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Objective: To examine changes in mortality in rural South Africa over the period 1992–1995 by age, sex and cause of death.

Design: As with much of sub-Saharan Africa, South Africa lacks effective vital registration and information on mortality is lacking. The Agincourt demographic and health surveillance system was established to inform health policy and practice with regard to rural subdistrict populations.

Methods: Prospective community-based study involving annual update of a household census with enquiry into all birth, death and migration events. All reported deaths \( n = 1001 \) are the subject of a verbal autopsy.

Results: An increasing trend in overall mortality relative to general population growth in the study area is apparent. There is evidence for a reversal in the previously declining trend in mortality among women 20–44 years. A comparison of 1992–1993 with 1994–1995 shows that most of the increase in mortality is concentrated in the younger adult (20–49 year) age group. AIDS and related diseases, particularly tuberculosis, appear primarily responsible. Injuries and violence (especially homicide) and circulatory disease are important, under-recognized causes of death, although their levels have remained constant over the period.

Conclusions: Mortality from AIDS and related diseases appears responsible for the probable reversal in mortality emerging in South Africa’s rural northeast. Findings carry implications for the emerging system of decentralized health care.

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Introduction

Lack of vital registration in sub-Saharan Africa has seriously compromised the application of mortality data to health planning and practice. Trends in health sector reform away from centralized towards decentralized, usually district-based, health systems accentuate this gap [1]. While global 'burden of disease' studies are proving highly influential in shaping intervention and research priorities at regional and international level [2], they do not remove the critical need for empirically derived data on national and district mortality patterns.

The Agincourt field site was established in 1992 and covers a subdistrict in the Bushbuckridge area of South Africa’s rural northeast, adjacent to its border with Mozambique. Part of the Bushbuckridge district health initiative, the site was established to support the
national effort in decentralized health system development. Demographic and health surveillance in Agincourt provides population-based information to support district health planning and practice, as well as a programme of advanced community-based research [3].

Here we examine changes in mortality over the period 1992–1995 by age, sex and cause of death. Despite the short time period, clear changes can be discerned. They will impact on local health services and have wider implications for South Africa’s new system of decentralized (district-based) health care. The data should also contribute to addressing the substantial gaps in our understanding of mortality in sub-Saharan Africa [4] and South Africa in particular [5].

Methods

Study area
South Africa’s apartheid policy resulted in the forced resettlement and concentration of Africans into geographically dispersed and economically inhospitable ‘homelands’. Part of the former Gazankulu area, Agincourt is home to some 63,000 people, of whom 44% are below the age of 15 and 26% are of Mozambican origin [3]. Given a population density of 148 persons per square kilometre and the low rainfall, there is little opportunity for subsistence agriculture and the area is better suited to cattle or game farming. Opportunities for employment outside the public sector are scarce and labour migration is high, affecting more than half of all men aged 25–59 years. The population lives in 20 village settlements, most with a primary school that is attended (despite late enrollment) by a majority of children. Only 6% of school-goers complete secondary school. One health centre linked to four satellite clinics serves the area, with the district hospital some 40 km away.

Fertility and mortality indicators established by surveillance (total fertility rate (TFR) = 3.5; life expectancy 65 years) seem to be close to the national average, although more precise comparisons are not possible because of a lack of reliable data at the national level (when available, results from the national census of 1996–1997 and the demographic and health survey 1998 should improve comparative work considerably). More information on the demographic characteristics of the Agincourt population can be found elsewhere [3].

Data collection
In 1992, all 20 villages of the field site were mapped and a household census conducted [2]. This baseline has been updated approximately annually, including documentation of all special events (births, deaths and in- and out-migrations). Data is computer-entered using a custom-made data entry program onto an Access database. Analysis to date has used the Microsoft Excel spreadsheet program, statistical packages including STATA and SYSTAT, and Epiinfo 6.02.

All recorded deaths are the subject of a verbal autopsy during which a questionnaire is administered by a trained, lay fieldworker to the closest caregiver of the deceased. The verbal autopsies are assessed by three medical officers who, blind to each other, use a series of consensus criteria to arrive at a diagnosis. Where a diagnosis cannot be reached, the cause of death is described as ‘undetermined’. The verbal autopsy instrument used in Agincourt is an adaptation of that developed in Niakhar, Senegal [6].

The field team comprises local youth, recruited from villages of the field site, who have completed secondary school. Community acceptance of their work, and the repeated process of household visits that this entails, is high and is reinforced by efforts to maintain a stable relationship between the field team and the study community. Regular opportunities for village-level feedback and dialogue, based on survey results, have characterized the project and constitute part of the ‘contract’ between study team and local communities.

Community acceptance of the project, quality checks on a 2% random sample of households, manual checking of data-capture forms, computerized validation routines and repeat visits to households where necessary contribute to the reliability of the census and special events data. A proportion of verbal autopsy diagnoses have been validated against hospital reference diagnoses by calculating the sensitivity, specificity and positive predictive value of each cause of death for which a hospital diagnosis could be found (K. Kahn, S.M. Tollman, M. Garenne, J.S.S. Gear, manuscript submitted).

Three census rounds have resulted in a longitudinal data set covering births, deaths and migrations for the period 1992–1995. Verbal autopsies have been conducted on 932 of the total 1001 deaths recorded during this time. No suitable respondent could be found for the outstanding 7% of deaths, largely because of out-migration of family members and sometimes whole households.

Analysis of female mortality
During the baseline census in 1992, the survival status of the mothers of all those in the resident population was established as completely as possible. This allowed retrospective study of survival among adult women using indirect demographic methods (maternal orphanhood technique); this technique estimates adult survivorship from the proportions of respondents not orphaned. The method is based on an equation that relates the female probability of surviving from age x
(e.g. 20 years) to \( x + n \) years to the proportion of respondents (in contiguous age groupings) whose mother was still alive at the time of interview. From the resulting survivorship probabilities, life-table estimates can be made [7]. The approach adopted was that described by Timaeus [8], which improves on the methods of Brass and Hill-Trussell [7] and yields more accurate estimates.

Estimates of maternal survival were converted to estimates of the mortality quotient (probability of dying) for women between the ages of 20 and 44 years using United Nations model life tables. From the prospective data (not shown), the general model life table was chosen as closest to the Agincourt situation. In the maternal orphanhood method, the probability of dying estimated from the youngest age group of respondents (i.e., the most recent estimate) is virtually insensitive to the choice of model life table. This choice can only affect the slope of the trend in the retrospective estimate. The indirect (retrospective) estimates could then be compared with the direct (prospective) life-table estimates of the same quotient (25q20 = the probability of dying between 20 and 44 years of age) derived from the routine demographic and health surveillance system. These estimates are comparable provided that the quality of the data is adequate.

Ethical considerations
Community consent and informed consent at individual and household level have been obtained and are integral to the research process. The University of the Witwatersrand's Committee for Research on Human Subjects (Medical) has reviewed and approved the research protocol (No. M 960720).

Results
Detailed analysis of the mortality profile, based on 1001 deaths between 1992 and 1995, provides insight into the cause-of-death pattern. Of note, is the continuing high level of deaths from infectious and nutritional causes among children (diarrhoea and kwashiorkor), coupled with strikingly few deaths from the vaccine-preventable diseases and acute respiratory infections. Notable amongst adults is the high level of circulatory disease among the older middle-aged and young elderly (heart failure and cerebrovascular accidents) and an unexpectedly high level of violent death among young men [9].

Trends in mortality
Figure 1 shows the number of deaths occurring in Agincourt each month during the period June 1992 to July 1995. The observed trend in mortality differs significantly from the trend that would be expected if deaths were increasing only because of population growth \( (P < 0.038) \). This finding is independent of population migration and indicates a relative increase in mortality over the three years 1992 to 1995.

Evidence of a steady, declining trend in adult female mortality for the 4 to 13 years prior to the survey (1979–1988) was found in the analysis of retrospective data (Fig. 2). In contrast, in the period of the prospective study (1992–1995), adult female mortality between 20 and 44 years was significantly higher (25q20 = 61.6 per 1000; \( P = 0.014 \)) than the most recent indirect estimate (43.3 per 1000 in 1984–1985), indicating a recent rise in the mortality of younger female adults. When the earlier trend is taken into account, the prospective estimates are 4.2 times higher than the 1979–1988 trend prolonged to 1992–1995. Even though the value of the slope based on indirect estimates can be questioned, the results suggest a serious reversal in the previously downward trend in mortality among women of reproductive age.

Age and sex patterns of mortality 1992–1995
Based on data from the prospective study, life tables were prepared for the periods between the censuses: between census 1 and 2 covering 19 months in 1992–1993 and between census 2 and 3 covering 21 months in 1994–1995.

Results show that most of the increase in mortality is concentrated in the 20–49 year age group (Table 1). There was a slight decline in mortality among children under 15 years (not shown). However, in somewhat less than 2 years, the mortality increase at age 20–49 was 23% for both sexes combined, and slightly higher

![Fig. 1. Number of deaths by month in Agincourt, June 1992 to July 1995.](image)

![Fig. 2. Estimates of female mortality at age 20–24 years at Agincourt. *The probability of dying between 20 and 44 years of age.](image)

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>1992–1993⁵</th>
<th>1994–1995⁶</th>
<th>Relative risk (2/1)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quotient⁶</td>
<td>Quotient⁶</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both sexes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–49</td>
<td>0.07571</td>
<td>0.09751</td>
<td>0.11966</td>
<td>1.23</td>
</tr>
<tr>
<td>50–74</td>
<td>0.40255</td>
<td>0.50225</td>
<td>0.42224</td>
<td>1.05</td>
</tr>
<tr>
<td>75–84</td>
<td>0.51572</td>
<td>0.51201</td>
<td>0.53319</td>
<td>1.03</td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–49</td>
<td>0.12342</td>
<td>0.12342</td>
<td>0.15385</td>
<td>1.25</td>
</tr>
<tr>
<td>50–74</td>
<td>0.50225</td>
<td>0.50225</td>
<td>0.50210</td>
<td>1.00</td>
</tr>
<tr>
<td>75–84</td>
<td>0.51201</td>
<td>0.51201</td>
<td>0.60976</td>
<td>1.19</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–49</td>
<td>0.07039</td>
<td>0.07039</td>
<td>0.06834</td>
<td>1.19</td>
</tr>
<tr>
<td>50–74</td>
<td>0.30415</td>
<td>0.30415</td>
<td>0.34496</td>
<td>1.13</td>
</tr>
<tr>
<td>75–84</td>
<td>0.51834</td>
<td>0.51834</td>
<td>0.47689</td>
<td>0.92</td>
</tr>
</tbody>
</table>

⁵Census 1 to census 2. ⁶Census 2 to census 3. ⁷Quotient: probability of dying within age group.

The increase in death rates between the two prospective periods selected (1992–1993 and 1994–1995) was not statistically significant. However, considering the significant increasing trend in deaths over the whole period, together with the evidence for a reversal of the previous declining mortality among women aged 20–44 years, the results support a finding of continuous increase in mortality during the prospective period. This conclusion is reinforced when changes in the cause-of-death pattern are examined.

Cause of death
To examine the cause-of-death profile during the period of prospective study (1992–1995), all diagnosed deaths were classified into four main categories: infectious and parasitic, non-communicable, accidents and injuries, and undetermined causes. Contrasting 1992–1993 with 1994–1995, there was no major change in the cause-of-death pattern, with the exception of the infectious and parasitic category. Breaking down this category by disease type called attention to AIDS, tuberculosis and chronic diarrhea, three causes of death that are closely related to HIV infection. In addition, the number of deaths from undetermined causes showed a slight but sustained increase, suggesting that some AIDS-related deaths might have presented atypical clinical patterns that were not recognized by the verbal autopsies.

Figure 3 shows the pattern of deaths from AIDS, pulmonary tuberculosis and chronic diarrhea combined. In the period July 1992 to July 1993 there was a declining trend with all but one of the deaths resulting from tuberculosis. The trend reverses thereafter, with deaths resulting from AIDS and chronic diarrhea manifesting in the study area from July 1993 onwards.

Deaths from these causes affect primarily younger adults, and children to a lesser extent (Table 2). AIDS deaths are concentrated in the middle to younger ages. While in the first period there was only a single AIDS death, an adult woman, there were 20 in the second period, 11 males and nine females. Thirteen were adults 15–49 years, and seven were children under the age of 2 years. Of the children, the youngest died at 4 months, the oldest at 19 months, with an average of 12 months. Adult AIDS deaths ranged from 22 to 47 years, the average being 35 years. The four cases of chronic diarrhoea were all in the second period and mainly among young children. The increase in tuberculosis between the two periods (+10 deaths) affected males and females similarly and was concentrated among younger men and older women.

Death by injury and deaths from non-communicable causes
The verbal autopsy analysis reveals violent death (suicide and homicide, especially in young men), accidents (motor vehicle and household accidents) and circulatory disease [cerebrovascular accidents and heart failure among the older middle-aged (50+) and elderly] to be of major public health importance. However, the level of mortality from violent deaths and circulatory disease showed little change over the period 1992–1995. Close examination of homicide deaths does indicate an increase in the number of female deaths 15 years and over, from two to seven. This computes to a relative risk of 3.25, accentuating the issue of physical violence as a threat to women’s health and raising the possibility of an increasing trend. The
circumstances of death range from domestic violence (n = 3) to accusations of witchcraft (n = 3).

Undetermined causes
Combining deaths for both sexes from undetermined causes, the relative risk for the ages 15–49 and 50+ is 1.25 and 1.21, respectively, when the 1994–1995 period is compared with 1992–1993. These figures, in light of the rising mortality from AIDS and related diseases, may include further AIDS-related deaths that are difficult to diagnose.

Discussion
The results presented cover a relatively short period, 1992 to 1995. Nevertheless, they relate to a time of great social and political change and open a window onto a situation and context for which information on mortality is largely unavailable [4,10–12]. The most striking finding is the steep 42% rise in adult female mortality between the mid-1980s and the early 1990s. Evidence for this increase is compelling since it cannot be attributed to the demographic model chosen, is unlikely to be a consequence of defects in the retrospective data (which are consistent over the many age groups considered) and is consistent with other available epidemiological data (see below).

As documented in Zambia and the Ivory Coast [13,14] and comprehensively discussed in Timaeus’ recent work based on national surveys and censuses [15], reversals of what was once assumed to be a generally declining trend in mortality are now recognized in sub-Saharan Africa. Although AIDS and its sequelae are, in many cases, the prime factors responsible, it is important to examine the evidence for other potential contributors. In Zambia in 1993, persisting levels of poor nutrition, declining access to Western health services (affecting rural areas particularly) and short birth intervals have been cited as partial explanations for worsening child mortality [13]. In contrast, and despite the impact of the HIV epidemic, infant and child mortality in Uganda as a whole appears to have fallen during the early 1990s, very likely as a result of effective child health interventions [15]. The Agincourt evidence to-date highlights rapidly growing AIDS-related mortality, particularly among younger to middle-age adults but also among infants and young children in parts of rural northeastern South Africa.

The significant impact of AIDS-associated mortality on mortality rates in rural Zimbabwe, Tanzania and Uganda has been well documented in a few district or provincial settings [16–19]. In rural Tanzania, in a population of relatively low HIV prevalence (4%), HIV was shown to increase overall adult mortality by more than 50% over the 2-year period 1991–1992 and 1993–1994 [17]. Similar results were obtained in Masaka district, Uganda over the 1-year period between 1989–1990 and 1990–1991 [19]; while mortality findings between 1990 and 1991 from the higher sero-prevalence Rakai district complement these results and show a gradation of population attributable risk from a level of 83% in high-prevalence trading centres (HIV prevalence of 35%), to 59% in intermediate trading villages, to 48% in lower prevalence (11.8%) rural villages [18] (the last being consistent with findings from nearby Masaka as well as from Mwanza in northwest Tanzania).

This picture derives from empirical work, often prospective community studies, seeking to establish the extent of AIDS-related mortality, and rates of infection, at different stages of the HIV epidemic. In South Africa, despite the extent and impact of HIV/AIDS, as evidenced by antenatal clinic studies and data on hospital patient mix [20], little empirical work on the evolving mortality impact of the epidemic is available. As a middle-income country somewhat further along the demographic transition than other countries of southern and east Africa, it is useful to be able consider the mortality impact of AIDS in a broader context of overall adult and child mortality.

AIDS and related diseases (in particular tuberculosis) and homicide, affecting both men and women, can be identified as critical emerging health problems in the Agincourt subdistrict. However, attention to these emerging concerns must be balanced against the major burden of illness posed by long-standing problems (diarrhoea and kwashiorkor in children) and the weakly recognized contribution of circulatory disease in adults.

Data reliability and validity can be assessed by comparison with other sources of data. The demographic finding

Table 2. Number of deaths from AIDS, tuberculosis and chronic diarrhoea, by age, sex and time period.

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–14</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>15–49</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>50+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–14</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>15–49</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>50+</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Chronic diarrhoea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–14</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>15–49</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>50+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>33</td>
</tr>
</tbody>
</table>

*Numbers in the table are small and should be interpreted with caution. Nevertheless, the changes are largely in one direction and suggest an emerging trend. Census 1 to census 2. Census 2 to census 3.*
of increasing mortality is consistent with the epidemiological data available. Progression of the AIDS epidemic in South Africa has been well documented, primarily in urban settings [21,22] but also with consideration for the mode of spread into rural populations. Recent estimates of HIV seroprevalence amongst antenatal clinic attenders in the public sector show a steady increase nationwide, with a figure of 17.7% for this part of South Africa in 1996 [23].

Recent estimates of HIV seroprevalence amongst antenatal clinic attenders in the public sector show a steady increase nationwide, with a figure of 17.7% for this part of South Africa in 1996 [23].

Projections of overall mortality based on the Metropolitan/Doyle model for this part of northeastern South Africa (Mpumalanga and Northern Province) show rapidly rising mortality among both sexes that does not plateau by the year 2010 (projections made by T. Mühr, Metropolitan Life Insurance, South Africa). In the age group 15–59 years, overall female mortality, while clearly lower than male mortality up until the year 2000, begins to exceed that of males from the year 2005. When the 'best estimates' for adults aged 15–59 years in Mpumalanga are contrasted with Agincourt findings for the same age group, there is a marked difference, the Agincourt results being approximately half those estimated for men and women in Mpumalanga in 1995 (and closer to estimates for the late 1980s). The higher male mortality rates are, however, also found in Agincourt. The difference does not necessarily mean that the projections are flawed (although our understanding of fertility levels makes it possible that the model's assumptions regarding prevailing fertility rates are overestimates); rather, the Agincourt findings may more closely approximate the Northern Province situation (regarded as 4–5 years behind the Mpumalanga epidemic). The contrast does, however, highlight that the HIV/AIDS epidemic in Agincourt is at an earlier stage, with a window of opportunity still open for concerted action.

Verbal autopsy interviews were assessed in the same way throughout the study, with assessing medical officers unaware that the earlier and later periods were to be compared. Validation of 127 adequately documented verbal autopsies, involving comparison with hospital reference diagnoses, showed relatively high sensitivity (82%) and specificity (93%) for infectious and parasitic diseases overall. For pulmonary tuberculosis alone, the sensitivity was 92% and specificity 99%, while for diarrhoea these were 83% and 99%, respectively. Numbers of hospital deaths from AIDS were too low to permit such calculations (K. Kahn, S.M. Tollman, M. Garenne, J.S.S. Gear, manuscript submitted).

It is essential to locate the evolving pattern of mortality within the context of change in South African health care. The country is moving rapidly towards a decentralized health system involving the devolution of resources and authority to the district level [24,25]. If the Agincourt findings are sustained, the brunt of responsibility for coping with the added — and changing — disease burden will fall onto local and district health services and their associated communities. In anticipation, there are important initiatives that can be taken. These include drawing on lessons and experience from elsewhere in Africa and beyond; taking deliberate steps to ensure health personnel have the appropriate skills; strengthening health centre and outreach services and supporting home-based and other forms of non-institutional care [26]; and introducing demonstration programmes designed to inform the rural public health sector and other public sector groups on a range of feasible and appropriate responses.

South Africa lacks a vital registration system able to cover its rural population as well as expanding urban centres adequately. However, a number of recent initiatives offer the opportunity to substantially strengthen access to population-based information and, in some cases, to allow national averages to be broken down to provincial and/or district-specific levels. Improving the system of national health statistics will require a coordinated effort to link three related activities effectively: (i) the ongoing efforts to further develop the vital registration system [27], which is a vital component of data collection, must be strengthened; (ii) the three existing field sites based on demographic and health surveillance should be linked and coupled with strategic development of additional field and/or facility-based surveillance sites [28,29] (In addition to Agincourt there are 11 Hlabisa field sites in northern KwaZulu-Natal, part of the University of Natal, University of Durban-Westville and Medical Research Council's Wellcome Africa Centre; and the Dikgale site just outside Pietersburg in the Northern Province, University of the North.); and (iii) the just-introduced annual national household survey. The cost implications, when weighed against the substantial investments already committed, may well not be excessive. In the longer run, however, developing a nationwide comprehensive vital registration system is imperative to support the country's emerging local government and decentralizing health system.

Acknowledgements

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References
