 88.3 | 86.2 | 83.4 | 81.5 |
| 28 | | | | 89.4 | 87.9 | 86.1 | 82.8 |
| 29 | | | | 90.0 | 88.2 | 87.8 | 84.5 |
| 30 | | | | 90.2 | 88.9 | 88.5 | 85.4 |
| 31 | | | | | 89.6 | 89.5 | 87.1 |
| 32 | | | | | 90.3 | 90.2 | 88.4 |
| 33 | | | | | 91.2 | 91.2 | 90.1 |
| 34 | | | | | 91.7 | 91.5 | 90.5 |
| 35 | | | | | 91.7 | 91.8 | 91.4 |

three-year moving averages were obtained for the different years. All ages show an overall decline in fertility rates in recent years (1971–7). This is particularly clear in the decline in the total fertility rate during the last six years, shown in the last column of table 25. These values are obtained by cumulating the age-specific fertility rates across the five-year age groups (from 15 to 49) and multiplying by five (since the rates refer to five-year age groups). The values drop from 7.5 in 1971 to 5.4 in 1977, ie a decrease of almost two children per woman. For age group 15–19, the rates are almost constant during the period 1964–7, with a drop over the next three years (1968–70) and from 1971 onwards there is a steady decline, as is the case with overall fertility. For age groups 20–24 and 25–29, the rates are constant for a longer period, ie 1964–8. For the age group 30–34, sharp fluctuations in the rates are observed in the same period. For example, the rate increased from 262 in 1964 to 269 in 1968 and dropped again to 262 in 1970.

Though all ages exhibit fluctuations in the rates, these fluctuations are possibly more pronounced at ages 20–24 and 30–34. This could be due either to fluctuations in the reported number of births through the years (the numerator) or to fluctuations in the number of years of exposure (denominator).

**Cohort–period rates**

The ASFRs examined in the preceding section revealed some implausible irregularities in the maternity data. A more refined analysis of the data can be carried out by means of cohort–period fertility rates (CPFR). The conventional ASFRs studied above are difficult to calculate because of the need to allocate fractions of person-years of exposure of different age groups to different time periods; if events are allocated by calendar year of occurrence, we have only partial information for the calendar year of the survey (Goldman and Hobcraft 1982). In that sense, CPFRs which consider the number of children ever born to a selected group of women throughout their reproductive span up to the time of the survey are more suited to the study of maternity history data. In this analysis, a cohort refers to women of the same current age passing through the same age range at each period; these are usually referred to as 'real cohorts'. 'Synthetic cohorts', on the other hand, refer to women in different age groups at a particular point of time. Cohorts can also refer to women with the same number of years elapsed since marriage – 'marriage cohorts' – or since first birth – 'motherhood cohorts'.

To study cohort and period trends in fertility we

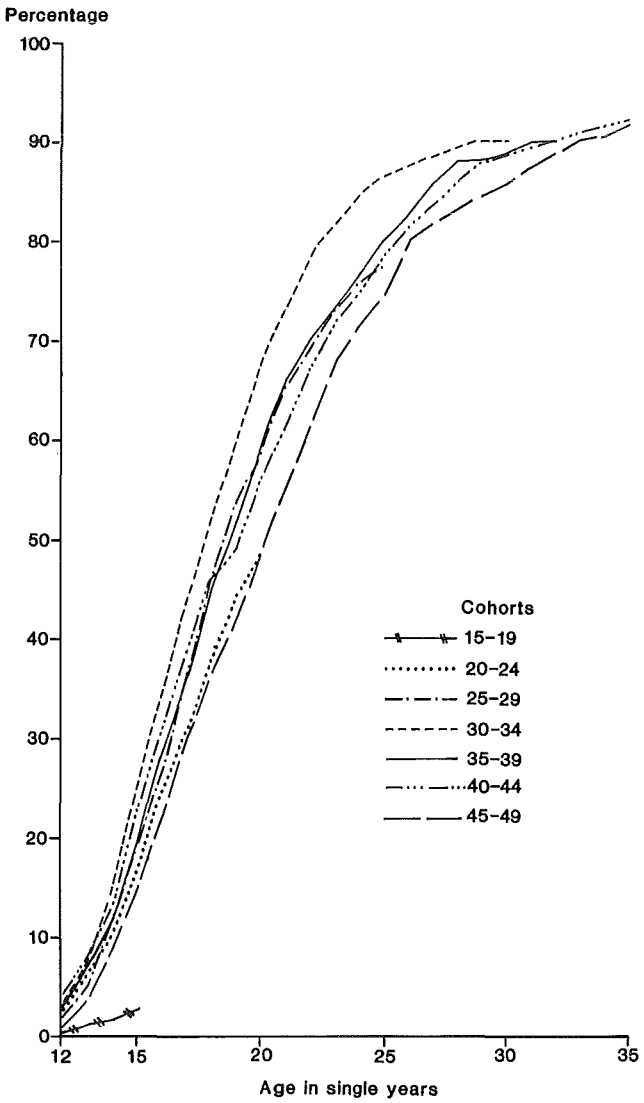


**Figure 6** Cumulative proportions who are mothers by exact ages, by birth cohort

present table 26. Panel A gives the cohort–period rates. In this panel, the rates for a given period are located within a column, rates for a given cohort across a row and rates for different cohorts at the same age interval along a diagonal. Cohort rates are also illustrated in figure 8. Panel B shows cohort–period rates cumulated over time ($P_i$). Panel C shows cohort–period rates cumulated over cohorts for each time period ($F_i$). In this context the $P_i$ and $F_i$ values are expressed as:

$$P_i = \sum_{y=1}^{y=i} Z_{xy}$$

and

$$F_i = \sum_{y=1}^{y=i} Z_{xy}$$

where $Z_{xy}$ denotes the fertility rate of cohort x in period y.

Looking diagonally at the data in panel A and comparing the most recent periods with the most distant ones, we gain the impression that the rates at each age group increase and then fall during periods closer to the survey. For example, for age group 15–19 the rate increases from as low as 0.052 in the period 30–34 years before the survey, as exhibited by cohort 45–49, to 0.090 over 15 years, as exhibited by the cohort 30–34 in the period 15–19 years before the survey. In other words, there is a 73 per cent increase in 15 years. For age group 20–24 it also increases from 0.175 in the period 25–29 years before the survey to 0.245 fifteen years later to decline again to 0.197 at the time of the survey. These values are shown in figure 8 where a general fall in the rates can be seen. In the absence of any evidence for a fall in fertility, this pattern should be interpreted with caution. Older women probably misstated the dates of their births by transferring events which occurred at earlier periods to later periods. This kind of error, known as the Potter effect, was found to exist in many surveys conducted under the WFS programme (Chidambaram *et al* 1980). This might have accounted for the low rates at earlier periods, especially for older cohorts, and therefore leads to a rise in subsequent periods and an apparent decline in recent periods before the survey. At this point, it should be mentioned that the effect of other errors has not been disentangled. Among older women, age misstatement and omission of births are also very common. This could also have contributed to producing such inconsistencies. For example, the ages of women of 40–49 with high fertility could have been deliberately overstated by interviewers beyond the maximum age of eligibility for the interview. Or again, women in the same age range with relatively lower fertility may have been shifted to younger ages. This, in fact, would also help to explain the implausibly high P/F ratio depicted by cohort 30–34 (panel D).

In order to examine the trends indicated in panel A, cumulations were done horizontally in panel B to show the behaviour of the 'real cohorts' and vertically in C in order to reveal the fluctuations, if any, in the fertility of the 'synthetic cohorts'. Through this exercise, errors are slightly reduced, although some irregularities remain. In panel B cumulative fertility to certain ages (diagonal figures) still shows a rise and fall across the cohorts. For example at age 20–24, the mean number of children ever born increases from 1.1 for the cohort aged 45–49 to almost 1.7 for the cohort aged 30–34 and drops again to 1.4 during the most recent period before the survey. Panel A, of course, shows similar patterns. For different cohorts, as expected, the mean number of children ever born increases over time, even though for some periods the increase is not very substantial. For example, for the two oldest cohorts the increase is only about 11 and 7 per cent for age groups 40–44 and 45–49 respectively in the most recent period over the values in the next most recent.

Panel C shows that reported fertility has declined sharply in the period immediately prior to the survey. Cumulated period fertility up to age 40–44 falls by more than one from 6.9 to 5.6. This is true to about the same extent at all ages. At very early ages, however, the apparent decline is greater and this may reflect a real trend caused by the rising age at marriage. Misplacement

**Table 25** Age-specific fertility rates and total fertility rates by calendar year, 1949–77

| Year | Age-specific fertility rate | | | | | | | Total fertility rate[a] |
|---|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 | |
| 1949 | 126.5 | | | | | | | |
| 1950 | 139.6 | | | | | | | |
| 1951 | 138.3 | | | | | | | |
| 1952 | 154.9 | | | | | | | |
| 1953 | 168.3 | 212.6 | | | | | | |
| 1954 | 163.5 | 215.8 | | | | | | |
| 1955 | 164.0 | 198.9 | | | | | | |
| 1956 | 157.9 | 213.4 | | | | | | |
| 1957 | 174.2 | 237.5 | | | | | | |
| 1958 | 164.2 | 249.7 | 285.1 | | | | | |
| 1959 | 166.4 | 267.2 | 263.3 | | | | | |
| 1960 | 173.1 | 267.7 | 283.8 | | | | | |
| 1961 | 197.5 | 278.8 | 266.6 | | | | | |
| 1962 | 209.2 | 291.6 | 281.9 | | | | | |
| 1963 | 206.9 | 284.3 | 297.6 | 218.3 | | | | 6.7 |
| 1964 | 194.3 | 306.4 | 308.7 | 262.2 | | | | 7.1 |
| 1965 | 200.1 | 303.6 | 312.4 | 288.2 | | | | 7.2 |
| 1966 | 196.6 | 314.6 | 307.4 | 294.9 | | | | 7.3 |
| 1967 | 202.2 | 302.2 | 306.4 | 287.0 | 185.0 | | | 7.2 |
| 1968 | 168.9 | 305.0 | 303.1 | 269.1 | 233.9 | | | 7.2 |
| 1969 | 178.0 | 318.0 | 316.1 | 266.2 | 215.4 | | | 7.2 |
| 1970 | 182.0 | 325.0 | 329.9 | 262.4 | 225.6 | | | 7.4 |
| 1971 | 202.3 | 337.2 | 335.9 | 272.4 | 204.5 | | | 7.5 |
| 1972 | 186.9 | 318.6 | 328.4 | 276.6 | 176.9 | | | 7.2 |
| 1973 | 163.6 | 302.6 | 316.4 | 280.4 | 176.6 | 121.5 | | 7.0 |
| 1974 | 151.5 | 282.3 | 309.7 | 267.7 | 158.1 | 103.1 | | 6.6 |
| 1975 | 137.7 | 269.1 | 288.3 | 259.9 | 154.2 | 119.0 | | 6.3 |
| 1976 | 117.1 | 255.7 | 266.0 | 241.8 | 136.1 | 92.7 | | 5.7 |
| 1977 | 101.7 | 237.2 | 242.1 | 232.8 | 133.7 | 102.4 | 39.1 | 5.4 |

[a]For the years with incomplete information, the TFR has been obtained by completing the missing information with estimated rates, assuming that the fertility of the last calendar year for which information is available has remained constant back in time

of births in time is likely to be the cause of the reported decline at older ages.

The P/F ratios (panel D) can also be used to assess omission and displacement errors. If the P/F ratios are more than unity and are increasing steadily with age, then we can confidently conclude that there has been a decline in fertility. This is because the older cohorts would have experienced more of their childbearing during earlier times of higher fertility. During the last period prior to the survey, the ratios, though high, are inconsistent and so it is very difficult to identify a specific trend. The low ratios exhibited by women aged 45–49 in the two periods prior to the survey indicate either omission or misplacement of births by those women. It is also possible that older women might have experienced longer periods of subfecundity at young ages, before giving birth to their first children. The survey data indicate that the mean interval between the date of first union and date of first birth was 52 months for women aged 45–49 whereas it was only 20 for women aged 15–19.

**Cohort–period rates by place of residence**

Having identified some of the errors in the cohort–period rates, we now proceed to see which group of the population has contributed most to these irregularities. Tables 27 and 28 show cohort–period fertility rates cumulated by cohort and period as well as the P/F ratios for urban and rural women respectively.

From the two tables, it can be seen that the cumulated cohort rates for rural women, with the exception of the oldest cohort, are consistently higher than the rates for urban women. The overall values indicate a recent decline in fertility in rural areas. This is not true of urban women, where the decline for different age groups took place at different periods. For example, for age groups 25–29 and 30–34, the decline started in the most recent period, whereas for age groups 15–19, 20–24 and 35–39 it started in the period 5–9 years before the survey.

Comparing the $P_i$ values in the two tables during the most recent period, we see that rural women show an inconsistent pattern, with a decrease in parity from age

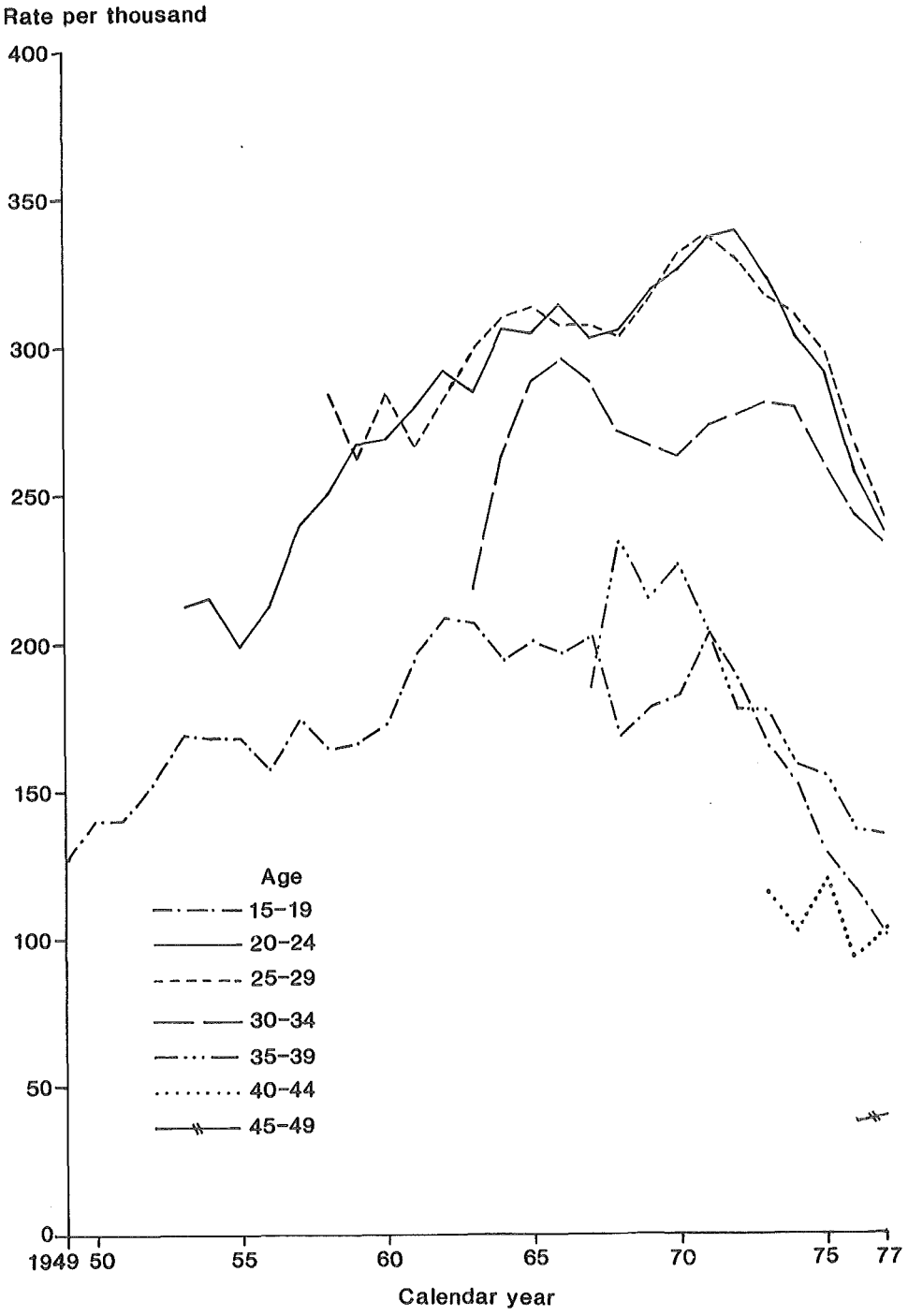


**Figure 7** Age-specific fertility rates for calendar years, by age group

40–44 to 45–49. On the other hand, urban women show a fairly consistent pattern in the number of children ever born, the number increasing with age. The omission of births and displacement of events observed in the preceding sections is more pronounced among rural women. This is also evidenced by the low P/F ratios shown by the two oldest rural cohorts, which suggest more omission or displacement of births in earlier periods. Again, the omission of 45–49 year old high-parity women, because their ages were overstated, produces an artificially low value of P, and of the P/F ratio for that age group.

**Rates by duration of marriage and of motherhood**

Changes in fertility may be the result of an increase in the average age at marriage, or else a decline in marital fertility, or both. In order to try to disentangle the relative effects of these two factors on overall fertility, tables 29 and 30 have been constructed. They show fertility according to duration of marriage and duration of motherhood respectively. From table 30, it can be seen that the P/F ratios for the period immediately before the survey are around one, in sharp contrast to

**Table 26** Cohort–period fertility rates, cumulative cohort and period fertility and P/F ratios by age at survey (total population)

| Age group | Estimated number of women | Years before the survey | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 | 25–29 | 30–34 |
| A Cohort–period fertility rates (per thousand women) | | | | | | | | |
| 15–19 | 1052 | 0.030 | | | | | | |
| 20–24 | 807 | 0.197 | 0.078 | | | | | |
| 25–29 | 802 | 0.284 | 0.239 | 0.081 | | | | |
| 30–34 | 524 | 0.276 | 0.340 | 0.245 | 0.090 | | | |
| 35–39 | 601 | 0.225 | 0.320 | 0.305 | 0.221 | 0.081 | | |
| 40–44 | 307 | 0.117 | 0.224 | 0.302 | 0.282 | 0.195 | 0.069 | |
| 45–49 | 261 | 0.081 | 0.170 | 0.239 | 0.264 | 0.222 | 0.175 | 0.052 |
| B Cumulative fertility of real cohorts ($P_i$) | | | | | | | | |
| 15–19 | | 0.154 | | | | | | |
| 20–24 | | 1.400 | 0.413 | | | | | |
| 25–29 | | 3.043 | 1.624 | 0.430 | | | | |
| 30–34 | | 4.766 | 3.396 | 1.698 | 0.473 | | | |
| 35–39 | | 5.795 | 4.671 | 3.070 | 1.545 | 0.439 | | |
| 40–44 | | 5.947 | 5.364 | 4.244 | 2.733 | 1.323 | 0.347 | |
| 45–49 | | 6.023 | 5.619 | 4.770 | 3.574 | 2.254 | 1.145 | 0.270 |
| C Cumulative fertility of synthetic cohorts ($F_i$) | | | | | | | | |
| 15–19 | | 0.154 | | | | | | |
| 20–24 | | 1.141 | 0.391 | | | | | |
| 25–29 | | 2.561 | 1.585 | 0.430 | | | | |
| 30–34 | | 3.941 | 3.283 | 1.655 | 0.474 | | | |
| 35–39 | | 5.066 | 4.883 | 3.181 | 1.580 | 0.430 | | |
| 40–44 | | 5.649 | 6.004 | 4.692 | 2.990 | 1.406 | 0.378 | |
| 45–49 | | 6.052 | 6.852 | 5.888 | 4.310 | 2.515 | 1.253 | 0.260 |
| D P/F ratios | | | | | | | | |
| 20–24 | | 1.227 | | | | | | |
| 25–29 | | 1.188 | 1.025 | | | | | |
| 30–34 | | 1.212 | 1.035 | 1.026 | | | | |
| 35–39 | | 1.144 | 0.956 | 0.965 | 0.978 | | | |
| 40–44 | | 1.053 | 0.893 | 0.904 | 0.914 | 0.941 | | |
| 45–49 | | 0.995 | 0.820 | 0.810 | 0.829 | 0.896 | 0.914 | |

the values in table 27, based on ASFRs, which are substantially greater than one. This suggests that marital fertility has not changed significantly over the previous 20–24 years, while the age of marriage has recently increased. The hypothesis of later marriage is supported by the fact that the fertility rates for women in the first five years of marriage have increased over the last couple of periods. This would happen because these women are older and therefore early subfecundity is less common among them.

In addition, it can be seen that the P/F ratios are low for the period 5–9 years before the survey, suggesting that births may have been bunched into that period in the reporting.

Table 30 shows a similar pattern to that of table 29, which is not surprising, as marriage and the start of motherhood occur close together.

## 4.6 CONCLUSION

In this chapter a detailed evaluation of the fertility data collected during the SUDFS was carried out. Birth history data were used to examine recent trends in fertility.

Inspecting the distribution of mothers according to age at birth of children, we detect an unusual pattern of heaping. This is characterized by systematic heaping at two-year intervals. This irregularity is attributed to the way in which interviewers sometimes estimated the age of the child, ie simply by adding two years to the date of birth of the previous birth. Comparing the mean parity in the two surveys, it is evident that the values are very close to each other, thus indicating a similar age pattern of fertility. This was to be expected, since the two schedules were completed in a single visit to the house-

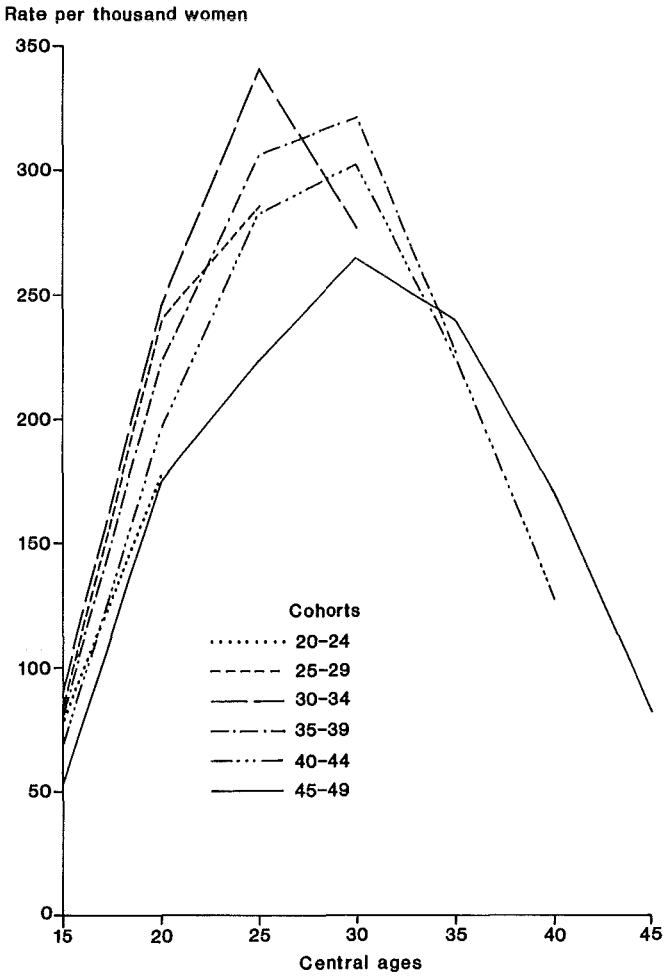


**Figure 8** Cohort fertility rates shown according to central ages for five-year cohorts

**Table 27** Cohort–period fertility rates, cumulative cohort and period fertility and P/F ratios by age at survey (urban women)

| Age group | Estimated numbers of births | Years before the survey | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 | 25–29 | 30–34 |
| A Cohort–period fertility rates (per thousand women) | | | | | | | | |
| 15–19 | 369 | 0.024 | | | | | | |
| 20–24 | 258 | 0.161 | 0.066 | | | | | |
| 25–29 | 243 | 0.252 | 0.216 | 0.093 | | | | |
| 30–34 | 152 | 0.247 | 0.330 | 0.260 | 0.090 | | | |
| 35–39 | 158 | 0.193 | 0.297 | 0.304 | 0.251 | 0.084 | | |
| 40–44 | 82 | 0.114 | 0.192 | 0.289 | 0.318 | 0.204 | 0.063 | |
| 45–49 | 80 | 0.041 | 0.109 | 0.244 | 0.299 | 0.206 | 0.222 | 0.067 |
| B Cumulative fertility of real cohorts ($P_i$) | | | | | | | | |
| 15–19 | | 0.129 | | | | | | |
| 20–24 | | 1.168 | 0.362 | | | | | |
| 25–29 | | 2.829 | 1.571 | 0.491 | | | | |
| 30–34 | | 4.649 | 3.416 | 1.766 | 0.467 | | | |
| 35–39 | | 5.663 | 4.699 | 3.213 | 1.691 | 0.438 | | |
| 40–44 | | 5.912 | 5.340 | 4.382 | 2.937 | 1.345 | 0.325 | |
| 45–49 | | 6.264 | 6.058 | 5.512 | 4.292 | 2.796 | 1.465 | 0.356 |

**Table 27** (*Continued*)

| Age group | Estimated numbers of births | Years before the survey | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 | 25–29 | 30–34 |
| C Cumulative fertility of synthetic cohorts ($F_i$) | | | | | | | | |
| 15–19 | | 0.129 | | | | | | |
| 20–24 | | 0.935 | 0.335 | | | | | |
| 25–29 | | 2.192 | 1.415 | 0.499 | | | | |
| 30–34 | | 3.426 | 3.065 | 1.799 | 0.476 | | | |
| 35–39 | | 4.390 | 4.551 | 3.321 | 1.729 | 0.434 | | |
| 40–44 | | 4.961 | 5.509 | 4.766 | 3.321 | 1.454 | 0.337 | |
| 45–49 | | 5.167 | 6.055 | 5.986 | 4.818 | 2.785 | 1.446 | 0.340 |
| D P/F ratios | | | | | | | | |
| 20–24 | | 1.249 | | | | | | |
| 25–29 | | 1.290 | 1.110 | | | | | |
| 30–34 | | 1.357 | 1.115 | 0.982 | | | | |
| 35–39 | | 1.290 | 1.033 | 0.968 | 0.978 | | | |
| 40–44 | | 1.192 | 0.969 | 0.919 | 0.884 | 0.924 | | |
| 45–49 | | 1.212 | 1.000 | 0.921 | 0.891 | 1.004 | 1.013 | |

**Table 28** Cohort–period fertility rates, cumulative cohort and period fertility and P/F ratios by age at survey (rural women)

| Age group | Estimated number of births | Years before the survey | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 | 25–29 | 30–34 |
| A Cohort–period fertility rates (per thousand women) | | | | | | | | |
| 15–19 | 695 | 0.033 | | | | | | |
| 20–24 | 549 | 0.214 | 0.083 | | | | | |
| 25–29 | 561 | 0.297 | 0.248 | 0.076 | | | | |
| 30–34 | 371 | 0.288 | 0.343 | 0.239 | 0.090 | | | |
| 35–39 | 442 | 0.237 | 0.329 | 0.306 | 0.211 | 0.080 | | |
| 40–44 | 225 | 0.117 | 0.236 | 0.307 | 0.268 | 0.192 | 0.071 | |
| 45–49 | 181 | 0.098 | 0.197 | 0.237 | 0.249 | 0.202 | 0.154 | 0.045 |
| B Cumulative fertility of real cohorts ($P_i$) | | | | | | | | |
| 15–19 | | 0.165 | | | | | | |
| 20–24 | | 1.509 | 0.437 | | | | | |
| 25–29 | | 3.125 | 1.641 | 0.403 | | | | |
| 30–34 | | 4.825 | 3.386 | 1.669 | 0.475 | | | |
| 35–39 | | 5.847 | 4.664 | 3.021 | 1.493 | 0.439 | | |
| 40–44 | | 5.952 | 5.366 | 4.188 | 2.655 | 1.313 | 0.355 | |
| 45–49 | | 5.919 | 5.427 | 4.444 | 3.258 | 2.015 | 1.004 | 0.232 |
| C Cumulative fertility of synthetic cohorts ($F_i$) | | | | | | | | |
| 15–19 | | 0.165 | | | | | | |
| 20–24 | | 1.237 | 0.418 | | | | | |
| 25–29 | | 2.721 | 1.656 | 0.399 | | | | |
| 30–34 | | 4.162 | 3.373 | 1.592 | 0.473 | | | |
| 35–39 | | 5.345 | 5.015 | 3.120 | 1.527 | 0.429 | | |
| 40–44 | | 5.931 | 6.193 | 4.653 | 2.868 | 1.388 | 0.392 | |
| 45–49 | | 6.422 | 7.176 | 5.840 | 4.111 | 2.399 | 1.165 | 0.225 |
| D P/F ratios | | | | | | | | |
| 20–24 | | 1.220 | | | | | | |
| 25–29 | | 1.148 | 0.991 | | | | | |
| 30–34 | | 1.160 | 1.004 | 1.048 | | | | |
| 35–39 | | 1.094 | 0.930 | 0.968 | 0.978 | | | |
| 40–44 | | 1.004 | 0.866 | 0.900 | 0.926 | 0.946 | | |
| 45–49 | | 0.922 | 0.756 | 0.761 | 0.792 | 0.840 | 0.862 | |

**Table 29** Cohort–period fertility rates and P/F ratios by duration of marriage

| Marriage cohort | Number of women | Years before the survey | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 | 25–29 | 30–34 |
| A Cohort–period fertility rates (per thousand women) | | | | | | | | |
| 0–4 | 483 | 0.33 | | | | | | |
| 5–9 | 609 | 0.35 | 0.34 | | | | | |
| 10–14 | 615 | 0.32 | 0.37 | 0.30 | | | | |
| 15–19 | 545 | 0.27 | 0.36 | 0.34 | 0.29 | | | |
| 20–24 | 407 | 0.20 | 0.31 | 0.34 | 0.32 | 0.26 | | |
| 25–29 | 294 | 0.10 | 0.21 | 0.30 | 0.29 | 0.27 | 0.22 | |
| 30–34 | 131 | 0.06 | 0.13 | 0.21 | 0.26 | 0.24 | 0.25 | 0.20 |
| B P/F ratios | | | | | | | | |
| 5–9 | | 1.03 | | | | | | |
| 10–14 | | 1.00 | 0.93 | | | | | |
| 15–19 | | 1.01 | 0.93 | 1.01 | | | | |
| 20–24 | | 1.00 | 0.90 | 0.95 | 0.94 | | | |

**Table 30** Cohort–period fertility rates and P/F ratios by duration of motherhood

| Motherhood cohort | Number of women | Years before the survey | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 | 25–29 | 30–34 |
| A Cohort–period fertility rates (per thousand women) | | | | | | | | |
| 0–4 | 523 | 0.27 | | | | | | |
| 5–9 | 660 | 0.35 | 0.30 | | | | | |
| 10–14 | 568 | 0.30 | 0.38 | 0.29 | | | | |
| 15–19 | 484 | 0.24 | 0.35 | 0.37 | 0.29 | | | |
| 20–24 | 302 | 0.15 | 0.27 | 0.35 | 0.37 | 0.29 | | |
| 25–29 | 173 | 0.07 | 0.19 | 0.27 | 0.29 | 0.32 | 0.28 | |
| 30–34 | 51 | 0.02 | 0.10 | 0.24 | 0.29 | 0.27 | 0.34 | 0.20 |
| B P/F | | | | | | | | |
| 5–9 | | 1.03 | | | | | | |
| 10–14 | | 1.05 | 0.97 | | | | | |
| 15–19 | | 1.06 | 0.96 | 0.99 | | | | |
| 20–24 | | 1.07 | 0.96 | 0.98 | 0.99 | | | |

hold. As anticipated, the mean values increase with age, though at older ages the increase in the values is either negligible or non-existent. Comparing the number of children reported by the respondents in the household schedule and in individual questionnaire, we see that about 96 per cent reported the same number of children in the two surveys. Examining the proportions who are mothers according to the birth cohorts, we note some irregularities. The birth cohorts 30–34 and 40–44 show a pattern of early fertility compared to older cohorts, suggesting upward shifting of mothers from the age group 30–34 to 35–39, and selective overstatement of age among 45–49 year old women.

Analysis of the smoothed ASFRs by calendar year suggests a decline in the rates, though some minor discrepancies are present. This is also apparent when the cohort–period rates are examined. In the absence of any evidence for recent changes in fertility, the observed decline is doubtful. It seems that the type of place of residence of the respondent affects the quality of these data. The analysis of the cohort–period rates reveals better and more consistent rates for urban women than their counterparts in rural areas.

In conclusion, we can say that the evaluation of the fertility data revealed no strong evidence of omission of children. The problem seems to arise mainly, though only to a small extent, from misstatement of the dates of vital events, especially by older women. This could be due to the shifting of their own age or to the misdating of the births of their children, or both.

# 5 Infant and Child Mortality

During the SUDFS, detailed information pertaining to mortality was collected in the two surveys. The household schedule included questions which probed the number of children ever born and those surviving among them. These questions were asked about all ever-married females in the household. These are the traditional questions used to collect information needed for the application of indirect techniques to estimate childhood mortality. For the most recent birth, the survival status of the child was also obtained. For each woman the number of children was obtained according to sex. Questions were also included to obtain the data needed for the estimation of adult mortality. These included the survival status of the parents of each respondent and whether he/she (the respondent) was the eldest surviving son/daughter of his/her mother or father. For those with previous marriages, the survival status of the former spouse was also obtained. A question on deaths during the last 24 months in the household was also asked. The returns on this question were very few, and these data were therefore discarded in the analysis. In addition to direct questions on the number of children ever born to each woman and those deceased, the individual questionnaire contained the maternity history which collected data on the particulars of each birth as well as age at death (if applicable).

In the present analysis, we are mainly concerned with the data on infant and early child deaths derived from the maternity history. Nevertheless, for the purpose of comparison, data from the household survey and the population census are used.

## 5.1 SOURCES AND EFFECTS OF ERRORS

Mortality measures based on this type of data are subject to many biases and errors, especially when the data have been collected in areas with high levels of illiteracy and ignorance of exact dates, as in the Sudan. Before checking the quality of data, a word should be said about the errors most likely to affect reporting. Most important among these is omission of vital events. We noted in the last chapter that among the children most likely to be omitted are dead children, especially those who died a long time ago. There is also the problem of defining a stillbirth. A child who died shortly after birth might be treated as a stillbirth and therefore completely ignored. Transference of dates of vital events is another problem. Misplacement of such events not only alters period trends and patterns but may also distort the level of some measures. Apart from this, there is the truncation and censoring bias inherent in the WFS surveys. The truncation bias arises from the fact that the maximum age of women eligible for the individual interview was 50 years. Because of this, rates for earlier periods are truncated at progressively younger ages and hence estimates for the oldest ages are available only from the most recent periods. This censoring effect distorts the overall rates. In the case of infant children, for example, a child who is below one year at the time of the survey might die shortly afterwards.

Having mentioned some of the errors that may affect the data, we now move on to the analysis.

## 5.2 AGE AT DEATH

As mentioned above, for each deceased child the woman was asked to provide information on how long he/she actually survived. This information, in completed years and months, was converted into months. Out of 1990 cases, in only one case the number of years was not given, and in another 40 cases the number of months was not given. Looking at the distribution of children by years since birth according to survival status, we observe some irregularities. This is clearly seen in figure 9. Though the two curves depict implausible patterns, heaping is more pronounced in the case of dead children. The exceptionally low proportion of deaths at the time of the survey is due to the censoring bias mentioned above.

Misreporting of age at death is particularly serious in distorting some mortality measures. This is more so in the case of infant and neo-natal rates. Age transference of young deaths can result in an underestimation or overestimation of the two rates, depending on whether these deaths are transferred beyond or within their specified range. With this in mind, we shall try to see whether this kind of error is present. Figure 10 shows the percentage distribution of children who died within the first three years of life, by age at death.

Substantial heaping is observed at 12, 18, 24 and 36 months. The heaping at age zero is exceptionally high, due to the high risk of death during the first days and weeks of a child's life. All these ages are divisible by 6 (half a year). Respondents might have tended to report completed years and fractions of years, which were converted into months. The age of 12 months has apparently gained from the adjacent ages. If many deaths were transferred from the younger ages, this would decrease the infant mortality rate which is computed using deaths below 12 months of age. The slight heaping on 7 could be explained by the fact that people usually assign that age to children when they start to crawl. Therefore a child who dies after reaching that stage is most likely to be reported as 7 months.

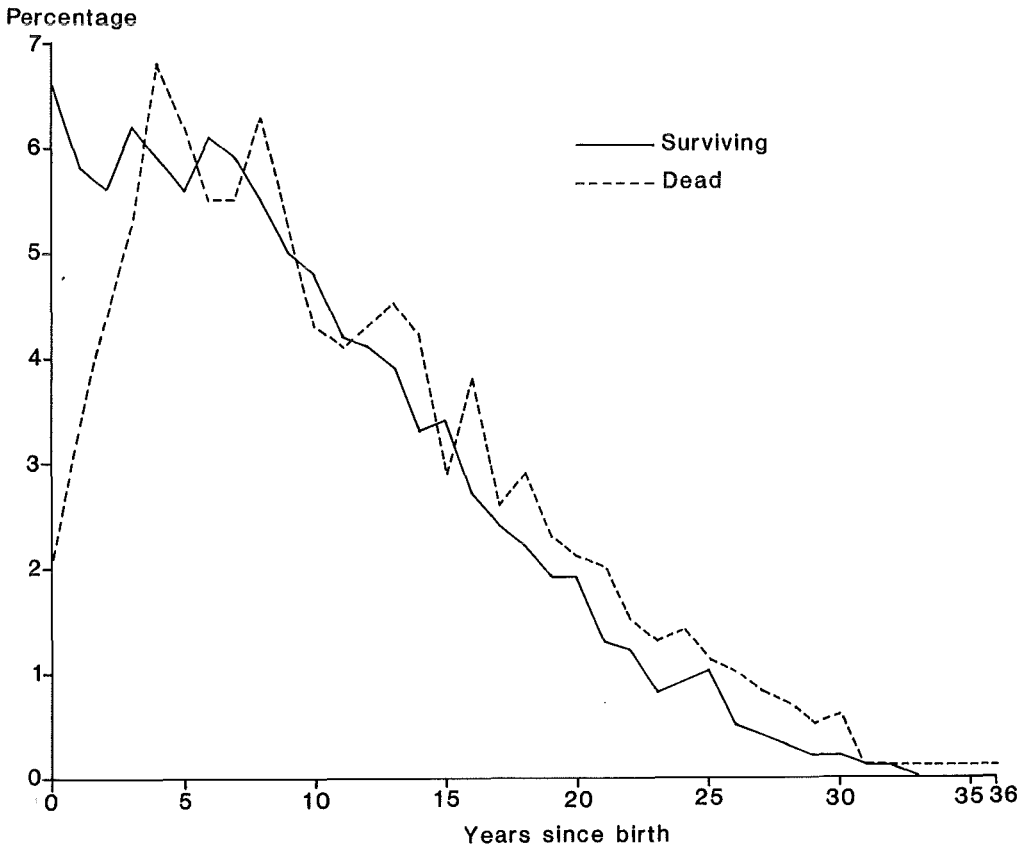


**Figure 9** Percentage distribution of children by years since birth according to survival status of child

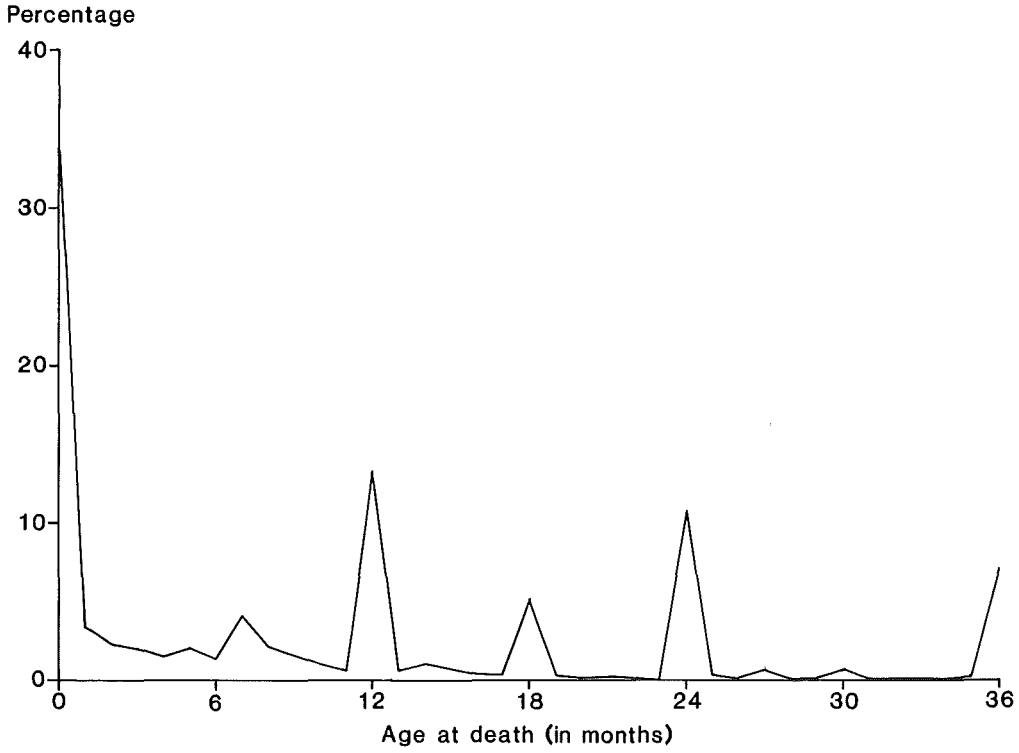


**Figure 10** Percentage distribution of children who died within three years of birth, by age at death (in months)

## 5.3 OMISSION OF DEAD CHILDREN

A simple way of checking on the omission of deaths is to consider the proportion of dead children by age group of the mother. In the absence of reporting errors, the proportions dead are expected to rise with the age of the mother. This is because children born to older women are on average older at the time of the survey and have been exposed to the risk of dying far longer. Table 31 shows the proportions of dead children by age group of mother, as obtained from the two surveys.

In both surveys the proportions of dead children are slightly lower for the age group 25–29, which is explained by the age transference of women into those ages. (It was pointed out earlier that the number of women in the 25–29 age group was far too high compared with the 20–24 age group.) Younger women with younger children were probably transferred into that age group. The proportions are very close to each other for women aged 15–39 in both surveys, which suggests omission of deaths by the relatively older women. Older women aged 45–49 in the household show lower values than women aged 40–44 which is due either to omission or to understatement of their own ages.

### Period trends in mortality

One way to detect omission is to consider time trends in mortality. In this section, an attempt is made to inspect the different rates as shown at different periods of time. At this point, it should be mentioned that the incidence of death varies tremendously with age in infancy and early childhood. Demographers usually differentiate between mortality rates at different ages. The neo-natal rate – mortality in the first four weeks – is believed to be very high, arising from premature labour, birth defects in the child, and so on. The post-neonatal rate measures mortality between one month and one year of age. At this age, the rate is also very high, but slightly lower than the neo-natal rate. The combined neo-natal and post-neonatal rate is the infant mortality rate ($_1q_0$), which indicates the probability of dying before completing one year of life. The rate is considered to be a sensitive index of socio-economic development and improvement in health conditions in the country. There is also the probability of death between ages one and five years ($_4q_1$). The overall early childhood rate ($_5q_0$) summarizes the mortality experience of children below age five.

The data available from the maternity histories permit the computation of all these rates. To test for omission or misdating of events, the different rates at successive time periods before the survey are examined. These are shown in table 32 where panels A and B show the rates separately for males and females respectively and panel C represents the rates for the two sexes together. As can be seen from panels A and B, fewer cases are observed in the earlier periods. Because of this, the results in the earliest two periods for the two sexes separately should be interpreted with care, as they may be subject to sampling errors. Trends from early periods can be examined in panel C. With an improvement in health conditions, the various mortality rates are expected to decline over time. Comparing the values in the most recent period with those 20–24 years ago, we see that the infant mortality rate indicates either constancy or a gradual rise. It increases from 0.068 in the period 20–24 years before the survey to 0.079 in the most recent period, representing a 17 per cent increase. Neo-natal mortality increased slightly over ten years in the sixties and then dropped in the most recent period to almost the same level as in the period 20–24 years before the survey. The $_4q_1$ values suggest a slight decrease during the last 20 years or so and then an increase in the most recent period. These deviations from the expected declining trend of mortality can only be explained by errors in the data. Misplacement and omission of vital events can result in this kind of pattern. On the other hand, the $_5q_0$ values indicate a declining pattern, reaching a minimum of 0.136 in the period 5–9 years before the survey. The slight increase attained in the most recent period is possibly due to some events being shifted forwards.

Trends over time for males and females are shown in panels A and B. The different rates are also presented in figure 11. Due to the small numbers of cases in the early periods, we consider the values for the last 20 years only. Considering the two curves depicting the neo-natal and post-neonatal values for males, we see that they show conflicting patterns. The neo-natal values fall in the periods 15–19 and 5–9 years before the survey, with a substantial increase in the periods in between, while post-neonatal values increase in these two periods and decrease in the period 10–14 years before the survey. No real pattern is discernible. The inconsistency is probably due to misstatement of the child's age at death. The age of children who died in infancy might have been understated in the period 10–14 years before the survey, resulting in an increase in neo-natal values and a decrease in post-neonatal rates. The $_1q_0$ values are consistently higher for males than for females. For example, in the period 5–9 years before the survey, 92 out of 1000 male births died before completing their first year of life. The corresponding value was only 65 among females. In most societies, females enjoy more favourable mortality conditions than

**Table 31** Proportions of children dead by age group of mothers, individual and household surveys

| Source of data | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 |
| Individual | 0.15 | 0.16 | 0.12 | 0.14 | 0.15 | 0.17 | 0.19 |
| Household | 0.15 | 0.14 | 0.13 | 0.15 | 0.15 | 0.18 | 0.17 |

**Table 32** Probabilities of infant and child death by period and sex of child

| Measure | Years before the survey | | | | | |
|---|---|---|---|---|---|---|
| | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 | 25–29 |
| A Males | | | | | | |
| Neo-natal | 0.044 | 0.051 | 0.060 | 0.037 | (0.047) | (0.038) |
| Post-neonatal | 0.040 | 0.041 | 0.031 | 0.034 | (0.020) | (0.027) |
| $_1q_0$ | 0.084 | 0.092 | 0.091 | 0.071 | (0.067) | (0.065) |
| $_4q_1$ | 0.070 | 0.064 | 0.078 | (0.084) | (0.119) | (0.063) |
| $_5q_0$ | 0.148 | 0.150 | 0.162 | (0.149) | (0.178) | (0.124) |
| B Females | | | | | | |
| Neo-natal | 0.040 | 0.037 | 0.035 | 0.035 | (0.034) | (0.042) |
| Post-neonatal | 0.035 | 0.028 | 0.030 | 0.025 | (0.034) | (0.071) |
| $_1q_0$ | 0.075 | 0.065 | 0.065 | 0.060 | (0.069) | (0.112) |
| $_4q_1$ | 0.078 | 0.062 | 0.061 | (0.090) | (0.108) | (0.055) |
| $_5q_0$ | 0.146 | 0.123 | 0.122 | (0.143) | (0.169) | (0.161) |
| C Both sexes | | | | | | |
| Neonatal | 0.042 | 0.044 | 0.048 | 0.036 | 0.041 | (0.040) |
| Post-neonatal | 0.037 | 0.035 | 0.030 | 0.029 | 0.027 | (0.046) |
| $_1q_0$ | 0.079 | 0.078 | 0.079 | 0.065 | 0.068 | (0.085) |
| $_4q_1$ | 0.074 | 0.063 | 0.070 | 0.087 | (0.114) | (0.060) |
| $_5q_0$ | 0.147 | 0.136 | 0.143 | 0.147 | 0.174 | (0.140) |

NOTE: Figures in parenthesis are based on less than 500 cases.
*Source:* Rutstein 1983

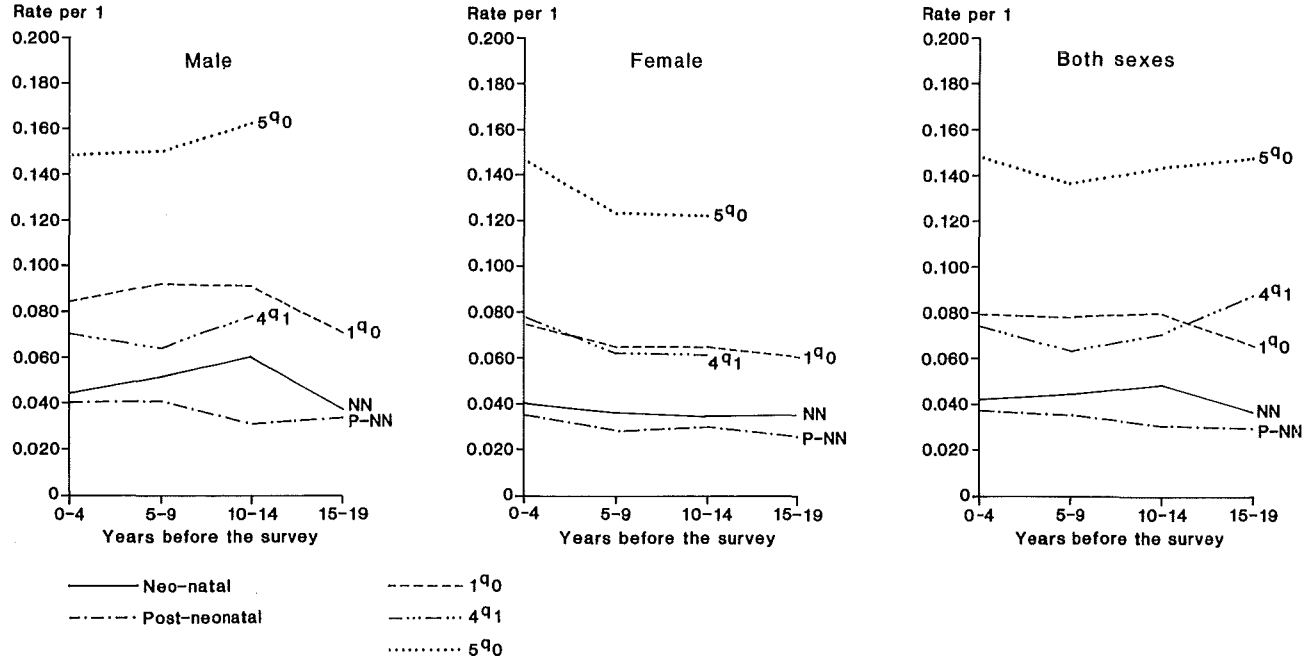


**Figure 11** Probabilities of infant and child mortality by period and sex of child

males. In the Sudan, where preference for a male child is prevalent, a deviation from this sex pattern of mortality was expected. Consequently, the gap between the two values should probably not be so wide. If the rates are fairly accurate for males, the low values shown for females can only be explained by omission of female deaths.

It is evident that neo-natal and post-neonatal rates can be affected not only by omission and displacement of vital events but also by the respondents' perception of a live birth. Children who die shortly after birth might not be considered to have lived, and will therefore be omitted. This would result in neo-natal deaths being underestimated. Because of these difficulties, mortality measures

**Table 33** Probabilities of dying by age one ($_1q_0$) and by age five ($_5q_0$), by period and age at birth

| Age at birth | Measure | Years before the survey | | | | |
|---|---|---|---|---|---|---|
| | | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 |
| <20 | $_1q_0$ | 0.115 | 0.109 | 0.091 | 0.091 | (0.082) |
| | $_5q_0$ | 0.193 | 0.177 | 0.150 | (0.163) | (0.200) |
| 20–29 | $_1q_0$ | 0.061 | 0.072 | 0.071 | 0.049 | 0.051 |
| | $_5q_0$ | 0.129 | 0.123 | 0.140 | (0.142) | (0.140) |
| 30–39 | $_1q_0$ | 0.084 | 0.062 | (0.081) | (0.050) | |
| | $_5q_0$ | 0.155 | (0.124) | (0.133) | (0.084) | |
| 40–49 | $_1q_0$ | (0.086) | (0.047) | | | |
| | $_5q_0$ | (0.175) | (0.317) | | | |

NOTE: Figures in parenthesis are based on small numbers of cases.
*Source:* Rutstein 1983

for deaths in the early days or weeks of life are not very reliable. Perhaps the overall measures of infant and early childhood mortality, ie $_1q_0$ and $_5q_0$, are more reliable, since they express or summarize mortality over longer durations. For this reason, we examine the trends by means of these two measures.

Table 33 shows the $_1q_0$ and $_5q_0$ values at five-year periods before the survey by age of mother at birth. To minimize the errors in the data, mothers were classified by larger age groups. As can be seen from the table, the values exhibited by the older cohorts are based on small numbers of cases only. It should also be recalled that these rates are affected by truncation bias. For women aged under 20 at birth, the $_1q_0$ values increase over time. In the period 20–24 years before the survey, 82 out of a thousand children born to women below age 20 died before reaching their first birthday. The value increases to 115 in the most recent period. For the same women the $_5q_0$ values indicate a rise in mortality over time. The increase is very sharp in the two most recent periods. This suggests that some vital events have been transferred from earlier periods into the later ones. The values shown by women aged 20–29 are consistently lower than those shown by women under 20 at the birth of their children.

Although the reasons for this are not clear, it is probably a result of the omission of dead children or age misstatement.

## 5.4 CONCLUSION

Examination of the distribution of children by years since birth according to survival status shows that heaping is more pronounced among children who have died than among children surviving. Again, heaping is marked in the reporting of deaths of children who died within three years of the survey. Rounding of ages results in heaping on months which are multiples of six.

The exercise of refining the analysis of trends in infant mortality by studying both neo-natal and post-neonatal mortality produces misleading results. The individual trends appear implausible, and lead us to the conclusion that $_1q_0$ and $_5q_0$ values are more likely to yield valid results. However, even here difficulties arise. Childhood mortality has declined very slightly over the past 20 years, followed by an increase in the most recent period. This rise in mortality risks could probably be explained by the displacement of child deaths into the most recent period from the period 5–9 years before the survey. Whether this is true or not, a similar trend is apparent when deaths are disaggregated into deaths to mothers of various ages. Overall, no real trend in mortality emerges.

# 6 Summary and Conclusions

The detailed analysis of age reporting, nuptiality and infant and child mortality reveals some errors. Most important are those in the age data. The errors detected in age reporting are heaping and age transference. These errors affect the quality of the demographic data. In evaluating the nuptiality data, we note that the proportions ever married do not increase smoothly with age, and this is attributed to age misstatement. Age misstatement is also detected when mean parity is examined in the fertility data. Older women with fewer children might have had their ages understated by the interviewer. This leads to an inflation of the proportions in the younger age groups and decreases numbers in the original groups. This problem is illustrated in chapter 4, where an early pattern of fertility is suggested by the birth cohort aged 30–34.

Just as respondents are often ignorant of their exact ages, so too are they unaware of the exact dates of their vital events. As chapters 3, 4 and 5 show, the data collected in the marriage and birth histories are subject to errors arising from the misdating of events. This is suggested by an apparent decline in the levels of fertility and mortality, probably a result of the systematic misplacement of births and deaths in time.

Misdating of vital events significantly affects both period trends and levels of fertility and mortality. In evaluating the age data, for example, we see that the infant mortality rate is underestimated, considering the conditions of high mortality prevailing in the country. The rounding of ages at death is used to explain this; children who die at ages 9, 10 and 11 months are often reported as dying at one year old, outside infancy.

In spite of these inaccuracies, the data seem to be better, especially with respect to age, than those previously obtained from the 1973 census. This might lead us to conclude that the quality of the data is relatively good, and with suitable demographic and statistical techniques can provide reasonable estimates of demographic patterns and trends in the Sudan.

# References


Brass W. *et al*, eds (1968). *The Demography of Tropical Africa*. Princeton: Princeton University Press.

Chidambaram, V. C., J. G. Cleland and Vijay Verma (1980). Some Aspects of WFS Data Quality: a Preliminary Assessment. *WFS Comparative Studies no 16.*

Department of Statistics (1977). *Socio-Economic Characteristics: Census Report*, vol I.

Department of Statistics (1980). *Population Dynamics: Census Analytical Report*, vol II.

Department of Statistics (1982). *First Country Report* vol I.

Goldman, N. and J. Hobcraft (1982). Birth Histories. *WFS Comparative Studies* no 17.

Potter, J. E. (1977). Problems in Using Birth History Analysis to Estimate Trends in Fertility. *Population Studies 31 (2)*: 335–64.

Rutstein, Shea Oscar (1983). Infant and Child Mortality: Levels, Trends and Demographic Differentials. *WFS Comparative Studies* no 24.

United Nations (1967). *Manual IV. Methods of Estimating Basic Demographic Measures from Incomplete Data.* ST/SOA/Series A/42. New York.