African Census Analysis Project (ACAP)
UNIVERSITY OF PENNSYLVANIA

Population Studies Center
3718 Locust Walk
Philadelphia, Pennsylvania 19104-6298 (USA)

Tele: 215-573-5219 or 215-573-5169
or 215-573-5165
Fax: 215-898-2124
http://www.acap.upenn.edu
Email: tukufu@pop.upenn.edu

Fertility Differentials in sub-Saharan Africa: Applying Own-Children Methods to African Censuses

Tukufu Zuberi and Amson Sibanda

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ABSTRACT

We use Zambian Census data as a case study of extending what we can learn about fertility utilizing African census data. This study presents and evaluates fertility estimates derived from linked own-children birth histories. The paper applies the own-children method of age-specific fertility estimation to the 1990 Zambia Census data. The first part of the paper focuses on developing strategies to link children to mothers. In our linking process, age at first birth and current ages of women are used as the lower and upper limits in the assignment process. Thus, for the first woman, we check if the relation code and that of the potential child are compatible. In addition, we double check if the ages of children fit in with the woman's reproductive window and if the number of children still residing with her matches the total number and sex of children who were enumerated. For each resident woman, we check information on children ever born and currently co-residing with their mother and if these children are listed under her. The linking of children stops when the number of children linked to a woman reaches the number of living children she reports. This step is repeated for additional resident women in the household. The second part presents estimates of fertility levels and trends based on the application of the own-children method and estimates from rejuvenated children and women. Our results suggest the need for a fuller exploitation of African censuses micro data in the study of fertility levels, trends and differentials in Africa. We present a comparison of our preliminary own-child estimates and other estimates. Lastly, we suggests methodological improvements to linking strategies that can be employed to get better fertility estimates in sub-Saharan Africa using census data.

Introduction

Census data offer information on fertility differentials by spatial, social and economic characteristics of the population that are not available in vital registration records or surveys. Since the 1960's African censuses have progressively collected information on children ever born, births in the past year, children surviving, children dead and the living arrangements of children. From these data we can estimate fertility measures like the total fertility rate, age-specific rates, gross reproduction rates, age-parity specific birth probabilities and parity progression ratios (Luther and Cho 1988; Retherford and Alam 1985). African census micro data are a greatly under-used resource even though vital registration data are non-existent in most African countries. Census micro data are a valuable source for understanding African social and demographic processes. Censuses are good at placing demographic rates within a spatial context, and they have been neglected in Africa during the very period when there has been an enormous increase in the data-crunching capacity necessary to analyze them. Unlike survey data, censuses do not suffer from problems of small sample cells, hence they give researchers leverage to calculate annual, age-specific fertility rates for various population subgroups (Rindfuss 1977). In this paper we limit ourselves to demonstrating the usefulness of African census micro data for fertility estimation using own-children methods. These methods give one the leverage to obtain fertility estimates for up to 15 calendar years using one census. This means that in countries where you have two successive decennial censuses, checks for consistency of fertility estimates can be made for the five-year overlap period. More importantly, "… the use of own children data provides a powerful tool for examining fertility *trends* when comparable vital statistics data do not exist." (Rindfuss 1976: 248). It is therefore hoped that the methodology suggested in this paper would inspire a fuller exploitation of existing and future census data for understanding fertility levels, trends and differentials in Africa.

The own-children method of fertility estimation was first developed and applied to United States Census data (Grabill and Cho 1965; Cho 1968; Cho, et al. 1970). The first application of these methods involved calculations of age-specific birth rates based on child-woman ratios. More recently, own-children methods have been refined and extended to estimate age-specific marital birth rates, duration-specific ever-married birth rates, age-parity-specific birth rates and birth probabilities, and age-specific birth rates for men. Own-child methods have the additional advantage of producing fertility estimates by social and economic characteristics asked about in censuses or surveys. This feature makes the use of census data useful in situations where survey data are limited, since some information on social, spacial, and economic characteristics are recorded in census data uniquely. Consequently, we may be able to use census data to further our understanding of the trends and tempos of fertility established by the examination of survey data over the last 20 years. Luther and Cho (1988) extended the traditional own-child methodology by adding a probabilistic process for the allocation of deceased and unlinked children in censuses. In this paper we apply the traditional own-children method.

The study of fertility from census data relies on the children ever born question, and the question about children born in the year proceeding the census date using well-developed methodologies. Some approaches, which have not been popular in Africa, are now possible because the quality of the censuses has steadily improved since the early 1960s. For example, the quality of the census age distributions in Africa has improved to the point where the own-children techniques can be used. In this paper we use Zambian Census micro data as a case study of extending what we can learn about fertility utilizing African census data. This study sets out to outline a method of linking children to their mothers in African census data. We develop a computer algorithm for matching children to mothers. The matched children are used to estimate the number of births by the age of the mother in previous years. A similar reverse-survival method allows us to estimate the numbers of women by age in previous years. We adjust our estimates for unlinked and dead children, since no attempt is made in this paper to assign fostered and dead children using a probabilistic process. We then estimate age-specific birth rates and fertility trends in Zambia using own-children birth histories using the 1990 Zambia Census micro data.

Zambian micro census data are available for 1980 and 1990. In addition, there has been Zambian Demographic Health Surveys in 1992 and in 1996. Fertility estimates have been made from these data and trends suggest that fertility declined by about 15% between 1980 and 1996. Zambia's total fertility rate dropped from 7.2 births per woman in 1980 to 6.7 in 1990 to 6.5 in 1992 and then 6.1 by 1996 (Central Statistical Office and Macro International 1996). This trend may be indicative of the onset of a sustained trend toward lower fertility or it may be a temporary change.

Reconstructing Birth Histories from African Census Data

Census micro data are a valuable source for understanding African demographic processes because of the dearth of vital registration data and the size of survey data. Census data provide total population counts, allowing us to escape the problem of small sample size and sampling errors or sampling bias. Hence, estimates of demographic rates and trends from censuses for small geographical locations may be more reliable than what is possible with national fertility surveys since the later tend to collect information from relatively small samples of women. Accurate district and provincial estimates of demographic levels and trends are indispensable in understanding social and economic processes. The need to implement efficient health and family planning programs has also increased the need for local and sub-regional demographic estimates so that societies can monitor such programs and ensure efficient operation and optimal allocation of scarce resources. When more than one census is available for an area, more robust trends will be obtained. In addition, censuses also give us the leverage to do cohort analysis over longer periods of time than survey data.

Most African censuses do not contain a complete birth history for all women. However, the census questionnaire typically includes questions on age and sex of the enumerated population, age at first birth, number of children ever born and surviving, births in the last twelve months, children dead, marital status, usual place of residence, and relation to head of household. This information can be carefully manipulated to reconstruct what are popularly known as Aown children@ birth histories by matching enumerated children to their mothers. Fertility levels and trends can then be calculated using own children methods. Own-children methods are reverse-survival techniques for the estimation of age-specific birth rates for years prior to a census. From the basic household records from census micro data, enumerated children are matched to mothers and fathers within households on the basis of answers to questions on age, sex, marital status, number of surviving children, usual place of residence, and relationship to the head of the household.

The application of such child-mother matching procedures to Zambia is not the first for any African census data. Cho et al. (1986) looked at fertility levels and trends in Kenya calculated from own children data and compared them to estimates from birth histories collected in the Kenya World Fertility Survey. The pattern of fertility estimates from own children data and from the Kenyan WFS birth histories coincided very well. On the other hand, year to year fluctuations in these fertility estimates were more marked for the own-children based estimates. Cho and his collaborators also showed that distortions in the estimated fertility levels tended to reflect similar age reporting errors for mothers and children. The method=s general applicability and robustness can be seriously examined in the context of recent African census micro data. More importantly, the use of this method allows us to establish a fairly detailed picture of the age and parity structure of fertility change provided the own children birth histories closely approximate Atrue@ or actual birth histories.

Outside sub-Saharan Africa, reconstructed census birth histories have been extensively used in fertility analysis in the US and Asia. These studies help us to appreciate how reliable the fertility measures calculated from reconstructed birth histories are. Experience from Asia and the US suggest that fertility measures calculated from reconstructed Aown-children@ birth histories provide a very good approximation to the results obtained from actual birth histories. For example, Luther et al. (1990) observed that in China the results from these two sources agreed remarkably well. Retherford et al. (1979) also exploited reconstructed own children birth histories to estimate fertility levels, trends and differentials for Thailand based on the 1970 census. The fertility estimates from these data were broadly in good agreement with other published fertility estimates. Illustrative evaluations of fertility estimates based on own children data for Korea and Pakistan also produced good results (Cho et al. 1986). In the case of Korea, Cho et al. compared overlapping fertility estimates from two censuses and one national fertility survey and all three sources produced estimates that were remarkably similar. In the United States, Retherford and Luther (1996) analyzed trends in fertility differentials by education using period parity progression ratios from census birth histories. Rindfuss (1976) compared annual fertility rates calculated using United States census own children data with estimates from vital statistics data and he found remarkable agreement in the levels and trends in total fertility rates. However, Rindfuss (1976:246) went on to caution that "these results suggest that own children data, unadjusted, can be used to estimate accurately fertility trends for various social, racial, and economic subgroups provided that the levels of age misstatement, under-enumeration, children not living with their mothers, and mortality remain stable over time."

Linking Procedure

This section is intended to indicate the operational principles involved in creating own children files. Mother-child linked data can be obtained by the manipulation of existing census micro data using computers. The coding operation takes advantage of the fact that households are the unit of census enumeration, so that many family members are grouped together on the schedules. The original linking procedures were developed by Wilson H. Grabill and Lee Jay Cho (1965) and applied to US census data. The matching procedures were extended to Asia by Cho et al. (1986), and to historical data by Strong et al. (1989) to link children and mothers in the 1910 US census, and to those used by Isiugo-Abanihe (1985) in his study of child fosterage in West Africa. Consider, for example, the variables we use to link mothers and children using the 1990 Zambia census data.

Relationship
1. Usual head
2. Spouse
3. Own son/ daughter
4. Step son/daughter
5. Other relative
6. Unrelated
7. Institutions

Membership Status
1. Usual member
2. Visitor
3. Member absent
4. Institutions

These variables allow us to make simple and complex mother-child links. Simple level links were used in situations where we had a nuclear family consisting of head of household, spouse and their children while more complex links were used in situations where we had more than one adult female in the household (i.e. polygamous unions, daughters with children, daughters-in-law and other relatives or non-relatives staying with their children). To reconstruct birth histories using Zambian census micro data, we start by linking each woman aged 12 to 65 with enumerated children who are listed as her own biological children. The greatest challenge to our linking strategy is the nature of living arrangements and the depth of relationship codes retained in census micro data. In Zambia, as in many other African countries, polygyny and adoption are common. In addition, average family sizes are fairly large and complex, and most male household heads are susceptible to frequent job related movements. These conditions generally create more mismatches than in situations where each biological child was enumerated using a unique mother identification number (Levin and Retherford 1982). However, since females in rural areas are less migratory than males, the likelihood of having a successful link is potentially high. The codes of the relationship to head of household and the membership status codes we utilize in our linking algorithm gave us the leverage we needed to accomplish a refined match of children to their mothers.

We linked women and their children using a two-prong strategy. The first strategy made simple links of children and their biological mothers. The simple links were the more obvious links in the data. The second prong of our strategy was to link the less obvious cases of mothers and children. Our strategy applies only to children living in households and does not apply to children living in any other institution.

Simple Level Links. Children were linked to their biological mothers if:

1: The woman was enumerated as spouse of head and the child had a relationship code that indicated that he or she was a child of head. The later relations are quite common in male-headed households. If the woman was listed as spouse and child was listed as stepchild, we assign the child to the woman since she might have brought that child into a new marriage. Alternatively, this link was established if the child was listed as Achild= of head and the woman was listed as head. This is a more direct link since the head of the household is a woman.

2: The ages of the mother and child were biologically feasible. We rejected any links if a woman is younger than age 12 and the oldest child in the set of children that could have been potentially linked to the mother had an age that did not equal or was above the woman's age at first birth. In other words, if any child has age out of range then that child would not be allowed to be linked in that household. In those cases where there is a man who is widowed, divorced or remarried with children from both the first and second wives, we made an effort to segregate the children into two sets so that we could only link children to their biological mother. We used each woman=s reproductive window to determine which children were assigned to her.

3: The total number of children linked to the mother was no greater than the number of surviving children she reported or the number enumerated in the household with her. However, there was one exception to this rule. In cases where children enumerated in the household were more numerous than children reported to be surviving and living at home, we disregarded the living at home total and we used children ever born as our maximum. In conditions 3 and 4, our main aim was just to link enough kids to bring her under quota or to equal the number she said she has given birth to. Thus, we had to reject any excess children attached to a woman just to equal or bring her under quota.

4.The mother did not report a zero number of surviving children. This implies that there were no links that were established if a woman was childless.

Higher Level Links. For us to match children to mothers in households with additional female boarders (other than the spouse or household head) present in the household, we had to filter on relationship to head of household. For example, a child who is listed as Aother relative@ can only be matched with a daughter of head, step-daughter of head, or another relative and not matched with the head, spouse or non-relative. At higher level links, we aimed at rejecting cases selectively. For the higher level links we repeat the simple level rules with qualifying modifications and examine all remaining children for possible links. The position of the children and mother in the household listing was crucial here. Because of the instructions given to the enumerators we expect potential own-children to be listed under their potential mother. However, in cases where enumerators did not follow the outlined procedures for the listing of household members we first try to assign the first children listed in the household to the first woman until her quota of living children and residing with her is met. After that, we move to the next woman and so on.

Using this general framework, children were then matched with potential biological mothers if:

> H1.The ages of the woman and child were biologically feasible. We rejected any links if a woman was under 12 years of age and the oldest child in the set of children linked to the mother had an age that did not equal or was above woman's age at first birth. The "set" is all children listed below the woman. So if a single child in the household has age out of range then no child can be matched to that woman.
>
> H2. If child is listed under woman and has not been included in first link.
>
> H3.The total number of children linked to the mother was no greater than the number of surviving children she reported or the total number of children currently staying with her.
>
> H4.The mother did not report a zero number of surviving children.

Because of the complex nature of some of the households we encountered, we had to flush out some household cases so that we could manually determine how to selectively reject some of the children listed in the household under a woman. In the next section we present some examples of the linking strategy outlined above.

Examples of Linking Zambian Census Micro Data

The 1990 Zambia census provides a separate record for each person in the household and each household has a unique identification number. The census records age, age at first birth, children surviving by sex and place of residence for each woman. We use this information to reduce the likelihood that more children are matched to a mother than the total number of male and female children she reported as children ever born or residing with her on the night of the census. We illustrate the matching procedures used with several examples from the 1990 Zambia census.

Household 1.(nuclear, all family members present)

First, we consider a family with five family members (household # 1). Line number simply reflects the order in which each family member was supposed to be listed on the household questionnaire. The first example, (household 1) is clearly a nuclear family, hence searching and linking all 3 children to their mother was easy since we only had 1 potential mother and 3 potential children to deal with. All the ages of the children fit in with the mother's reproductive window and their sex distribution matches that indicated by the mother. Finally, each child's relationship code was compatible with a mother-child link.

Household 1.(nuclear, all family members present)

Line No.	Membership Status	Relationship to Head of Household	Sex	Age	Marital Status	Age at First Birth	Children Surviving (Male)	Children Surviving (Female)	Children living with mother (Male)	Children living with mother (Female)	Children Living Elsewhere (Male)	Children Living Elsewhere (Female)	Child Linked to Woman in line number
1	Usual member	Usual head	male	49	married	na	na	na	na	na	na	na	None
2	Usual member	Spouse	female	44	married	24	2	1	2	1	0	0	None
3	Usual member	Own son	male	20	Never married	na	na	na	na	na	na	na	2
4	Usual member	Own son	male	15	Never married	na	na	na	na	na	na	na	2
5	Usual member	Own daughter	female	7	Never married	na	na	na	na	na	na	na	2

Household 2. (Nuclear but some of the children live elsewhere)

This example is also a typical household in Zambia. You have some of the children living elsewhere. To establish the mother-child link, we repeat the steps employed in household number 1. So our linking program scans the household and identifies the woman in line number 2 as the potential mother since her relationship code is spouse. The other females aged 12+ in the household are dropped as potential mothers because they are not married and they did not indicate children ever born or age at first birth. Thus, in this household, we easily link all children who were staying at home with their mother (5 out of 8 children) since their relationship codes were own son/daughter. All the ages of the children fit in with the mother=s reproductive window and their sex distribution matches that indicated by the mother. The Amissing kids@ can only be assigned to the mother using a probabilistic process.

Household 2 (nuclear, but some of the children live elsewhere)

Line No.	Membership Status	Relationship to Head of Household	Sex	Age	Marital Status	Age at First Birth	Children Surviving (Male)	Children Surviving (Female)	Children living with mother (Male)	Children living with mother (Female)	Children Living Elsewhere (Male)	Children Living Elsewhere (Female)	Child Linked to Woman in line number
1	Usual member	Usual head	male	48	married	na	na	na	na	na	na	na	None
2	Usual member	Spouse	female	41	married	18	3	5	2	3	1	2	None
3	Usual member	Own daughter	female	17	Never married	na	na	na	na	na	na	na	2
4	Usual member	Own son	male	14	Never married	na	na	na	na	na	na	na	2
5	Usual member	Own son	male	12	Never married	na	na	na	na	na	na	na	2
6	Usual member	Own daughter	female	8	Never married	na	na	na	na	na	na	na	2
7	Usual member	Own daughter	female	8	Never married	na	na	na	na	na	na	na	2

Household 3.

Our third example also reflects fairly common living arrangements in Zambia. In this household, you have female boarders who are potential mothers to the children listed in this household. To establish the mother-child link, our linking program identifies potential mother number 1 and then searches and links 5 potential children. Our task is made easier for this woman because she is listed as head of household, so the relationship codes of her children are own son/daughter. Thus, children in line numbers 2, 3, 7, 9 and 10 are matched to woman in line 1. This household also presents the expected listing of household members. The two female children are also staying with their own children. Our linking algorithm matches the first 3 Aother relatives@ listed after the 24 year old daughter in line 2. Thus, we are able to identify children in lines 4, 5, and 6 as her own. Their ages fit in with the woman=s reproductive window and their sex distribution matches that reported by their potential mother. The second daughter in line 8 has 1 female child living with her. The Aother relative@ in line 8 is identified as her own child. Her age matches woman in line 8's age at first birth. Lastly, the head of the household is matched to the 90-year-old female in the household.

Household 3. (Household with female boarders)

Line No.	Membership Status	Relationship to Head of Household	Sex	Age	Marital Status	Age at First Birth	Children Surviving (Male)	Children Surviving (Female)	Children living with mother (Male)	Children living with mother (Female)	Children Living Elsewhere (Male)	Children Living Elsewhere (Female)	Child Linked to Woman in line number
1	Usual member	Usual head	female	53	Widowed	20	3	3	3	2	0	1	11
2	Visitor	Own daughter	female	24	Married	15	1	2	1	2	0	0	1
3	Visitor	Own son	male	9	Never married	na	na	na	na	na	na	na	1
4	Visitor	Other relative	female	6	Never married	na	na	na	na	na	na	na	2
5	Visitor	Other relative	female	2	Never married	na	na	na	na	na	na	na	2
6	Visitor	Other relative	male	0	Never married	na	na	na	na	na	na	na	2
7	Usual member	Own daughter	female	16	Married	15	0	1	0	1	0	0	1
8	Usual member	Other relative	female	0	Never married	na	na	na	na	na	na	na	7
9	Usual member	Own son	male	23	Never married	na	na	na	na	na	na	na	1
10	Usual member	Own son	male	23	Never married	na	na	na	na	na	na	na	1
11	Usual member	Other relative	female	90	Widowed	20	2	2	0	1	2	1	none

Household 4 (Polygynous)

In Zambia, polygyny is most prevalent in rural areas and its more common among older women than among younger women. Its prevalence (1 in 5 women) creates complex family structures. Despite this complexity, household number 4 clearly show that it is possible to match children to mothers even in such complex households. In this household, we have a 53-year-old male who is married to two women in lines 2 and 9. The first wife (line 2) has given birth to 7 children in her lifetime but she is only staying with 5 of these children. She has brought a 29-year-old daughter into this marriage. Children in lines 3, 5, 6, 7 and 8 are matched to her because their ages fit in with her reproductive window and their sex distribution matches that reported by mother. The second wife in this household has 2 children (in lines 10 and 11). The other female relative (line 4) is not linked to any woman, therefore she is a non-own child.

Household 4 (polygynous)

Line No.	Membership Status	Relationship to Head of Household	Sex	Age	Marital Status	Age at First Birth	Children Surviving (Male)	Children Surviving (Female)	Children living with mother (Male)	Children living with mother (Female)	Children Living Elsewhere (Male)	Children Living Elsewhere (Female)	Child Linked to Woman in line number
1	Usual member	Usual head	male	53	Married	na	na	na	na	na	na	na	none
2	Usual member	spouse	female	50	Married	17	1	6	1	4	0	2	none
3	Usual member	Own son	male	13	Never married	na	na	na	na	na	na	na	2
4	Usual member	Other relative	female	15	Never married	na	na	na	na	na	na	na	none
5	Usual member	Step daughter	female	29	Divorced	19	0	2	0	1	0	1	2
6	Usual member	Step daughter	female	10	Never married	na	na	na	na	na	na	na	2
7	Usual member	Own daughter	female	7	Never married	na	na	na	na	na	na	na	2
8	Usual member	Step daughter	female	3	Never married	na	na	na	na	na	na	na	2
9	Usual member	Spouse	female	40	Married	20	1	1	1	1	0	0	none
10	Usual member	Own daughter	female	20	Never married	na	na	na	na	na	na	na	9
11	Usual member	Own son	male	15	Never married	na	na	na	na	na	na	na	9

Our estimates are limited to thirteen years prior to the census, and we estimate births for children under age 13 at the time of the census enumeration. The own-child linked birth histories include most of the births up to age 13 (and the majority of births up to age 19). Figure 1 presents the percentage of children linked by age for Zambia in 1990. The basic linking of children with mothers is not complete because it excludes birth of deceased children, surviving children living outside the mother=s place of residence, and children surviving a deceased mother.

Figure 1. Percentage of Children Linked by Age for Zambia, 1990

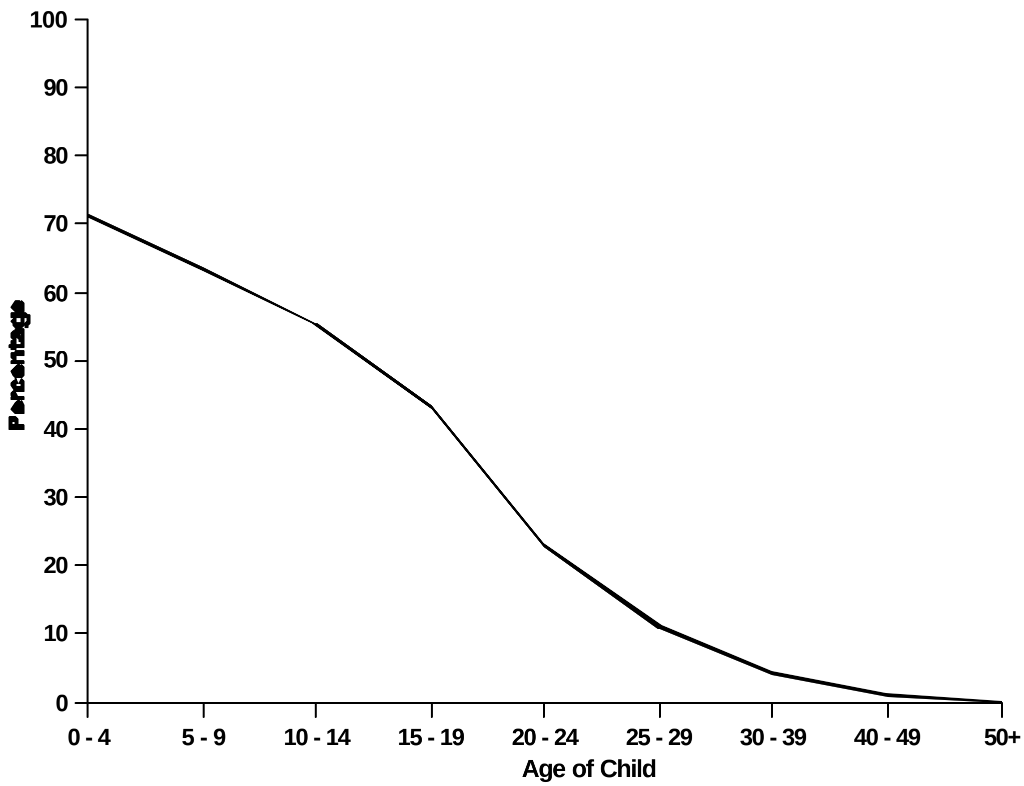


Figure 1 shows that most children begin to live away from their mothers after age 15. This means that more recent births are more likely to be linked, hence fertility estimates for the recent period should be more robust than those for the distant past. Figure 1 also shows that about 20% of children aged 0-9 were not linked to their mothers. Within the unlinked group, you have orphaned children, adopted children and grand children. Given that mortality increases with age, the increase in unlinked, or Anon-own@, children observed in the data with increasing age is not surprising. Mothers of older children are more likely to have died, and older children are generally more likely to live elsewhere.

The ›own-child= linking procedure works perfectly well in households where you have one woman living with her children and husband only. However, it is important to note that high levels of polygyny and child fosterage complicate matching children in sub-Saharan Africa. For instance, in Zambia, 1 in 5 children are fostered while 17% of currently married women are in polygynous union (McDaniel and Zulu 1996; Central Statistical Office and Macro International 1996).

In Table 1 we present the percent of women linked by type of marital union. As expected, the majority of children under age 14 were either linked to women in monogamous or polygynous unions (68 and 63 per cent respectively). Being able to link 63 per cent of children enumerated in households with more than one wife is very significant in the Zambian context since 20 per cent of Zambian women are polygynous marriages. Polygynous households require more complex strategies for coding of mother-child linkages. In the case of Zambia, the enumerators were clearly instructed to start by listing the name of the head of the household whether or not he or she spent the previous night in the house. In order to be systematic, enumerators were then instructed to write the name of the spouse of the head of household after that of the head, followed by the names of their unmarried children, married children and their families and lastly, those of other relatives and the non-relatives in that order. In cases where the head of a household had more than one wife living in one household, the enumerator had to enter first the name of the first wife then her children, and then the next wife and her children and so on (Central Statistical Office, 1990). Such a systematic listing of household members would allow us to assign children to mothers directly. When the enumerators followed these instructions we could make simple links and when this was not the case, more complex methods of linking were employed. We create a reproductive window for each woman. This window is created by incorporating information on age at first birth and current age of women. Once we create this reproductive window, we use information on age of each child to establish when a particular woman gave birth.

Table 1. Percent Linked/Unlinked by type of Union

Age of Child	Polygamy	Statuses	
	Union Type	Unlinked	Linked
0-14	No Wives	56.05	43.95
	1 Wife	32.18	67.82
	2+ Wives	37.45	62.55
15+	No Wives	82.49	17.51
	1 Wife	83.21	16.79
	2+ Wives	84.97	15.03
All Ages	No Wives	78.09	21.91
	1 Wife	60.11	39.89
	2+ Wives	64.87	35.13

Table 2 presents the percentage of linked children by age group and their relationship to the household head. As expected the highest percentage of links occur where the child is a son or daughter of the household head. For children between 0-14 over 77 percent of children classified as son or daughter of the household head are linked to their mother. An unanticipated observation is the high percentage of unmatched stepchildren. Although, step children account for a small number of all children, it is not clear why they are less likely to be in households with their mother. One possible explanation is that stepchildren are more likely to be fostered and to be unlinked if their mother dies. It is also possible that stepchildren are more likely to be a miscoding of the relation to head of household code or respondent errors. At any rate the number of stepchildren is small and does not significantly influence the overall trend of the data.

Table 2. Percent Linked/Unlinked by Relationship to Household Head

Age of Child	Relationship	Linked
0-14	Usual Head	0.01
	Spouse	0.64
	Child	77.08
	Step-Child	26.20
	Other Relative	19.43
	Unrelated	18.70
	Missing	7.64
15+	Usual Head	0.00
	Spouse	0.02
	Child	59.40
	Step-Child	23.15
	Other Relative	2.32
	Unrelated	1.41
	Missing	1.13

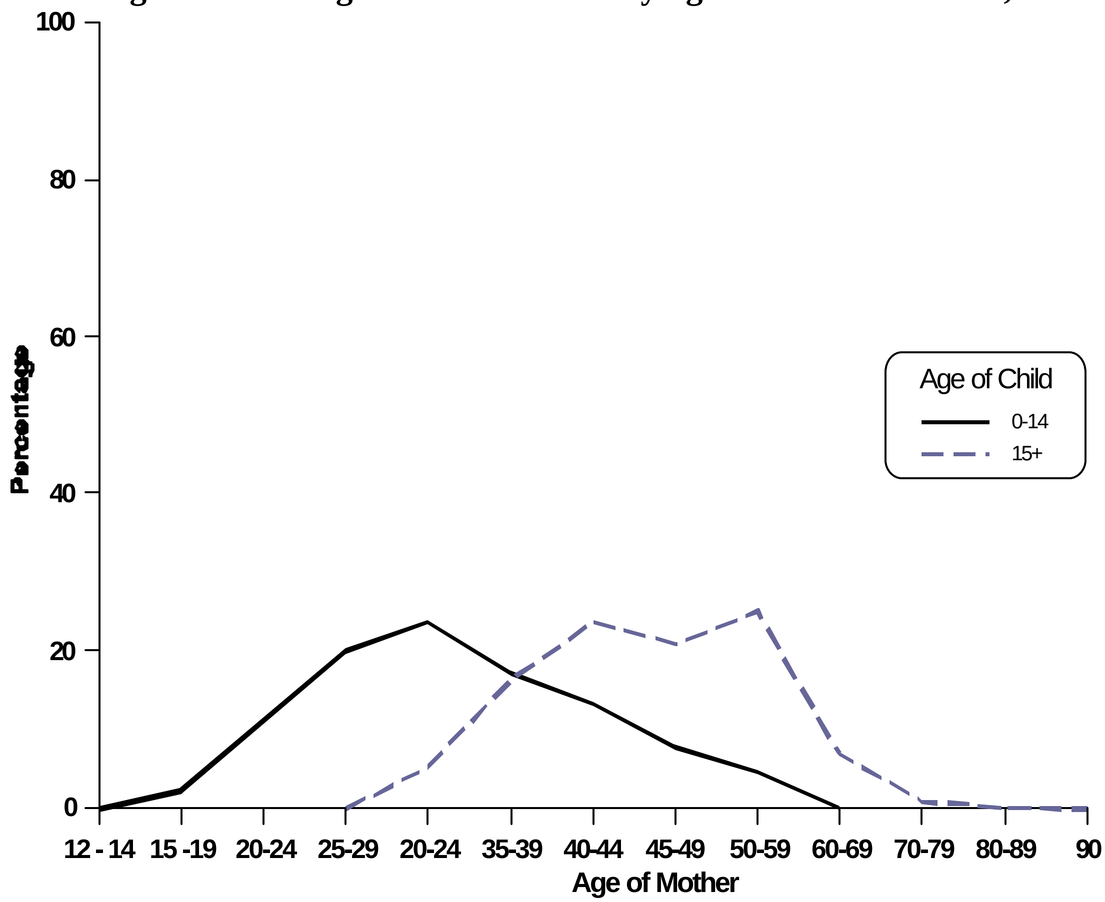
After the number of own children ages 0 - 14 has been determined, the data can be tabulated in association with other characteristics of the woman and her family as are indicated in the census. Tabulation made for most African nations include such characteristics as education, marital status, labor force status, occupation, place of residence and quality of housing. Such information gives researchers leverage to study differential fertility using own children methods.

Fertility Estimates from Reconstructed Census Birth Histories

We estimate the number of linked children for each year prior to the census date and the distribution of linked children by age of mother. Using the own children technique to calculate age specific fertility rates for the last 13 years allows us to evaluate if the partially reconstructed birth histories yield fertility estimates that are just as good as those obtained from actual birth histories.

The distribution of women by age and total number of linked Aown@ children ever born provides the basic data. Figure 2 presents the percent of children linked by age of mother. As expected the majority of linked mothers are between the ages of 20 and 39 for children between the ages of 0 and 14. As expected the links for older births were not as successful, and we focus on children aged 0 to 14. We have linked children to mothers within households using information on mother=s age, child=s sex, age, marital status, children ever born, children living at home, children living elsewhere and relation to head of household. Now we can reverse-survive both the children and mothers to establish the number of women

Figure 2. Percentage of Children Linked by Age of Mother for Zambia, 1990



aged x in any given year and the number of births by age of mother in years prior to the date of the census. Thus, the goal of the birth reconstruction procedure is to establish Acrude@ birth intervals and then link them to the year of occurrence. This will then allow us to calculate time trends.

We use the basic method outlined by Cho et al. (1986). For simplicity we consider that numbers of women and children at the time of the census have been adjusted for the presence of unlinked children, underenumeration, and that mortality has been constant over the estimation period. Table A1 shows the adjustment factors we used to account for the 'non-own' children who were not linked. We denote t as the time of the census, thus,

$$B_{a-x}(t-x) = C_{x,a}(l_0 / l_x) \qquad \textbf{(1)}$$

Equation 1 reverse-survives children aged x of mothers aged a at time t to births of mothers age $a - x$ at time $t - x$. And,

$$W_{a-x}(t-x) = W_a(t)(l^f_{a-x} / l^f_a) \qquad \textbf{(2)}$$

Equation 2 reverse-survives women aged a at time t to women aged $a - x$ at time $t - x$. These values are used to calculate central birth rates for women by age. We adjust the number of own children for unlinked children by a factor computed as the reciprocal of the proportion of children aged x to $x + 1$ at the time of the census who are linked to mothers. Once we have corrected the estimates for unlinked children and child and women mortality (using North Model Level 13) we estimate the age specific central birth rate, referred to here as the age-specific fertility rate, as

$$f_{a-x}(t-x) = B_{a-x}(t-x) / W_{a-x}(t-x) \qquad \textbf{(3)}$$

Table 3 presents our estimates of the adjusted age-specific birth rates for Zambia applying own-child methods to the 1990 census micro data. The unadjusted age specific fertility rates are shown in Table A2. As expected, the unadjusted fertility estimates are fairly low when compared to the adjusted estimates.

Table 3. Own-Child Based Estimates of Age-Specific Fertility Rates and Total Fertility Rates for Zambia: 1977-90

Year	Age-Specific Fertility Rates							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TFR
1977	0.153	0.349	0.338	0.305	0.209	0.128	0.063	7.7
1978	0.157	0.373	0.388	0.349	0.263	0.154	0.085	8.8
1979	0.136	0.337	0.348	0.317	0.240	0.135	0.079	7.9
1980	0.143	0.359	0.399	0.367	0.292	0.166	0.094	9.1
1981	0.120	0.316	0.340	0.306	0.244	0.140	0.075	7.7
1982	0.115	0.312	0.353	0.326	0.265	0.161	0.083	8.1
1983	0.103	0.279	0.314	0.285	0.229	0.143	0.066	7.1
1984	0.095	0.271	0.316	0.292	0.238	0.154	0.069	7.2
1985	0.090	0.255	0.292	0.277	0.223	0.143	0.066	6.7
1986	0.087	0.257	0.306	0.291	0.240	0.157	0.077	7.1
1987	0.082	0.230	0.263	0.255	0.203	0.133	0.065	6.2
1988	0.074	0.211	0.247	0.237	0.198	0.124	0.065	5.8
1989	0.066	0.190	0.218	0.211	0.172	0.105	0.050	5.1
1990	0.072	0.203	0.227	0.216	0.176	0.104	0.049	5.2

Several interesting patterns are apparent in Table 3. First, it is apparent that the fertility levels are lower than expected for some years and higher than expected for other years. In part this distinction is a result of using linked own children in our numerator and women who reported their ages in the denominator. (Women who did not provide their ages were left out of the linking algorithm program). Secondly, own children data for the more distant past provide lower fertility estimates than do data for the recent past, consequently the adjustment factor is higher for these ages. This is to be expected because of the pattern we saw in Figure 1, that is, we linked a higher percentage of 0-14 year old children. Thirdly, the own children estimates yield the expected age-specific fertility shape, with fertility peaking between ages 20-29. Lastly, it appears that fertility began to decline only recently in Zambia. All age groups appear to be contributing to the recent decline, although the decreases are greater for the younger age groups.

Another approach to evaluate fertility trends obtained from our own-child estimates is to compare them with estimates from other sources. Figures 3 and 4 and Table A3 compare our estimates of the age specific birth rates to those derived from other sources for 1980 and 1990. The fertility estimates from these data sources indicate that Zambia has been experiencing high fertility levels, which have only shown a decline in the recent past. However, in view of the different methodologies used to collect these data (censuses versus surveys), a rigorous comparison of these age-specific fertility rates should be done with caution.

Figure 3. Age Specific Fertility Rates for Zambia, 1980

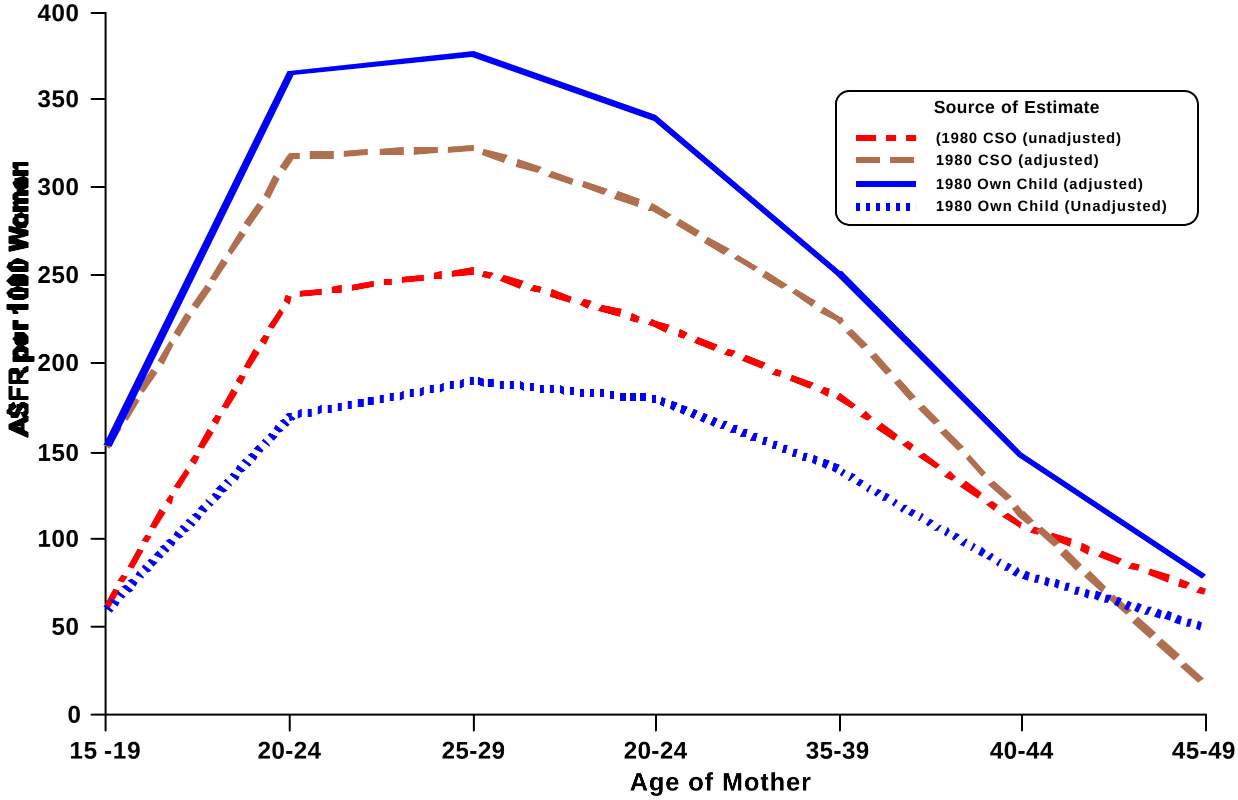


Figure 4. Age Specific Fertility Rates for Zambia, 1990

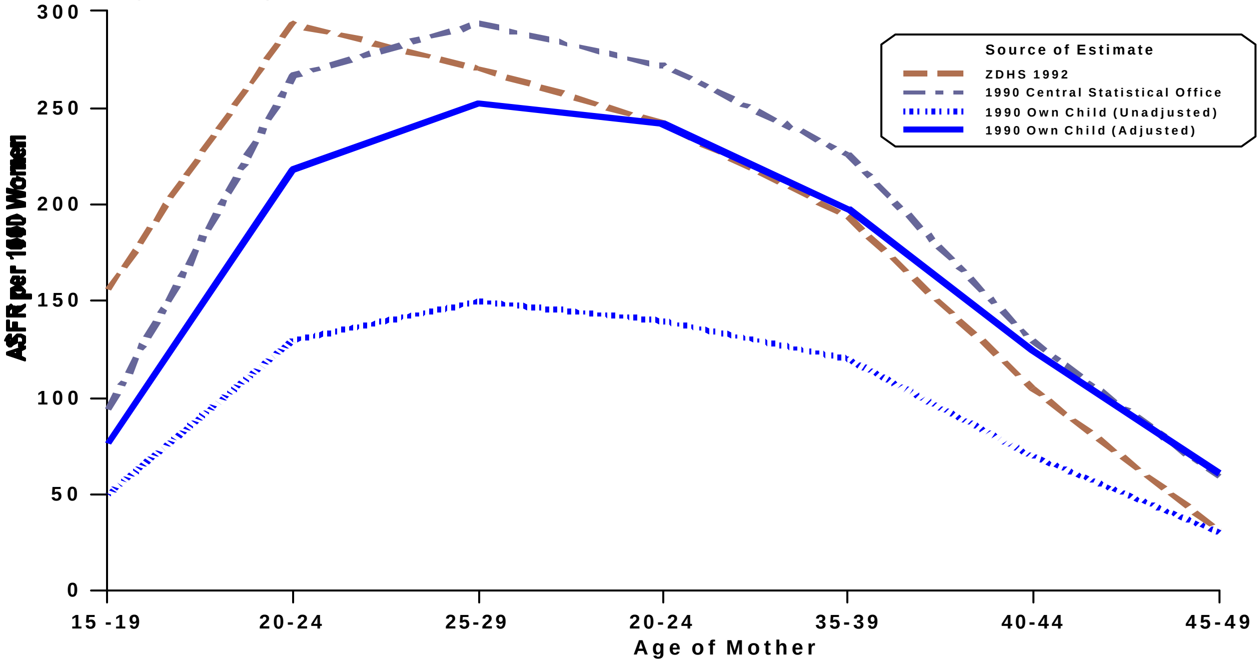


Figure 3 presents the age specific fertility rates for Zambia in 1980. Our own-child estimates present a higher rate of fertility than those estimated and adjusted by the Zambian Central Statistical Office (CSO). The patterns are generally the same but our adjustments inflate our rates much higher than those employed by the CSO. Interestingly, our estimates and those of the CSO both peak at ages 25-29. We do not know enough about the CSO adjustments to account for the differences in the adjusted rates (Central Statistical Office, 1980).

Figure 4 also shows that for the 1990 census, we have three sets of age-specific fertility estimates. The first set of estimates was derived from unadjusted own children data, hence the very low age specific fertility rates. The second set of estimates refer to the fertility measures we get after rejuvenating dead children and dead women, and adjusting our estimates for unlinked children. The age-specific fertility rates increase as expected, but are lower than the official set of estimates that were computed using the Relational Gompertz Model (Central Statistical Office 1995). It is interesting to note that while the peak of the age specific fertility rates for the two Zambia DHS surveys is in the 20-24 age group, in all the census estimates (including those based on own children and rejuvenated children and women), the peak shifts to age 25-29.

These differences may be the result of high under-enumeration of non-marital births. Our process of estimation, and those of Brass methods, favor the age-specific fertility structure of married women, and may be biased against the fertility structure of unmarried women. In this same vain of reasoning it may be that infant and child mortality differs for children of unmarried mothers. At any rate the difference in the age-specific structure of fertility in estimates from census and survey data merit closer attention.

Conclusion

This primary goal of this article was to examine the applicability of own children methods to the African context using African census micro data. The above results suggest that own children data derived from African censuses can be cautiously used to estimate fertility levels and trends. However, a major limitation of the fertility estimates calculated using partially reconstructed census birth histories is that they are biased since we do not have complete birth information for women with surviving children not residing in the same household, and deceased children. Own-children birth histories have been successfully used to estimate fertility levels in many Asian countries and the United States. Our efforts to replicate these estimates using African census micro data suggest the usefulness of such techniques for Africa. However, the Zambian case also raises several questions about the application of the traditional own-children techniques. The Zambian example exposes some fundamental limitations of using these rejuvenated data to estimate fertility levels and trends. We linked 64% of children ages 0 to 14 to mothers. Our fertility estimates were lower than estimates from other sources although we did replicate the shape of the fertility curve produced by Brass techniques.

To get accurate and consistent fertility estimates, own-children birth history data require that respondents should report their ages and that they report them accurately. Our underestimation of fertility suggests errors in the reporting of age for both children and mothers. It is not clear if errors in the distribution of women by age introduced more noise in the own-children birth history data than errors in the distribution of children by age. However, Retherford et al. (1979) contend that in the majority of cases, own children based fertility estimates for a given year are severely affected by age misreporting of woman.

The use of extensions of the own-children methods may address some of the shortcomings in our estimates. The method of reconstructing complete birth histories from census data is an extension of the own-child methods of estimating fertility. The basic extension method, developed by Luther and Cho (1988), is based on a probabilistic procedure in which a woman's incomplete birth history derived from a listing of her own-children by age is used together with supplementary information on the number of children ever born and her number of surviving children. Using these data Luther and Cho estimated a woman's deceased and fostered (or children no longer living with her) children. The total number of such children is then probabilistically assigned to a woman to establish a complete reconstructed birth history.

To improve the household roster of linked children we could impute the birth dates and birth order number of all dead children and those living elsewhere using a probabilistic method. Given a woman's reproductive window (that is current age minus age at first birth) plus the ages of surviving children matched to a woman, we calculate the ages of all the dead children and those living elsewhere since we know the total number of children ever born. To reverse-survive dead children and infer their birth dates, requires a suitable life table that can match mortality patterns in Zambia in the last 10 to 20 years. Such life tables are available from the Gwembe demographic laboratory (Clark et al. 1995). For Zambia, we should assume changing mortality over time because of the economic reversals in the country that have devastated the lives of many people.

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APPENDIX

Table A1. Adjustment Factors for Unlinked Children

Child's Age	Adjustment Factors
0	1.2937
1	1.3574
2	1.4200
3	1.4507
4	1.4949
5	1.5151
6	1.5244
7	1.5875
8	1.6064
9	1.6628
10	1.6972
11	1.8426
12	1.8085
13	1.8268

Table A2. Unadjusted Age Specific Birth Rates and TFR, Zambia 1980

	Age-Specific Fertility Rates							
Year	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TFR
1977	0.070	0.160	0.150	0.140	0.100	0.060	0.030	3.6
1978	0.070	0.170	0.180	0.160	0.120	0.070	0.040	4.1
1979	0.060	0.150	0.150	0.140	0.100	0.060	0.040	3.5
1980	0.060	0.170	0.190	0.180	0.140	0.080	0.050	4.4
1981	0.060	0.150	0.160	0.150	0.120	0.070	0.040	3.8
1982	0.060	0.160	0.180	0.170	0.140	0.080	0.040	4.2
1983	0.050	0.140	0.160	0.150	0.120	0.070	0.030	3.6
1984	0.050	0.140	0.170	0.160	0.130	0.080	0.040	3.9
1985	0.040	0.130	0.160	0.150	0.120	0.080	0.040	3.6
1986	0.040	0.140	0.170	0.160	0.130	0.080	0.040	3.8
1987	0.050	0.130	0.150	0.150	0.110	0.080	0.040	3.6
1988	0.040	0.120	0.150	0.140	0.120	0.070	0.040	3.4
1989	0.040	0.120	0.140	0.130	0.110	0.070	0.030	3.2

Year	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TFR
1990	0.050	0.130	0.150	0.140	0.120	0.070	0.030	3.5

Table A3. Age Specific Fertility Rates and Total Fertility Rates from Various Sources, Zambia

Age Group	Census 1980 (Unadjusted)	Census 1980 (Adjusted)	Census 1990 (Own children data)	Census 1990 (Adjusted own-children estimates)	Census 1990 (Official)[1]	Zambia DHS 1992	Zambia DHS 1996
15-19	0.061	0.153	0.050	0.073	0.094	0.156	0.158
20-24	0.239	0.318	0.130	0.205	0.267	0.294	0.280
25-29	0.253	0.323	0.150	0.230	0.294	0.271	0.274
30-34	0.223	0.289	0.140	0.218	0.272	0.242	0.229
35-39	0.181	0.225	0.120	0.178	0.226	0.194	0.175
40-44	0.108	0.115	0.070	0.140	0.129	0.105	0.077
45-49	0.070	0.017	0.030	0.050	0.059	0.031	0.024
TFR	5.7	7.2	3.45	5.3	6.7	6.5	6.1

[1]Adjusted using the Brass Relational Gompertz Model