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Estimates of provincial fertility and mortality in South Africa, 1985–1996

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Abstract

This paper presents estimates of South African provincial child and adult mortality, and fertility for 1986 to 1996. Fertility and child mortality rates are derived using data from the 1996 census adjusted where necessary using information from the 1998 Demographic and Health Survey. Adult mortality rates for 1996 were produced using the vital registration data in combination with the population data from the 1996 census and completeness of the registration of child deaths. These estimates suggest that the national total fertility rate fell from 3.67 in 1986 to 3.29 in 1996 and ranged between 2.63 to 4.01 for the individual provinces in 1996. Child mortality ($_5q_0$) fell from 73 per 1 000 in 1986 to 57 per 1 000 in 1992 before increasing to 70 per 1 000 by 1996, and ranged between 40 and 95 for individual provinces in 1996. Life expectancy at birth in 1996 was 57 years for males (ranging from 53 to 61.5 for individual provinces) and 65 for females (ranging from 62 to 69 for individual provinces).

Keywords

South Africa, mortality, fertility, infant mortality rate, life expectancy

INTRODUCTION

A number of studies have produced national estimates of South African mortality (for example, Nannan, Timæus, Bradshaw *et al.* 2002; Statistics South Africa 2000; Timæus, Dorrington, Bradshaw *et al.* 2001; Udjo 1999a) and fertility (for example, Dorrington, Nannan and Bradshaw 1999; Moultrie and Timæus 2002, 2003; Udjo 1999b). However, it is much more difficult to

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estimate these rates at a provincial level. As far as we know, only Statistics South Africa (2000) has attempted to produce life tables for each province, while only Dorrington, Nannan, and Bradshaw (1999) have attempted to estimate provincial fertility rates. Neither of these studies estimated trends in these rates over time.

Estimates of mortality and fertility are key indicators of the demographic status of a population. In general, measures of overall fertility and mortality in particular years suffice for this purpose, such as those produced by the studies mentioned above. However, the projection of population change requires detailed time series of estimates of age-specific rates that can be used to update the baseline population to the current year and extrapolate fertility and mortality into the future. In South Africa, provinces are demographically heterogeneous. Thus, to produce adequate projections at a provincial level requires province-specific series of demographic indicators. Unfortunately most surveys, in particular the South African Demographic and Health Surveys (DHS), interview too small a sample to estimate adult mortality sub-nationally or to provide time series of estimates of total fertility and child mortality by province that are sufficiently precise to be useful. The aim of this paper is to produce such series of estimates. It is based primarily on the two data sources available currently that are intended to have universal coverage – the 1996 Census (or rather the 10 per cent sample of the unit records drawn as described in Statistics South Africa (1998)) and the civil register of deaths (as captured by the Department of Home Affairs and Statistics South Africa and processed by the Medical Research Council (personal communication with Ria Laubscher, MRC)). Where appropriate, these data are supplemented by, or checked at the aggregate level against, the more detailed information collected in the 1998 DHS.

DATA AND METHODS – OVERVIEW

In order to make the detailed exposition of the methods used to derive the various rates easier to follow, we first provide an overview of the approach. The steps followed are:

- Fertility rates are calculated for Africans by province and for the other population groups nationally using 1996 census data on births in the last year and lifetime fertility that have been adjusted for reporting of stillbirths as live births and various other data errors. After inspecting the current fertility schedules for plausibility and comparing weighted averages of them

(using the number of women in the various age ranges in the census as weights) with the national aggregate results by population group and for the population as a whole, best estimates of fertility rates by race and province are decided on. The trend in these rates over time is estimated using the lifetime fertility data from 1996 census.

- The 1996 census data on children ever born corrected as described above are then used in combination with census data on the proportions of children that are still alive by the age of their mothers to derive a set of estimates of infant and under-five mortality for Africans in each province, for the Coloured population in two groups of provinces, and for Whites and Asians nationally. These estimates are also inspected for plausibility and compared with the national results before being aggregated across population groups to produce provincial estimates. As part of this process, the time location of the various estimates is used to derive trends in the rates. As the 1996 census did not collect separate information on girls and boys, the rates are disaggregated by sex in ratio to estimates from the 1998 South Africa DHS.
- Adult mortality is estimated from registered deaths after correcting for under-reporting. A major problem with these data is that some people who die in a province different from where they reside according to the censuses are reported on their death certificate to be residents of the province in which the death occurred. This numerator-denominator mismatch produces bias in rates calculated by dividing deaths in a province by census-based population estimates for that province. This is evident, for example, from the fact that the *unadjusted* death rates for the Western Cape and Gauteng, the most developed provinces, are higher than the adjusted rates for South Africa as a whole. Faced with this problem and with high rates of inter-provincial migration, we estimate the completeness by province of adult death reporting relative to the 1996 census by assuming that it is linearly related, though not equal, to the completeness of child death reporting. We use our child mortality estimates to calculate the completeness with which child deaths are registered in each province. With this information and the additional assumption that, as is the case at the national level, reporting of men's deaths in each province should equal that for women's deaths, we determine the completeness of registration of adult deaths by province. These provincial estimates are then adjusted proportionately to ensure that their weighted average remains equal to the completeness of registration for adults in the country as a whole. Having determined the completeness of

registration, we scale up the deaths recorded in each province in 1996 to calculate adult mortality. We suggest that rates for earlier years can be estimated on the assumption that non-AIDS mortality rates did not change appreciably between 1985 and 1996.

FERTILITY

Method

The methods used to correct the deficiencies identified in the 1996 census data on fertility have been described in detail elsewhere (Moultrie 2002; Moultrie and Timæus 2002). National estimates of fertility are presented in Moultrie and Timæus (2003). Here, emphasis is placed on the derivation and description of the results for provinces, including the method used to estimate the level of fertility (by province for African South Africans, and nationally for other population groups) in the years before the 1996 census.

First, the data are corrected for the fact that large numbers of women were categorised as "parity not stated". As the great majority of these women are young, most of them are likely to be childless women for whom the answer box for this question was left blank by the enumerator. An El-Badry correction (El-Badry 1961), which estimates the proportion of "parity not stated" women that should be "parity zero", was applied to the provincial data for each race separately. The number of births in the last year borne by these women was also reset from "not stated" to zero.

Second, comparison of the national data from the 1996 census with those from the 1998 DHS indicates that many of the stillbirths to African and Coloured women were reported erroneously as live births and therefore included in the fertility rates. Moultrie and Timæus (2002) derived correction factors, by population group, to reduce the reported children ever borne accordingly. (No correction was made to the census reports on White and Asian/Indian women, since no clear evidence exists of erroneous reporting of stillbirths as live births among these women).

Third, the census data were adjusted for the fact that many women were recorded as having the same number of births in the last year as the number of children they had ever borne. If this error is not adjusted for, the resulting estimates of fertility will be excessively high for older women who, in general, have borne more children. The correction restricts the maximum number of births in the year before the census to two.

Fourth, the census data were corrected for a reporting error observed

among older women of parity one, who tended to report that their child had been borne in the past year.

Fifth, the shape of the fertility curves for African and Coloured women were adjusted further through the use of a Relational Gompertz model. This adjustment corrects the shape of the fertility distribution as the proportion of births attributed to women aged 45–49 still seemed implausibly high even after all the other corrections had been made to the data, but does not affect the level of fertility. As the Relational Gompertz model standard is inappropriate for use with the age distribution of fertility for Whites and Asians/Indians and as it is unclear that the data on them are affected by this error, the correction was not made to the data on these two population groups.

Unlike the raw data (and with the exception of the Indian population where the 1998 DHS data are too scanty to yield precise estimates), the resulting national fertility distributions by population group are virtually identical in shape to those reported in the 1998 DHS (Moultrie and Timæus 2003). However, eliminating spurious births in the last year and adding childless women to the denominators reduces the level of fertility calculated from the data on births in the year before the census to approximately half the unadjusted estimate. A variant of the Brass P/F method (United Nations 1983a) derived by Feeney (Feeney 1998) was applied to these rates to adjust them upward to be consistent with the reports on lifetime fertility. This variant does not presuppose knowledge of the "true" level of fertility, but uses Ryder's observation that the total fertility rate at a point in time closely corresponds with the total lifetime fertility of women who at that time are at the mean age of childbearing (Ryder 1983).

One advantage of Feeney's approach is that it allows results from the Brass P/F method to be interpreted as indicating the time trend in total fertility. The P/F ratios for different cohorts are used to scale the observed schedule of fertility rates, and – using Ryder's observation – are then deemed to apply to different points in time. In the absence of reliable census or survey data for the period before 1996, the Feeney approach was used to derive time series of estimates of fertility for the subpopulations investigated.

The original intention was to derive 36 series of estimates, one for each combination of province and population group. However, after deriving separate provincial estimates for Coloureds, Whites and Asians/Indians, it was apparent that even census data are too sparse to produce such detailed estimates. As the apparent variation by province in fertility is small for the

minority population groups, it was decided to apply the national estimates for these three population groups originally presented in Moultrie and Timæus (2002) to each of the provinces. In contrast, the 1996 census data can be used to produce estimates of fertility by province for African South Africans. Thus, in total, 12 series of fertility estimates were produced (estimates of African fertility in each of the nine provinces of South Africa and national estimates for Coloureds, Indians and Whites). By averaging these using appropriate weights, estimates of fertility can be made for entire provinces, African South Africans, or all South Africans.

Results

The resulting schedules of age-specific fertility rates are shown in Figures 1 to 3. Table 4, in the Appendix, presents the fertility rates for the 12 subpopulations and the weighted totals for African South Africans and all South Africans. The weights used to derive aggregate estimates are based on the reported numbers of women in each province and each age group. The fertility of Africans living in Gauteng is markedly lower (fewer than three children per woman) than that of Africans living in other provinces. Fertility is highest among Africans living in a geographical band running from the Eastern Cape through KwaZulu-Natal, Mpumalanga and Limpopo Provinces.

Figure 1 Age-specific fertility rates by province, African women, 1996

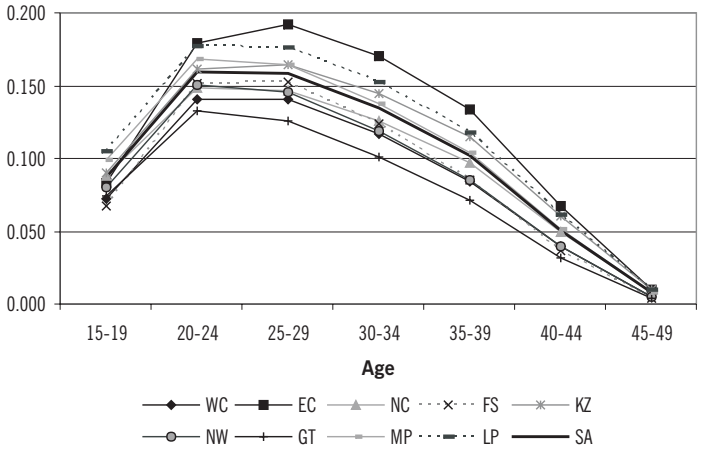


Figure 2 Age-specific fertility rates by population group, 1996

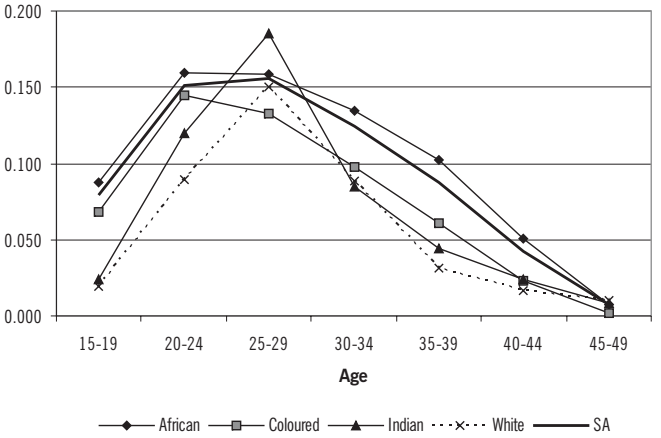
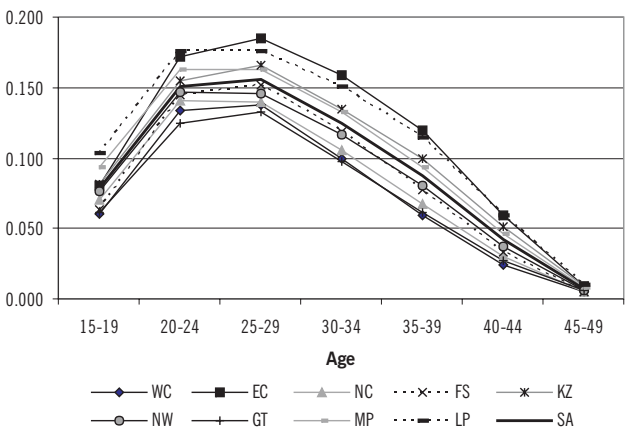


Figure 3 Age-specific fertility rates by province, all population groups, 1996



Fertility among Coloured, Indian and White women is markedly lower. The fertility of White women is close to, or possibly below, replacement level, while that of Coloured and Asian/Indian women is approximately 2.5 children per woman. These results are plausible when compared with those from the 1998 DHS data (which are a little lower, but refer to a younger, more urban

and more educated population than was enumerated in the 1996 census). The re-weighted national estimate of total fertility in 1996 (3.24 children per woman) is only slightly higher than the 3.23 originally estimated by Moultrie and Timæus (2002).

As mentioned above, in addition to estimating the current level of fertility at the time of the 1996 census, the Feeney approach allows the estimation of fertility in earlier time periods, using the calculated Brass P/F ratios as scaling factors. Applying the correction and interpolating, estimates of total fertility in the 10 years before the 1996 census are shown in Table 5 for the 12 sub-groups and in Table 6 for the nine provinces. National estimates for years prior to 1996 can be derived as weighted averages of the disaggregated estimates, weighting by the relative age distributions of women aged 15–49 from the ASSA 2000 model.

Over the period 1985 to 1996 fertility fell fastest among African women in the Western Cape, North West and Free State (a total fall of around 15.5 per cent), and slowest in the Eastern Cape (7.3 per cent). Fertility among African women in other provinces fell by between 11 and 13 per cent over the same period. Total fertility among Coloured, White and Indian women fell by 12.8, 9.5 and 7.8 per cent respectively. For the years up to 1996, no evidence exists that fertility was falling faster in the provinces affected most severely by the HIV/AIDS epidemic.

CHILD MORTALITY

Method

We estimate child mortality from the 1996 census data on the proportion dead of children ever borne by age of mother using a variant of the method originally proposed by Brass (United Nations 1983b). The method converts the proportions into probabilities of dying using a set of multipliers determined by the average parities of women. The data were adjusted first for misreporting of stillbirths and misstatement of parity as described in the previous section. Responses from mothers aged 15–19 are not analysed as they are not representative of mortality of all young children because children of very young mothers tend to suffer higher mortality. Brass's relational logit system is applied to the Princeton West family of model life tables (Coale, Demeny and Vaughan 1983) to estimate the infant mortality rate (q_0) and probability of a child dying before their fifth birthday ($_5q_0$) that correspond to the differing indices of mortality obtained from data on each age group of mothers. West models are broadly consistent with the age pattern of mortality

within childhood nationally, as indicated by the 1998 DHS. While the relative severity of infant and child mortality may vary between provinces, the choice of standard table does not affect the estimates of under-five mortality greatly. The responses of women in different age groups (and hence whose children were born on average at different times) are then used to identify the time trend in under-five and infant morality.

Initially, the method was applied to each combination of province and population group. However, inspection of the estimates for Coloureds, Whites and Indians showed that, as for fertility, the census data are too sparse to produce reliable province-level estimates for these groups. Thus, while the census data for African South Africans are used to derive province-specific rates for this population group (Figure 4), it was again decided to use the weighted average national estimates across all the provinces for Whites and Indians. However, inspection of Figure 5 suggests that in estimating the level of and trend in Coloured child mortality one should distinguish between the rates in the Eastern Cape and Western Cape, on the one hand, and those in the Northern Cape, on the other, these being the provinces with the largest Coloured populations. Thus, given the uncertainty surrounding the estimates for the other provinces, it was decided to group the provinces closest to each of these two levels of mortality and thus to estimate one set of child mortality rates for the Coloured populations of Western Cape, Eastern Cape,

Figure 4 Under-five mortality ($_5q_0$) by province, African children

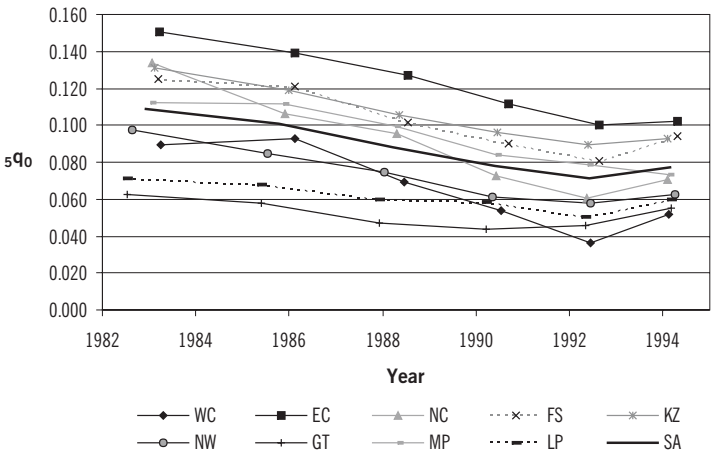


Figure 5 Under-five mortality ($_5q_0$) by province, Coloured children

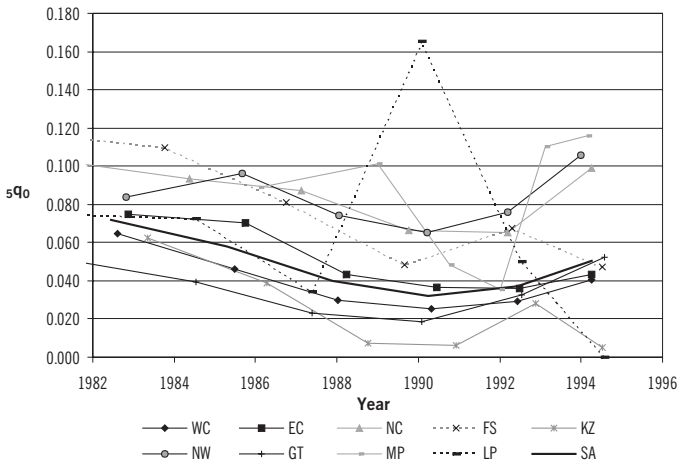
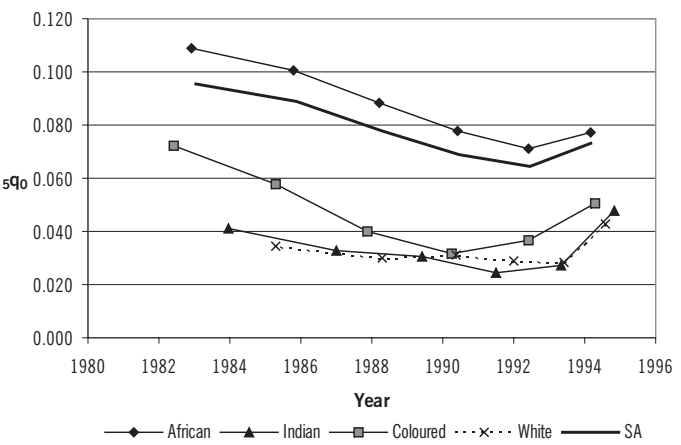


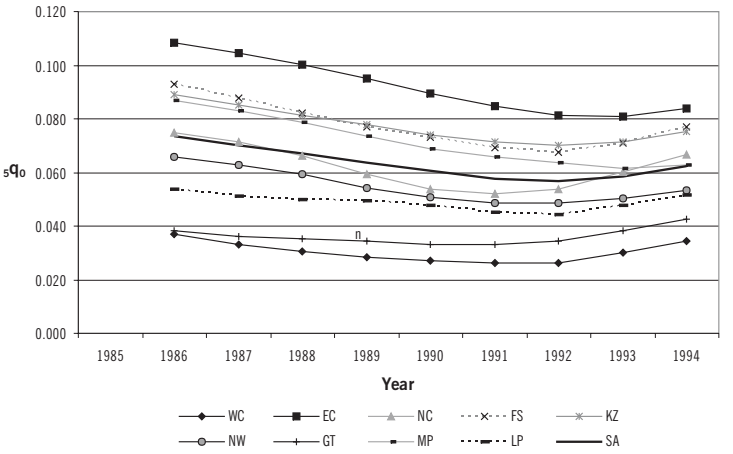
Figure 6 Under-five mortality ($_5q_0$) by population group



KwaZulu-Natal, Gauteng and Limpopo, calculated from their combined data. The other four provinces were then combined to produce a second set of rates.

Thus, 13 series of child mortality estimates were derived in all, which were then combined to produce provincial and national weighted estimates (Figure 6). Evidence suggests that the Brass method tends to overestimate

Figure 7 Under-five mortality ($_5q_0$) by province



under-five mortality in South Africa as a result of the unusually long birth intervals that characterise the population. In particular, indirect estimates made from the 1998 DHS data are substantially higher than estimates calculated directly from the same data. Taking this discrepancy as indicative of the size of the biases in the indirect estimates, all the census-based estimates of under-five mortality at the provincial level were reduced by 16 per cent to produce final estimates.

Finally, these under-five mortality rates were split, first into rates for boys and girls and then into infant mortality and child mortality ($_4q_1$) rates, using relationships derived from the 1998 DHS.[5]

Results

The summary results are shown in Figure 7 and detailed estimates of infant and under-five mortality for boys and girls are presented in Tables 7 to 10 in the appendix. These sex-specific estimates apply to the calendar years in question and were derived by interpolation from the time trends produced by the Brass

5 $q_f(5)/q(5)=1.9968q(5)+0.7286$
$q_m(5)/q(5)=-2.1728q(5)+1.2822$
$q_f(1)/q_f(5)=-1.1279q(5)+0.7843$
$q_m(1)/q_m(5)=-0.9058q(5)+0.805$

method. Rates for the period 1994–1996 were assumed to increase by 6 per cent per year, which is consistent with the annual rate of increase in under-five mortality since 1993 in the country as a whole according to the 1998 DHS.

According to these estimates, under-five mortality in Eastern Cape is more than double that in Western Cape and Gauteng. Infant and child mortality are lower in Limpopo and North West provinces than in the three eastern provinces – Eastern Cape, KwaZulu Natal, and Mpumalanga. Free State also has rather high child mortality. Under-five mortality has tended to fall more rapidly in the higher mortality provinces. In addition, the Coloured population benefited from a rapid decline in mortality in between the mid-1980s and mid-1990s (Figure 6), as did Africans in Western Cape (Figure 4). The latter trends are offset in the estimates for Western Cape province as a whole by the changes in the racial composition of its population over the period.

ADULT MORTALITY

Method

In order to derive adult mortality rates for each of the provinces from vital registration data, one needs first to correct the deaths for under-reporting.[6] However, inter-provincial rates of migration are likely to be an order of magnitude higher than rates of international migration for the country as a whole. Thus, application of the standard indirect techniques for estimating the completeness of adult deaths (Bennett and Horiuchi 1984; Brass 1975; Hill 1984; Preston, Coale, Trussell *et al.* 1980) could only be used if one could allow for internal and international migration to and from each of the provinces. Since reliable estimates of migration are not available at the provincial level, such methods are likely to produce implausible results.

Instead, the relative level of completeness of adult death registration (*Ca*) in the provinces has been inferred from the completeness of registration of child deaths (*Cc*). Although the procedure adopted is somewhat arbitrary, various constraints were placed on the results to prevent them being implausible.

As a first step, *Cc* was estimated for each province in 1996 and for the country as a whole over time. This was done by dividing the recorded deaths

6 To the extent that deaths of residents of one province may be misrecorded as deaths in another (probably adjacent) province, one can also get 'over-recording' of deaths.

under age five by the expected number of deaths. The expected number of deaths was calculated using the estimates of child mortality described in the previous section and an estimate of the number of births derived by applying the age-specific fertility rates described in the section before that to numbers of women aged 15–49 in provincial projections made with the ASSA 2000 package. These results are shown in Table 1[7].

To estimate *Ca*, the assumption is made that it is linearly related to *Cc*. Only limited evidence exists in support of this bold assumption. However, as Figures 8 and 9 show, a plot of the *reported* adult death rates for those in their sixties against 1-*Cc* for each of the provinces reveals a reasonably linear relationship, suggesting that in provinces where the registration of child deaths is low (i.e. 1-*Cc* is high) the unadjusted mortality rates for adults are also low. To the extent that this reflects under-reporting of deaths, it demonstrates a approximately linear relationship between *Ca* and *Cc*.

Table 1 Estimates of the completeness of registration of deaths under age five

	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
1986	–	–	–	–	–	–	–	–	–	**45%**
1987	–	–	–	–	–	–	–	–	–	**43%**
1988	–	–	–	–	–	–	–	–	–	**44%**
1989	–	–	–	–	–	–	–	–	–	**39%**
1990	–	–	–	–	–	–	–	–	–	**32%**
1991	–	–	–	–	–	–	–	–	–	**38%**
1992	–	–	–	–	–	–	–	–	–	**38%**
1993	–	–	–	–	–	–	–	–	–	**34%**
1994	–	–	–	–	–	–	–	–	–	**35%**
1995	–	–	–	–	–	–	–	–	–	**37%**
1996	64%	15%	65%	54%	39%	55%	64%	38%	17%	**39%**

Working on the assumption that *Ca* is a linear function of *Cc* across provinces, the slope and intercept of this line were determined initially by trial

7 For 1986–1995 the recorded deaths were those that occurred in the particular years. For 1996 the recorded deaths were those reported rather than those that occurred in 1996. This estimate was preferred since deaths that occurred in 1996 but were only reported later have yet to be processed.

Figure 8 Reported death rate at 65 to 70 ($_5m_{65}$) plotted against incompleteness of registration of child deaths (1-*Cc*) for each of the provinces, males, 1996

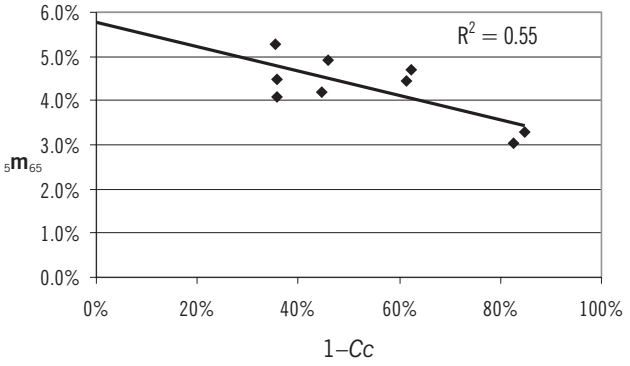
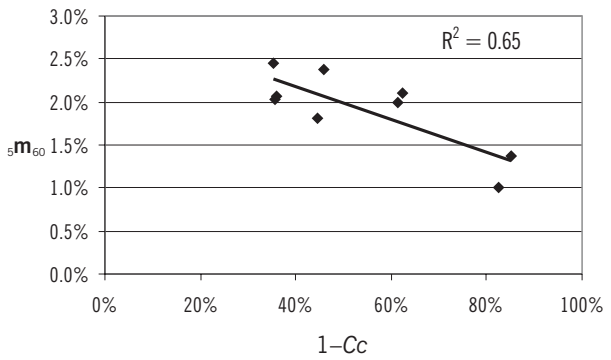


Figure 9 Reported $_5m_{60}$ plotted against incompleteness of registration of child deaths (1-*Cc*) for each of the provinces, females, 1996



and error so that the line would pass through *Cc* and *Ca* for the country as a whole and that the national estimates of $_5m_{65}$ for men and $_5m_{60}$ for women obtained by adjusting and aggregating the provincial data equalled the

adjusted estimates derived from data on the country as a whole. However, this procedure resulted in various inconsistencies, including an implausibly high and low *Cc* in some of the provinces, too low a correlation between childhood and adult mortality for males, and too high an estimate of adult mortality for men in Eastern Cape. Thus, it was decided to make the following assumptions:

- for women, that the fit of *Ca* to *Cc* by province that passed through the national estimates of *Cc* and *Ca* is chosen to maximise the correlation between ${}_{45}q_{15}$ and ${}_{5}q_{0}$ (R^2=88 per cent);
- that, as the proportions of men's and women's deaths reported nationally were equal in 1996, the proportion of adult men's deaths reported in each province also matched that for women.

The other source of adult mortality data that can potentially be used to estimate adult mortality at the provincial level is the questions on whether the mother and the father of each individual is alive that were included on the 1996 census schedule. Methods for estimating adult mortality from such orphanhood data are well established (Timæus 1992). Their most important limitation is that they can only yield broad estimates of the overall level of adult mortality, not detailed schedules of age-specific death rates. In addition, because they reflect the lifetime experience of respondents, the estimates refer to several years before they were collected, that is the late 1980s, rather than to the time of the census. Thus, one would not expect the orphanhood-based estimates of adult mortality to be the same as those we obtain from the registration statistics. Moreover, the orphanhood estimates, like the registration statistics, of mortality at the provincial level are subject to bias as a result of migration between provinces. For these data, the problem is that the parents who are being reported on may not live in the province in which their child was enumerated. The resulting misclassification bias may be particularly large for provinces such as Gauteng, in which much of the population was born elsewhere in South Africa. For these reasons, we do not employ the orphanhood data as a primary source of adult mortality estimates by province. However, such estimates are used as a partial check on the credibility of our registration-based estimates of adult mortality.

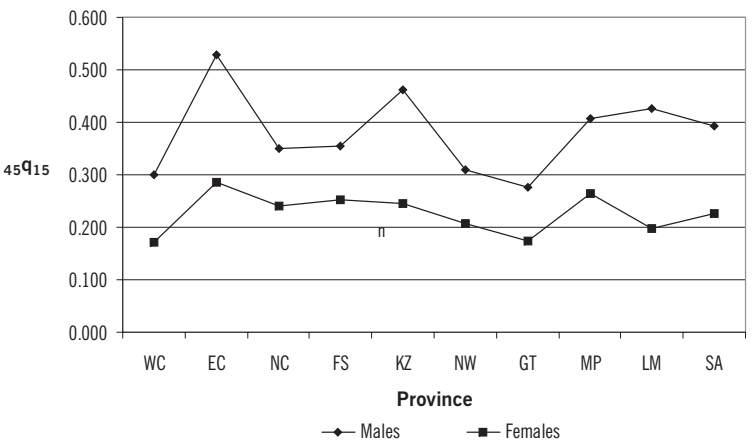
Results

The registration-based estimates of overall mortality in adulthood for men and women are compared in Figure 10.[8]

This comparison is a little disappointing, showing both inconsistencies between the rates for men and those for women in a number of provinces and surprisingly high rates for men in the Eastern Cape and perhaps KwaZulu-Natal. However, as we have no empirical grounds for adjusting these rates further, it was decided to accept them as the best estimates we can derive at present.

The corresponding estimates of completeness of reporting of adult deaths are given in Table 2. As might be expected, they indicate relatively high levels of registrations in the Western Cape, Northern Cape and Gauteng and low levels in the Eastern Cape, KwaZulu-Natal, Mpumalanga and Limpopo. Five provinces apparently have more than 100 per cent of deaths registered. It seems plausible that some deaths of people from other provinces may be recorded as deaths of residents in Western Cape, Gauteng and possibly the Northern Cape. It is more worrying to see coverage rates of more than 100 per cent in Free State and North West provinces. The most plausible

Figure 10 Estimates of the probability of dying between ages 15 and 60 ($_{45}q_{15}$) by province, all population groups, 1996



8 The points are joined by lines for visual impact and not to imply any continuity between the points.

interpretation of these statistics is not that non-existent deaths are being registered but that the coverage of the census in these provinces is worse than that of registration of adult deaths.

Table 2 Percent completeness, by province and nationally, of death registration relative to the census for adults in their sixties

	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
Males	117	57	118	105	86	107	118	85	60	**86**
Females	117	57	118	105	86	107	118	85	60	**86**

Rates for the provinces for the years prior to 1996 can be derived by assuming, in line with the assumption made at the national level, that the non-AIDS adult mortality remained constant between 1985 and 1996. Certainly there is empirical evidence that rates of mortality at ages over 60 have not changed much between 1985 and 1996 (Timæus, Dorrington, Bradshaw *et al.* 2001). Abridged life tables for 1996 produced by combining the census-based childhood mortality rates and registration-based adult mortality rates derived above are given in Tables 11 and 12.

DISCUSSION

The estimates of fertility presented here are the most reliable that we can make at the provincial level given the limitations of the data available. While it would have been useful to compare these results with those from other data sources, this is not possible with estimates as disaggregated as these. However, we were able to verify by comparison of standardised fertility distributions by population group with data presented in the 1983 President's Council Report (South Africa: Republic of 1983) that, over the period covered by our estimates, the (standardised) age distribution of fertility has not changed to any significant degree for any of the population groups. This obviates the need for further adjustments to allow for changing age distributions of childbearing.

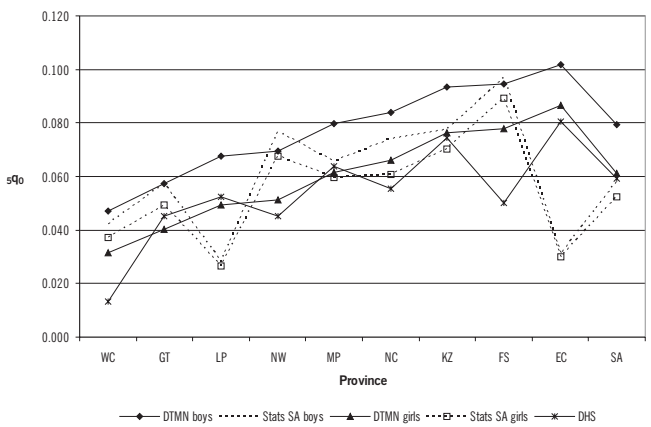
The results are consistent with earlier analyses of census data using reverse-survival methods (Moultrie 2002; Moultrie and Timæus 2002). Those analyses also pointed to a slow and gradual decline over an extended period in the level of fertility among South African women. On the other hand, comparison of the estimates of the national total fertility rate presented here with estimates based on other data suggest that the earlier estimates presented

here are somewhat too low. This is probably because the numbers of children ever borne by older women, upon which the estimates for the earlier years are based, are under-reported. Thus, we suspect that the rates shown in Tables 5 and 6 are some 10 per cent too low in 1985 with that difference reducing with time to 1990, from which point the rates may be assumed to be reasonably accurate.

Fertility in South Africa has declined gradually in each of the population groups over the period from 1985 to 1996. While this process of gradual decline cannot, of course, continue indefinitely, it seems unlikely that there will be a significant reversal in women's reproductive intentions and desires regarding birth spacing and childbearing in the short-to-medium term. By the same token, there are few grounds to suppose that the gradual decline in the level of fertility observed since the 1960s will not continue. And, given the spread of HIV and our knowledge of the relationships between infection with HIV and fertility, even fewer grounds exist for suspecting that fertility rates in South Africa may rise to any significant degree in the next few years.

As far as the child mortality rates are concerned, while we have attempted to produce the most reliable estimates possible given the limitations of the data, greater uncertainty remains as to their accuracy than does for those of fertility. As the 1998 DHS data do not allow one to examine differential trends between provinces in child mortality, we have had to rely on the census data.

Figure 11 Comparison of estimates of under-five mortality ($_5q_0$) for boys and girls with those of Statistics South Africa



However, as we have found that these data and the indirect estimation method suffer from various biases in South Africa, we scaled all the final estimates down by the same amount to allow for this. However, it may be that this adjustment should differ slightly by province. It is also possible that part of the discrepancy between the indirect and direct estimates of under-five mortality calculated from the 1998 DHS data arises from errors in the reporting of dates of birth and ages at death, rather than from bias in the indirect estimates resulting from long birth intervals. If this is so, we may have reduced the 1996 census-based estimates of child mortality by somewhat too much to produce final estimates. Lack of reliable provincial-level data with which to estimate the size of the increase in child mortality between 1994 and 1996 is a further residual problem.

It is of interest to compare our estimates of under-five mortality in 1996 with those from the official South African life tables for the same year (Statistics South Africa 2000) and the unadjusted estimates derived from the DHS data representing the 10-year period preceding the 1998 survey (Department of Health 2002). This comparison is shown in Figure 11.

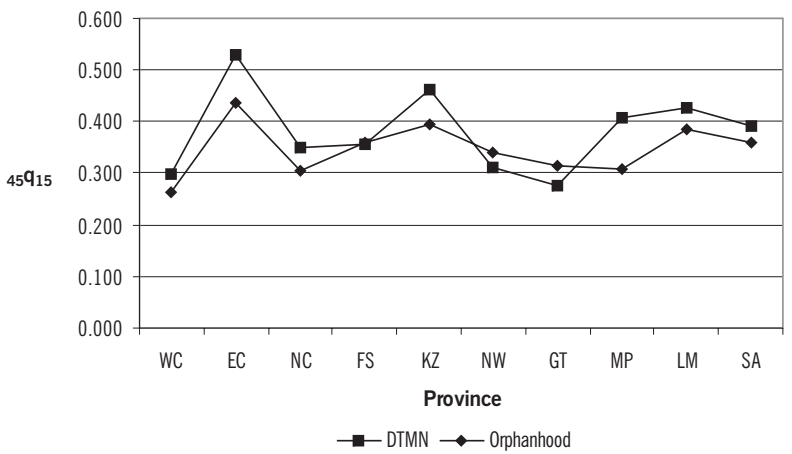
Four things are apparent from Figure 11. First, the official estimates of childhood mortality are lower than ours. Although Statistics South Africa does not describe exactly how it arrived at these estimates, they are consistent with Statistics South Africa having simply applied the level of completeness of reporting of adult deaths to child deaths. Second, there is very little difference between the official estimates of the rates for girls and boys (again this is probably the result of using adult levels of completeness). Third, the ranking of our rates by province is inconsistent with the official rates, which vary more between the provinces and indicate the very unlikely conclusion that rates of childhood mortality are lowest in the Eastern Cape and Limpopo. These happen also to be the provinces with the lowest level of reporting of adult deaths according to our analysis and also two of the poorest provinces. Finally, although both sets of estimates tend to be higher than those produced from the 1998 DHS, the estimates produced in this paper are much more closely correlated with those from the DHS (R^2 = 73 per cent) than are the estimates produced by Statistics South Africa (R^2 = 0 per cent). Where our rates do differ substantially from the 1998 DHS rates (Western Cape and Free State), the DHS rates seem implausibly low (Department of Health 2002).

A peculiar feature of the estimates derived from the 1996 census data is that there is an upturn in the child mortality rates in the most recent period (Figure 6)

for each of the population groups. It is not clear why this should be. The fact that the upturn is largest for the lowest fertility groups suggests that it is probably either an artefact of the method or the result of selection bias – the most recent estimates are based solely on data on the children of young women aged 20–24. For the Coloured, Indian and White population groups at least, the upturn cannot reasonably be attributed to HIV/AIDS. However it could reflect problems with the health services (or with access to health care) at around the time of the collapse of the previous regime.

In order to estimate adult mortality by province we have had to make some strong assumptions. In particular, we assume that a linear relationship exists across the provinces between the completeness of reporting of adult deaths and the completeness of reporting of child deaths. While it seems reasonable to assume that a positive association exists between the performance of the civil registration system in these two age ranges, it is less certain that this relationship is a linear one. For example, there may be several provinces in which reporting of adult deaths is virtually complete but between which the proportion of child deaths reported varies. Moreover, the propensity to register a death in different province from that recorded as the province of residence in the census may be greater for adults than children. One surprising feature of our results is the suggestion that registration of adult deaths may

Figure 12 Comparison of the registration-based estimates (DTMN) of adult mortality ($_{45}q_{15}$) with those from the 1996 census orphanhood data, men

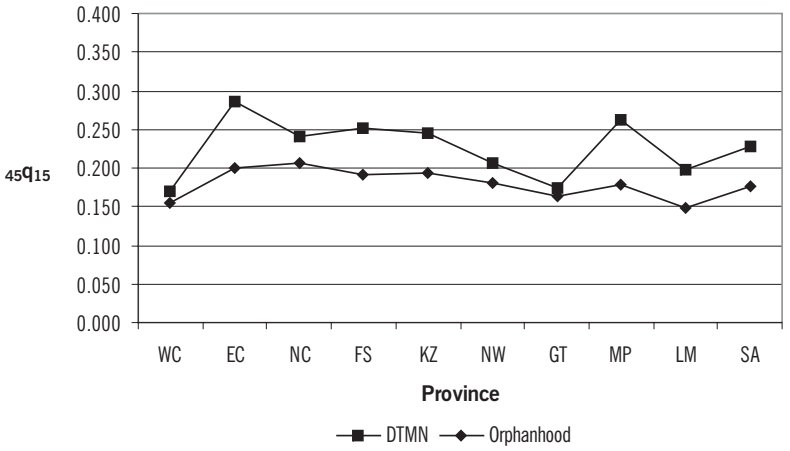


have been more complete than the census enumeration in 1996 in Free State and North West provinces. However, any fit that assumes a linear relationship between registration coverage for adult and child deaths but kept the coverage estimates for these provinces to less than 100 per cent would inflate adult mortality in Eastern Cape to very much higher (and probably implausible) levels than anywhere else in South Africa.

Despite these uncertainties, under-registration of adult deaths nationally and in all of the provinces except Eastern Cape and Limpopo was fairly low by 1996. Thus, the adjustments we make to the data are small. The impact of even a large proportional error in a small adjustment to the raw data is also small. Thus, while it remains unclear exactly how high adult mortality in Eastern Cape is, in other respects our estimates of adult mortality have a reasonably secure basis. For example, it is difficult to posit a pattern of under-registration that would alter the conclusion that men's mortality in KwaZulu-Natal is high compared both with that of men from other provinces and that of women from the same province.

Comparison of the death registration-based estimates of adult mortality with those derived for the late 1980s from the 1996 census orphanhood data lends some support to our estimates (Figures 12 and 13). First, the orphanhood data for men yield estimates of the overall level of adult mortality across

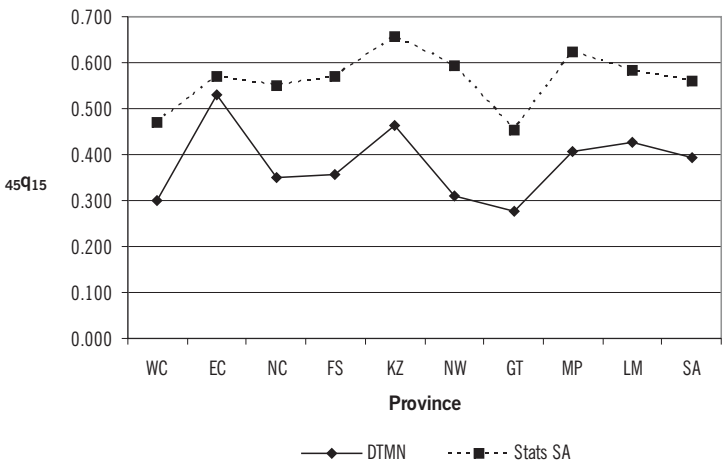
Figure 13 Comparison of the registration-based estimates (DTMN) of adult mortality ($_{45}q_{15}$) with those from the 1996 census orphanhood data, women



the country that are very similar to those calculated from registered deaths; the two series are also similar for women, though the orphanhood estimates are lower. Second, like the registration estimates, those from orphanhood indicate that the differences between the provinces in men's mortality are much larger than the differences for women. Third, both sets of estimates suggest that Eastern Cape, KwaZulu-Natal and Limpopo are high mortality provinces for men, whereas Western Cape and Gauteng have relatively low mortality. For women though, both sources suggest that Limpopo is a low mortality province as well as Western Cape and Gauteng. The biggest discrepancy between the two series is that the registration-based estimates indicate that Mpumalanga has fairly high mortality, while the orphanhood data indicate that it has fairly low mortality. The orphanhood estimates support our belief that, although the jury is still out on the exact level of under-reporting of adult deaths in the different provinces of South Africa, our estimates are as reliable as is possible given the defective recording of usual residence on death certificates.

Comparison of our estimates of adult mortality with those from the official life tables (Table 3 and Figures 14 and 15) shows that Statistics South Africa's estimates are much higher. As a result, although the official estimates of childhood mortality are lower than ours, the official estimates of life expectancy at birth are also three to five years lower than those presented here.

Figure 14 Comparison of the estimates of adult mortality, ${}_{45}q_{15}$ (DMNT) with the Statistics South Africa (Stats SA) estimates, men

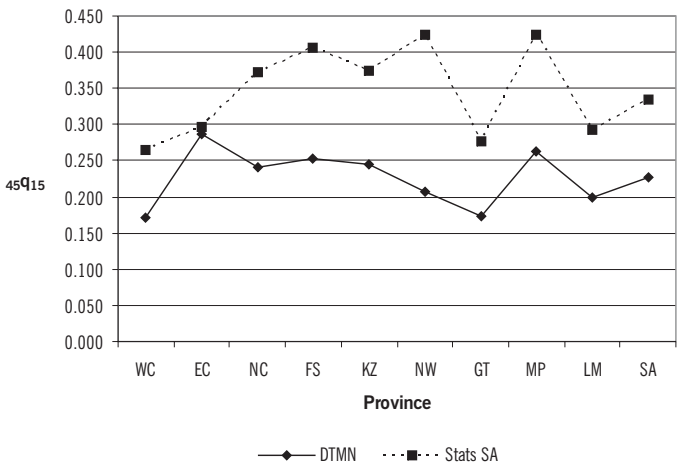


In both sets of estimates, the rates for men and women correlate only loosely. We feel confident that adult mortality nationally in 1996 was lighter than has been estimated by Statistics South Africa, while the reverse is the case for child mortality. Our sub-national estimates suggest this is true of every province, except perhaps for adults in Eastern Cape.

The most striking finding of this paper is that very large geographical variations in mortality exist within South Africa. For men, life expectancy at birth ranges from 53 years in KwaZulu-Natal, and probably less in Eastern Cape, to a high of nearly 63 years in Western Cape and Gauteng. For women, life expectancy at birth varies from just over 60 years to about 70 years. As a result, the difference between the two sexes in life expectancy at birth ranges from about 5 years in some provinces to an unusually large gap of nearly 10 years in others. The ranking of the provinces with respect to life expectancy is similar for the two sexes, with the exception that for women, unlike men, life expectancy at birth in KwaZulu-Natal is no worse than in Free State or Mpumalanga.

It can also be seen from Table 3 that some significant differences exist between our estimates of adult mortality in the various provinces and those used in the ASSA 2000 projection model distributed by the Actuarial Society of South Africa (Actuarial Society of South Africa 2002). The mortality rates used

Figure 15 Comparison of the estimates of adult mortality, ${}_{45}q_{15}$ (DMNT) with the Statistics South Africa (Stats SA) estimates, women



in the provincial version of the ASSA 2000 model were calculated as weighted averages of the national rates for each population group, weighting by the proportions of the different population groups in the province at each age. Our results suggest that this is not sufficiently accurate for some of the provinces. Thus, geographical differentials in mortality in South Africa are not just the product of racial inequalities in mortality. In addition, the mortality of the African population varies greatly between the provinces of South Africa.

Table 3 Comparison of estimates of adult mortality ($_{45}q_{15}$) and life expectancy (e(0)) with those of Statistics South Africa (Stats SA) and the ASSA 2000 model

	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
$_{45}q_{15}$										
Males										
Estimate	0.300	0.530	0.350	0.356	0.463	0.310	0.277	0.408	0.426	**0.392**
Stats SA	0.470	0.571	0.550	0.570	0.657	0.594	0.453	0.622	0.584	**0.560**
ASSA2000	0.356	0.377	0.365	0.375	0.382	0.382	0.352	0.388	0.384	**0.394**
Females										
Estimate	0.170	0.286	0.240	0.252	0.245	0.207	0.174	0.263	0.198	**0.227**
Stats SA	0.265	0.297	0.372	0.406	0.374	0.424	0.277	0.424	0.293	**0.335**
ASSA2000	0.214	0.238	0.227	0.235	0.248	0.240	0.214	0.251	0.243	**0.240**
e(0)										
Males										
Estimate	62.7	51.0	58.3	57.3	53.3	61.1	62.8	56.2	57.0	**57.0**
Stats SA	55.7	54.2	51.2	49.3	47.1	50.0	55.5	49.6	54.1	**52.1**
ASSA2000	60.6	56.7	59.2	57.8	57.1	58.1	60.3	57.4	58.3	**57.2**
Females										
Estimate	70.2	60.5	64.8	62.5	62.4	66.5	68.7	62.9	66.6	**64.8**
Stats SA	65.7	65.8	59.9	56.1	58.1	56.5	63.9	57.2	65.1	**61.6**
ASSA2000	68.4	63.6	66.6	64.8	63.5	65.0	67.6	64.0	65.0	**65.0**

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Table 4 Corrected estimates of fertility by province for African South Africans and for the other population groups, 1996 census (at the census date)

	Africans										*Coloureds*	*Indians*	*Whites*	***National***
	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	*Weighted*				
15–19	0.072	0.083	0.088	0.068	0.080	0.091	0.074	0.099	0.105	0.087	0.144	0.120	0.089	**0.079**
20–24	0.141	0.179	0.149	0.152	0.150	0.161	0.133	0.168	0.177	0.160	0.133	0.186	0.151	**0.151**
25–29	0.140	0.192	0.147	0.153	0.146	0.165	0.126	0.164	0.176	0.158	0.097	0.085	0.088	**0.156**
30–34	0.116	0.171	0.126	0.123	0.119	0.145	0.101	0.138	0.152	0.135	0.060	0.045	0.031	**0.125**
35–39	0.085	0.133	0.097	0.085	0.085	0.115	0.071	0.104	0.118	0.102	0.023	0.024	0.016	**0.087**
40–44	0.039	0.068	0.050	0.037	0.039	0.061	0.032	0.052	0.061	0.051	0.002	0.008	0.010	**0.042**
45–49	0.005	0.010	0.008	0.004	0.005	0.010	0.004	0.008	0.010	0.008	0.068	0.024	0.019	**0.007**
TFR	**2.99**	**4.18**	**3.32**	**3.11**	**3.13**	**3.73**	**2.71**	**3.66**	**4.00**	**3.50**	**2.64**	**2.45**	**2.02**	**3.24**

Table 5 Estimates of total fertility by province for African South Africans and for the other population groups, 1985–1996, based on the 1996 census results (at the start of the year)

	Africans											
Year	*WC*	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	*Coloureds*	*Indians*	*Whites*
1986	3.49	4.50	3.70	3.61	3.63	4.20	3.03	4.20	4.53	3.01	2.65	2.22
1987	3.42	4.48	3.67	3.53	3.56	4.15	3.00	4.14	4.49	2.97	2.62	2.21
1988	3.35	4.46	3.63	3.45	3.49	4.11	2.97	4.08	4.45	2.94	2.60	2.19
1989	3.31	4.44	3.59	3.41	3.44	4.07	2.95	4.04	4.42	2.90	2.59	2.16
1990	3.28	4.41	3.55	3.37	3.40	4.04	2.93	4.00	4.40	2.87	2.57	2.14
1991	3.24	4.38	3.50	3.33	3.35	4.00	2.91	3.95	4.38	2.83	2.56	2.12
1992	3.21	4.35	3.46	3.29	3.30	3.97	2.88	3.91	4.35	2.80	2.55	2.09
1993	3.17	4.32	3.42	3.25	3.26	3.94	2.85	3.86	4.33	2.76	2.53	2.07
1994	3.13	4.28	3.39	3.22	3.22	3.89	2.81	3.81	4.25	2.73	2.51	2.05
1995	3.08	4.25	3.36	3.18	3.19	3.84	2.78	3.76	4.16	2.70	2.49	2.04
1996	3.03	4.21	3.34	3.14	3.15	3.78	2.74	3.70	4.07	2.67	2.47	2.03

Table 6 Estimates of total fertility by province, 1985–1996, based on the 1996 census results (at the start of the year)

	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
1985	3.05	4.25	3.19	3.46	3.90	3.58	2.86	4.02	4.48	**3.67**
1986	3.00	4.22	3.15	3.39	3.86	3.51	2.84	3.98	4.44	**3.63**
1987	2.96	4.20	3.12	3.32	3.82	3.45	2.82	3.93	4.41	**3.59**
1988	2.92	4.18	3.08	3.26	3.78	3.39	2.80	3.88	4.37	**3.56**
1989	2.88	4.16	3.05	3.23	3.75	3.35	2.78	3.84	4.35	**3.53**
1990	2.85	4.13	3.01	3.19	3.73	3.31	2.77	3.81	4.33	**3.51**
1991	2.81	4.10	2.98	3.16	3.70	3.26	2.75	3.77	4.31	**3.47**
1992	2.78	4.07	2.96	3.12	3.68	3.22	2.73	3.73	4.29	**3.44**
1993	2.76	4.04	2.92	3.09	3.66	3.18	2.71	3.69	4.27	**3.41**
1994	2.73	4.01	2.90	3.06	3.62	3.15	2.69	3.64	4.19	**3.37**
1995	2.70	3.98	2.88	3.02	3.58	3.12	2.66	3.59	4.10	**3.33**
1996	2.67	3.95	2.85	2.99	3.53	3.09	2.63	3.54	4.01	**3.29**

Table 7 Probability of dying before age five ($_5q_0$) by province, 1986–1996, based on the 1996 census results, boys

	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
1986	0.044	0.114	0.084	0.100	0.097	0.075	0.046	0.095	0.063	**0.082**
1987	0.040	0.110	0.081	0.096	0.093	0.072	0.044	0.091	0.060	**0.079**
1988	0.037	0.107	0.076	0.091	0.090	0.068	0.042	0.087	0.059	**0.076**
1989	0.035	0.102	0.068	0.086	0.086	0.063	0.041	0.082	0.058	**0.073**
1990	0.033	0.097	0.063	0.082	0.083	0.059	0.040	0.078	0.056	**0.070**
1991	0.032	0.093	0.061	0.078	0.080	0.057	0.040	0.075	0.053	**0.067**
1992	0.032	0.090	0.063	0.077	0.079	0.057	0.041	0.073	0.053	**0.066**
1993	0.037	0.089	0.069	0.080	0.080	0.059	0.046	0.071	0.056	**0.068**
1994	0.042	0.092	0.076	0.086	0.084	0.062	0.051	0.072	0.060	**0.071**
1995	0.044	0.097	0.080	0.090	0.089	0.066	0.054	0.076	0.064	**0.075**
1996	0.047	0.102	0.084	0.095	0.093	0.069	0.057	0.080	0.067	**0.079**

Table 8 Infant mortality rate ($_1q_0$) by province 1986–1996, based on the 1996 census results, boys

	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
1986	0.034	0.080	0.061	0.072	0.069	0.055	0.035	0.068	0.047	**0.060**
1987	0.031	0.078	0.059	0.069	0.067	0.053	0.033	0.066	0.045	**0.058**
1988	0.029	0.076	0.056	0.066	0.065	0.051	0.033	0.063	0.044	**0.056**
1989	0.027	0.073	0.051	0.063	0.063	0.047	0.032	0.060	0.044	**0.054**
1990	0.026	0.070	0.047	0.060	0.061	0.045	0.031	0.057	0.043	**0.052**
1991	0.025	0.067	0.046	0.058	0.059	0.043	0.031	0.055	0.040	**0.050**
1992	0.025	0.065	0.047	0.056	0.058	0.043	0.032	0.054	0.040	**0.049**
1993	0.028	0.065	0.051	0.059	0.059	0.044	0.035	0.052	0.042	**0.050**
1994	0.032	0.067	0.056	0.062	0.061	0.047	0.039	0.053	0.045	**0.053**
1995	0.034	0.070	0.058	0.065	0.064	0.049	0.041	0.056	0.048	**0.055**
1996	0.036	0.073	0.061	0.068	0.067	0.052	0.043	0.058	0.050	**0.058**

Table 9 Probability of dying before age five ($_5q_0$) by province 1986–1996, based on the 1996 census results, girls

	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
1986	0.030	0.103	0.066	0.085	0.080	0.057	0.031	0.078	0.045	**0.064**
1987	0.026	0.098	0.062	0.079	0.076	0.054	0.029	0.074	0.043	**0.061**
1988	0.024	0.093	0.057	0.073	0.072	0.050	0.028	0.070	0.041	**0.058**
1989	0.022	0.087	0.050	0.068	0.069	0.046	0.027	0.064	0.041	**0.055**
1990	0.021	0.081	0.045	0.064	0.065	0.042	0.026	0.060	0.039	**0.051**
1991	0.020	0.076	0.043	0.060	0.062	0.040	0.026	0.057	0.037	**0.049**
1992	0.021	0.072	0.045	0.058	0.061	0.040	0.027	0.054	0.036	**0.048**
1993	0.024	0.072	0.051	0.062	0.062	0.042	0.031	0.052	0.039	**0.049**
1994	0.027	0.075	0.057	0.068	0.066	0.045	0.035	0.053	0.043	**0.053**
1995	0.029	0.081	0.061	0.073	0.071	0.048	0.037	0.057	0.046	**0.057**
1996	0.032	0.087	0.066	0.078	0.076	0.051	0.040	0.061	0.049	**0.061**

Table 10 Infant mortality rate ($_1q_0$) by province 1986–1996, based on the 1996 census results, girls

	WC	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
1986	0.022	0.069	0.047	0.058	0.056	0.041	0.023	0.054	0.033	**0.046**
1987	0.020	0.066	0.045	0.055	0.053	0.039	0.022	0.052	0.031	**0.044**
1988	0.018	0.063	0.041	0.051	0.051	0.036	0.021	0.049	0.031	**0.042**
1989	0.017	0.060	0.037	0.048	0.048	0.033	0.021	0.046	0.030	**0.039**
1990	0.016	0.056	0.033	0.045	0.046	0.031	0.020	0.043	0.029	**0.037**
1991	0.015	0.053	0.032	0.043	0.044	0.030	0.020	0.041	0.027	**0.036**
1992	0.016	0.051	0.033	0.042	0.043	0.030	0.021	0.039	0.027	**0.035**
1993	0.018	0.051	0.037	0.044	0.044	0.031	0.023	0.038	0.029	**0.036**
1994	0.021	0.053	0.041	0.048	0.047	0.033	0.026	0.039	0.032	**0.038**
1995	0.022	0.056	0.044	0.051	0.050	0.035	0.028	0.041	0.034	**0.041**
1996	0.024	0.060	0.047	0.054	0.053	0.037	0.030	0.044	0.036	**0.044**

Table 11 Provincial life tables, 1996, men

Age	*WC*	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	**1.0000**
1	0.9642	0.9274	0.9388	0.9319	0.9328	0.9485	0.9569	0.9416	0.9498	**0.9418**
5	0.9530	0.8982	0.9160	0.9054	0.9067	0.9306	0.9427	0.9202	0.9326	**0.9206**
10	0.9494	0.8950	0.9123	0.9014	0.9013	0.9274	0.9392	0.9161	0.9297	**0.9168**
15	0.9463	0.8921	0.9094	0.8981	0.8965	0.9243	0.9360	0.9117	0.9270	**0.9133**
20	0.9338	0.8827	0.8973	0.8896	0.8848	0.9176	0.9245	0.9016	0.9220	**0.9035**
25	0.9117	0.8593	0.8726	0.8720	0.8567	0.9029	0.9034	0.8804	0.9087	**0.8813**
30	0.8875	0.8232	0.8441	0.8426	0.8165	0.8788	0.8803	0.8516	0.8836	**0.8511**
35	0.8616	0.7769	0.8112	0.8067	0.7676	0.8518	0.8541	0.8152	0.8487	**0.8152**
40	0.8336	0.7294	0.7774	0.7715	0.7232	0.8186	0.8279	0.7801	0.8136	**0.7793**
45	0.8003	0.6750	0.7418	0.7297	0.6727	0.7835	0.7966	0.7367	0.7681	**0.7372**
50	0.7595	0.6111	0.6954	0.6812	0.6138	0.7367	0.7580	0.6785	0.7092	**0.6857**
55	0.7087	0.5420	0.6388	0.6296	0.5515	0.6873	0.7128	0.6181	0.6435	**0.6285**
60	0.6359	0.4637	0.5628	0.5586	0.4771	0.6178	0.6522	0.5367	0.5664	**0.5553**
65	0.5532	0.3936	0.4750	0.4812	0.4042	0.5519	0.5826	0.4609	0.4961	**0.4806**
70	0.4453	0.3051	0.3685	0.3722	0.3093	0.4446	0.4788	0.3465	0.3949	**0.3786**
75	0.3298	0.2174	0.2698	0.2648	0.2194	0.3347	0.3562	0.2367	0.2868	**0.2737**
80	0.2146	0.1124	0.1703	0.1437	0.1197	0.1910	0.2179	0.1180	0.1567	**0.1555**
$_{45}q_{15}$ =	**0.328**	**0.480**	**0.381**	**0.378**	**0.468**	**0.332**	**0.303**	**0.411**	**0.389**	**0.392**
e(0) =	**61.4**	**52.9**	**56.9**	**56.3**	**53.1**	**60.2**	**61.5**	**56.1**	**58.6**	**57.0**

Table 12 Provincial life tables, 1996, women

Age	*WC*	*EC*	*NC*	*FS*	*KZ*	*NW*	*GT*	*MP*	*LP*	***SA***
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	**1.0000**
1	0.9763	0.9405	0.9532	0.9457	0.9467	0.9628	0.9703	0.9561	0.9641	**0.9563**
5	0.9683	0.9133	0.9341	0.9221	0.9236	0.9488	0.9598	0.9385	0.9507	**0.9390**
10	0.9662	0.9110	0.9318	0.9192	0.9201	0.9462	0.9571	0.9356	0.9482	**0.9362**
15	0.9642	0.9089	0.9300	0.9165	0.9168	0.9436	0.9550	0.9323	0.9458	**0.9337**
20	0.9595	0.9041	0.9242	0.9104	0.9098	0.9374	0.9496	0.9256	0.9414	**0.9280**
25	0.9527	0.8927	0.9109	0.8946	0.8942	0.9242	0.9399	0.9118	0.9332	**0.9160**
30	0.9438	0.8749	0.8935	0.8723	0.8719	0.9055	0.9280	0.8927	0.9207	**0.8992**
35	0.9322	0.8545	0.8738	0.8472	0.8488	0.8835	0.9130	0.8681	0.9048	**0.8797**
40	0.9172	0.8321	0.8512	0.8215	0.8275	0.8613	0.8963	0.8455	0.8874	**0.8594**
45	0.8963	0.8053	0.8239	0.7937	0.8038	0.8374	0.8772	0.8179	0.8677	**0.8359**
50	0.8689	0.7725	0.7856	0.7618	0.7757	0.8098	0.8536	0.7846	0.8451	**0.8075**
55	0.8340	0.7363	0.7433	0.7241	0.7427	0.7798	0.8236	0.7447	0.8207	**0.7739**
60	0.7836	0.6791	0.6850	0.6703	0.6897	0.7343	0.7724	0.6856	0.7778	**0.7218**
65	0.7091	0.6108	0.6088	0.5918	0.6120	0.6684	0.7004	0.6033	0.7211	**0.6498**
70	0.6193	0.5096	0.5214	0.4890	0.5013	0.5724	0.5948	0.4974	0.6262	**0.5490**
75	0.5216	0.4105	0.4265	0.3973	0.3995	0.4771	0.4860	0.3906	0.5305	**0.4484**
80	0.4002	0.2507	0.3125	0.2526	0.2578	0.3273	0.3384	0.2348	0.3487	**0.3013**
$_{45}q_{15}$ =	**0.187**	**0.253**	**0.263**	**0.269**	**0.248**	**0.222**	**0.191**	**0.265**	**0.178**	**0.227**
e(0) =	**69.2**	**62.1**	**63.7**	**61.7**	**62.3**	**65.7**	**67.7**	**62.8**	**67.8**	**64.8**