Tropical Medicine and International Health

VOLUME 4 NO 6 PP 433–441 JUNE 1999

Who dies from what? Determining cause of death in South Africa's rural north-east

Kathleen Kahn[1], Stephen M. Tollman[1], Michel Garenne[2] and John S. S. Gear[1]

1 *Health Systems Development Unit, University of the Witwatersrand, Johannesburg, South Africa*
2 *French Centre for Population and Development (CEPED), Paris, France*

Summary Information on cause of death is essential for rational public health planning, yet mortality data in South Africa is limited. In the Agincourt subdistrict, verbal autopsies (VA) have been used to determine cause of death. A VA is conducted on all deaths recorded during annual demographic and health surveillance. Trained lay fieldworkers interview a close caregiver to elicit signs and symptoms of the terminal illness. Each questionnaire is reviewed by three medical practitioners blind to each other's assessment, who assign a 'probable cause of death' where possible. Of 1001 deaths of adults and children identified between 1992 and 1995, 932 VAs were completed. The profile of deaths reflects a mixed picture: the 'unfinished agenda' of communicable disease and malnutrition (diarrhoea and kwashiorkor predominantly) are responsible for over half of deaths in under-fives, accidents are prominent in the 5–14 age-group, while the 'emerging agenda' of violence and chronic degenerative disease (particularly circulatory disease) is pronounced among the middle-aged and elderly. This profile shows the social and demographic transition to be well underway within a rural, underdeveloped population. Validation of VA findings demonstrate that the cause of death profile derived from VA can be used with confidence for planning purposes. Findings of note include the high death rates from kwashiorkor and violence, emerging AIDS and pulmonary tuberculosis, and circulatory deaths in the middle-aged and young elderly. A deeper understanding of the causal factors underlying these critical health problems is needed to strengthen policy and better target interventions.

keywords cause of death, mortality, cause-specific death rates, verbal autopsy, public health policy, community-based research

correspondence Dr Kathleen Kahn, c/o Department of Community Health, Faculty of Health Sciences, University of the Witwatersrand, 7 York Road, Parktown, 2193 Johannesburg, South Africa. E-mail: 081kahn@chiron.wits.ac.za

Introduction

A prerequisite for rational public health planning is a functioning health information system, with reliable data on mortality being a critical element. Allocating resources, planning, monitoring and evaluating health services requires knowledge of causes of death in the target population. As South Africa adopts a district-based health system, with decentralization of decision-making and resources, this information is needed at local as well as provincial and national levels.

Mortality data in South Africa have serious limitations. While routinely collected vital statistics are of poor quality, reflecting marked under-reporting of deaths and misclassification of their causes (Botha & Bradshaw 1985; Bradshaw *et al.* 1992), unreliable census data undermine the population base necessary for calculation of rates (Yach & Buthelezi 1995). Information is weakest for blacks[1], particularly in rural areas, and most especially in the former 'homelands'. Most of the published work on national black mortality is based solely on data from 34 'selected' magisterial urban districts (Botha & Bradshaw 1985; Herman & Wyndham 1985; Yach & Buthelezi 1995). The validity of this information is further compromised by the absence of population-based data. No mid-year estimates of the populations of these areas has been

[1]The use of the terms 'black, white, Indian, coloured' follows previous South African apartheid policies and practices. They are used in this paper only in reference to data so categorized from that period.

available, other than for the census year once a decade (Wyndham 1984a,c).

Limitations such as these are shared by many developing countries. In response, the verbal autopsy (VA) has been developed. Still a prototype technique, this involves obtaining information on the terminal illness from a family member after the death, and then 'clinically' assessing it to determine the cause (Garenne & Fontaine 1990; Ross 1992; Snow & Marsh 1992; Chandramohan *et al.* 1994). Verbal autopsies were used as early as the 1950s and 1960s, in Khanna (Wyon & Gordon 1971), Narangwal (Kielman *et al.* 1983) and The Gambia (Greenwood *et al.* 1987). Later, structured questionnaires were developed in Bangladesh (Zimicki 1990), Senegal (Garenne & Fontaine 1990), and for maternal deaths (Fortney *et al.* 1986). In general, these early applications of the verbal autopsy were for all ages. Recent efforts, however, have focused on childhood deaths (Gray *et al.* 1990; Bang *et al.* 1992; Ross 1992; Snow & Marsh 1992; Snow *et al.* 1993), although some work in adult mortality has been done (Chandramohan *et al.* 1994).

Despite nearly 5 decades of experience with verbal autopsies, only a few validation studies have been conducted (Datta *et al.* 1988; Kalter *et al.* 1990; Mirza *et al.* 1990; Snow *et al.* 1992; Todd *et al.* 1994; Chandramohan *et al.* 1998). In general these demonstrate that the diseases most reliably diagnosed on VA have distinguishing signs and symptoms readily recognized by lay informants, such as measles, neonatal tetanus, malnutrition and accidents (Kalter *et al.* 1990; Snow *et al.* 1992). Non-communicable diseases, more prevalent amongst adults, share signs and symptoms and are consequently more difficult to diagnose.

This paper describes the methodology used, and cause of death profile obtained, for adults and children in the Agincourt subdistrict, South Africa, between 1992 and 1995. The implications of these findings for public health policy and community-based research are briefly discussed. Age and cause-specific death rates are presented here; overall death rates by age-group will be reported in a future publication.

Methods

The Agincourt field site in Bushbuckridge was established in South Africa's rural north-east in 1992. It supports a population of 63000 people in 20 villages, largely Shangaan, a quarter Mozambican, and 44% under 15 years of age. Employment opportunities are scarce; consequently 60% of men and 14% of women aged 30–49 years are labour migrants. While 85% of children aged 10–14 years attend primary school, < 50% continue to secondary school and 3% to any postsecondary education. Details of the site's development, and findings of the baseline census, are described elsewhere (Tollman *et al.* 1999).

The site had two related purposes: to establish and evaluate innovative subdistrict health centre programmes; and to provide valid population-based data to inform this process. Annual demographic and health surveillance included the recording of all births, deaths and migration events by 10 local enumerators. Data were entered onto a personal computer via a custom-designed data entry programme. Date of entry (by birth or migration) of each individual onto the database, and their departure (via death or migration) from it, was recorded, allowing person-years to be used as the denominator for the computation of rates.

Verbal autopsies

Each recorded death was subject to a verbal autopsy in which specially trained fieldworkers interviewed the closest caregiver of the deceased in their mother tongue. Development of the interview schedule involved adapting one used in Niakhar, Senegal to accomodate local disease prevalence (Garenne & Fontaine 1990), translating it into Tsonga, the local language, and modifying it to include only culturally accepted terminology. The questionnaire had several parts, the most important being an open section where the respondent described all symptoms and signs preceding death in his/her own words. This was followed by a series of filtering questions, e.g. 'Did the deceased cough?' When answered positively, detailed questions regarding that particular symptom were asked. If negative, the interview proceeded to the next filtering question. Further sections covered use of modern and traditional treatments and lifestyle practices.

Quality was initially enhanced by on-site supervision of interviews. A high standard was maintained by regular review of completed questionnaires with personalized feedback to the relevant fieldworker. Our approach based on clinician assessment of the completed questionnaire was similar to that described in other studies (Garenne & Fontaine 1990; Snow *et al.* 1992; Dowell *et al.* 1993; Todd *et al.* 1994). Two medical practitioners, blind to each other's assessment, reviewed the information and assigned a diagnosis for each death. If the same diagnosis was reached, this was accepted as the 'probable cause of death'. Where this was not the case, a third practitioner made a further blind and independent assessment. If two of three diagnoses corresponded, the medical practitioners discussed the case. If consensus was achieved the diagnosis was accepted, otherwise the cause of death was described as undetermined.

Where possible, a main (or underlying) cause, immediate cause, and contributory factors were assigned. For example, where diarrhoea was the only identified problem, it would be classified under 'main' cause of death. However, where kwashiorkor and diarrhoea were both determined, and the diarrhoea continued until death, kwashiorkor would be clas-

Table 1 Age and sex pattern of mortality, Agincourt 1992–95

Age	Male		Female		Total		
group	No. Deaths	Rate/million	No. Deaths	Rate/million	No. Deaths	Rate/million	M:F rate ratio
0–4	108	74	108	75	216	75	0.99
5–14	26	9	18	6	44	8	1.44
15–49	145	34	99	21	244	27	1.65
50–74	183	252	138	136	321	184	1.86
75 +	87	883	89	601	176	714	1.47
Total	549	59	452	44	1001	51	1.32

sified as the 'main' cause and diarrhoea as the 'immediate' cause of death. Bottle-feeding might have been a contributory factor. Multiple causes of death were not allowed in the analysis. The results presented are based on the underlying cause of death only, with the exception of cerebrovascular accident (CVA) and congestive cardiac failure (CCF) which were included so as not to lose vital information on the extent of mortality from noncommunicable disease.

Deaths were assigned to narrow causes first and later grouped into one of three broad categories: communicable disease, maternal, birth-related and nutritional conditions; accidents and violence; and noncommunicable disease. The resulting cause of death classification was derived directly from deaths in the area and conforms to the International Classification of Diseases, 9th revision (ICD-9, 1975) (ICD 1978).

EpiInfo 6.02 was used for analysis of the cause of death profile. Death rates were computed with number of deaths as numerator and person-years as denominator. 95% confidence intervals were computed for population-based rates of all causes of death. For ease of presentation these are provided for broad disease categories and selected specific causes only.

Results

Of the 1001 deaths identified during the period 1992–95, a verbal autopsy was completed on 932. No respondent could be found for the remaining 7%, largely due to migration of family members or entire households. The age and sex distribution of deaths is presented in Table 1. Age-specific death rates for males exceeded those for females in all age groups other than children under 5. However, cause-specific death

Table 2 Age and cause-specific death rates (per 100 000): communicable diseases

	Death rate/100 000 (number of deaths)									
Cause	0–4		5–14		15–49		50–74		75 +	
Diarrhoea	152†	(44)	5	(3)	1	(1)	23	(4)	243	(6)
ARI*, incl. pneumonia	38	(11)	–	(0)	1	(1)	12	(2)	41	(1)
AIDS	24	(7)	–	(0)	15‡	(14)	–	(0)	–	(0)
Vaccine preventable**	21	(6)	–	(0)	–	(0)	–	(0)	–	(0)
Acute infection	17	(5)	–	(0)	2	(2)	–	(0)	–	(0)
Septicaemia	14	(4)	–	(0)	–	(0)	–	(0)	41	(1)
Malaria	7	(2)	2	(1)	–	(0)	–	(0)	–	(0)
Pulmonary tuberculosis	3	(1)	2	(1)	13§	(12)	138	(24)	284	(7)
Worm infestation	3	(1)	2	(1)	–	(0)	–	(0)	–	(0)
Other	–	(0)	2	(1)	2	(2)	6	(1)	–	(0)
Total	279	(81)	13	(7)	35	(32)	178	(31)	609	(15)
95% confidence interval	219–340		3–22		23–47		115–241		301–916	
Percent communicable	38%		16%		13%		10%		8%	

* ARI, acute respiratory infection; ** measles (3), neonatal tetanus (1), whooping cough (2); † 95% CI: 107–197 per 100 000; ‡ 95% CI: 7–23 per 100 000; § 95% CI: 6–21 per 100 000

Table 3 Cause-specific death rates (per 100 000) for children under 5: birth-related and nutritional conditions

Cause	Death rate/100 000 (number of deaths)	
Malnutrition		
Kwashiorkor	100*	(29)
Unspecified	7	(2)
Marasmus	3	(1)
Subtotal	110†	(32)
Birth-related		
Prematurity	35	(10)
Foetal/birth anoxia	17	(5)
Low birth weight	10	(3)
Neonatal jaundice	3	(1)
Subtotal	66‡	(19)

*95% CI: 64–136 per 100 000; † 95% CI: 72–149 per 100 000; ‡ 95% CI: 36–95 per 100 000

rates are not presented for males and females separately because of the small number of deaths available for analysis.

Deaths for which no cause could be determined constituted almost a third of total deaths (31%, $n = 309$). The proportion of these deaths increased with age: 18% among the under-5 s ($n = 39$), 30% in the 5–14 ($n = 13$), 23% in the 15–49 ($n = 57$) and 34% in the 50–74 ($n = 109$) year age groups, and over half of those 75 years and older ($n = 91$).

Communicable disease, maternal, birth-related, and nutritional conditions

Deaths from communicable disease, including respiratory infections, are shown in Table 2. The percentage of communicable disease deaths decreased with age, from almost two-fifths of deaths in children under 5 to less than 10% in those over 75 years. Diarrhoea as a main cause of death constituted more than half (54%) of communicable disease deaths, 20% of all deaths under the age of 5, and was the immediate cause of death in 72% of kwashiorkor cases. In contrast, acute respiratory infections and vaccine-preventable deaths were relatively rare in this age-group (5% and 3%, respectively).

AIDS was evident in children aged 0–4 years (3% of all deaths) and in adults aged 15–49 (6%), while pulmonary tuberculosis (PTB) was hardly detected in children and contributed 7% of all deaths in the 50–74 years age group. Seasonal malaria occurs in Bushbuckridge, although only three deaths (all in children) were attributed to this cause.

Malnutrition, almost exclusively kwashiorkor, comprised 15% of deaths in children under 5 (Table 3). Malnutrition and diarrhoea together contributed over a third, and malnutrition and all communicable diseases over half of deaths in this age group. Birth-related causes (excluding stillbirths) were responsible for 9% of deaths under 5 and 16% of deaths under 1 years. The key feature distinguishing prematurity from low birth weight was a birth before term.

Eight maternal deaths were recorded among women aged 15–49 (8% of all female deaths in this age group). These included three cases of postpartum haemorrhage, one of antepartum haemorrhage, a septic abortion, an ectopic pregnancy, a case of puerperal sepsis and one of postpartum psychosis. The 'unfinished agenda' of deaths from communicable, maternal, birth-related and nutritional causes constituted nearly a quarter of deaths overall (24%) and 61% in children under 5.

Accidents and violence

Deaths from accidental and violent injuries are presented in Table 4. These comprised nearly a third of all deaths in the 5–14 and 15–49 years age groups. Disaggregation by gender revealed that death from injury constituted 35% of all male deaths in the 5–14 years age group (compared with 22% of female deaths), and 41% of all male deaths in the 15–49 years age group (compared with 16% of female deaths). Unin-

Table 4 Age and cause-specific death rates (per 100 000): accidents and violence

	Death rate/100 000 (number of deaths)									
Cause	0–4		5–14		15–49		50–74		75 +	
Assault	–	(0)	2	(1)	46	(42)	57	(10)	81	(2)
Motor vehicle accident	10	(3)	11	(6)	22	(20)	63	(11)	81	(2)
Suicide	–	(0)	2	(1)	10	(9)	23	(4)	–	(0)
Unintentional injury	41	(12)	9	(5)	6	(5)	40	(7)	81	(2)
Total	52	(15)	23	(13)	84	(76)	184	(32)	243	(6)
95% confidence interval	26–78		11–36		65–102		120–247		49–438	
% accid. & violence	7%		30%		31%		10%		3%	

Table 5 Cause-specific death rates (per 100 000) for adults: noncommunicable disease

Cause	Death rate/100 000 (number of deaths)					
	15–49		50–74		75 +	
Cancers						
Breast	4	(4)	6	(1)	41	(1)
Gastrointestinal	6	(5)	12	(2)	162	(4)
Genito-urinary	9	(8)	92	(16)	162	(4)
Unspecified	3	(3)	23	(4)	–	(0)
Other	–	(0)	12	(2)	–	(0)
Subtotal	22†	(20)	144‡	(25)	365	(9)
Circulatory						
Congestive cardiac failure	7	(6)	155	(27)	811	(20)
Cerebrovascular accident	7	(6)	218	(38)	446	(11)
Other	4	(4)	23	(4)	–	(0)
Subtotal	18§	(16)	396¶	(69)	1258	(31)
Other noncommunicable						
Asthma	2	(2)	6	(1)	–	(0)
Diabetes and gangrene	3	(3)	35	(6)	81	(2)
Epilepsy	3	(3)	–	(0)	–	(0)
Liver disease	7	(6)	75	(13)	122	(3)
Pulmonary disease	–	(0)	35	(6)	–	(0)
Renal disease/failure	2	(2)	6	(1)	41	(1)
Upper GIT bleed/PUD*	1	(1)	52	(9)	41	(1)
Other	3	(3)	6	(1)	41	(1)
Total	61	(56)	752	(131)	1947	(48)
95% confidence interval	45–78		624–881		1396–2498	
Percent noncommunicable	23%		41%		27%	

* GIT, gastrointestinal; PUD, peptic ulcer disease; † 95% CI (per 100 000) 12–32; ‡ 95% CI (per 100 000) 87–200; § 95% CI (per 100 000) 9–26 ¶ 95% CI (per 100 000): 303–490

tentional injury was prominent in children, with poisoning (mainly paraffin) and burns responsible for two-thirds of accidents. This was superseded by homicide and motor vehicle accidents in adults: 83% of assault deaths occurred in males, most the result of street violence with injuries from gunshot or stabbing.

Non-communicable disease

Among children under 5, there were 9 deaths due to noncommunicable diseases: 5 to congenital conditions, 2 to sudden infant death syndrome, 1 to a renal condition, and 1 to an unspecified malignancy (rate = 31/100 000; 4% of deaths in age category). Among 5–14 year-olds there were a further 9 deaths: 2 due to circulatory conditions, 2 to congenital causes, 3 to epilepsy, 1 to asthma, and 1 to a renal problem (rate = 16/100 000; 20% of deaths).

Adult deaths in this category are presented in Table 5. Because of the high proportion of undetermined diagnoses in older age groups, percentages should be interpreted with caution. However, given that most of these deaths were likely to be from noncommunicable causes (Bradshaw *et al.* 1992), these percentages are probably underestimates, particularly in the 75 + age-group.

Cancer and circulatory disease were responsible for roughly equivalent proportions of deaths in the 15–49 years age group. However, after 50, death rates were highest for circulatory disease. The rate from cerebrovascular accident was higher than that from congestive cardiac failure in those aged 50–74, while the opposite held for individuals 75 and older. Genito-urinary and gastrointestinal malignancies and liver disease also featured prominently in these age groups. Classification of malignant disease varied according to the quality of information obtained from the verbal autopsy. In some instances it was possible to diagnose the specific organ involved; more often though, it was only possible to identify the particular organ system.

Leading causes of death for different age groups are presented in Table 6. Variations between age groups point to differing priorities and call for a spectrum of public health responses.

Table 6 Leading causes of death, by age group, Agincourt 1992–95

Rank	Age group (years) 0–4	5–14	15–49	50–74	75+	Total
1	Diarrhoea	Motor vehicle accident	Assault	CVA*	CCF	Diarrhoea
2	Kwashiorkor	Unintentional injury	Motor vehicle accident	CCF*	CVA	Assault
3	Unintentional injury	Diarrhoea	AIDS	Pulmonary tuberculosis	Pulmonary tuberculosis	CVA
4	ARI*, incl. pneumonia	Epilepsy	Pulmonary tuberculosis	Genito-urinary cancer	Diarrhoea	CCF
5	Prematurity	Congenital defect	Suicide	Liver disease	Gastrointestinal cancer	Pulmonary tuberculosis
6	AIDS	Circulatory disease	Genito-urinary cancer	Motor vehicle accident	Genito-urinary cancer	Motor vehicle accident
7	Vaccine preventable	Malaria	Maternal	Assault	Liver disease	Unintentional injury
8	Acute infection	Pulmonary tuberculosis	CCF	Upper GIT bleed/PUD*	Assault	Kwashiorkor
9	Birth anoxia	Worm infestation	CVA	Unintentional injury	Motor vehicle accident	Genito-urinary cancer
10	Congenital	Assault	Liver disease	Diabetes & gangrene	Unintentional injury	Liver disease
11	Septicaemia	Suicide	Unintentional injury	Pulmonary disease	Diabetes &gangrene	AIDS
12	Motor vehicle accident	Asthma	Gastrointestinal cancer	Diarrhoea	ARI, incl. pneumonia	ARI, incl. pneumonia
13	Low birth weight	Renal condition	Breast cancer	Suicide	Upper GIT bleed/PUD	Suicide

*ARI, acute respiratory infection; GIT, gastrointestinal tract; PUD, peptic ulcer disease; CVA , cerebrovascular accident; CCF, congestive cardiac failure

Redistribution of 'undetermined' deaths

In their seminal work on the global burden of disease, Murray and Lopez (1996) advocate the redistribution of deaths ascribed to 'symptoms, signs, and ill-defined conditions'. Below age 5 these deaths could be redistributed among communicable, maternal, perinatal and nutritional conditions, and above age 5 among noncommunicable causes (Murray & Lopez 1996). This approach can be justified in the South African context, since the age distribution of ill-defined deaths in adult black South Africans is closer to that for noncommunicable disease than for infectious disease or trauma (Bradshaw *et al.* 1992).

Redistributing the 'undetermined' VA deaths along these lines indicates that 29% of deaths in Agincourt can be attributed to the 'unfinished agenda' of communicable, maternal, perinatal and nutritional conditions (instead of 24% before redistribution), 56% to noncommunicable disease (instead of 25%), and 15% to injuries (which remains constant). This in contrast to the rest of sub-Saharan Africa where noncommunicable causes have not yet assumed prominence relative to the communicable diseases (Murray & Lopez 1996).

Discussion

Cause of death profile

Much of the published data on cause of death in South Africa covers the apartheid years and demonstrates differences in the mortality profile between subgroups in the country. The pattern amongst whites and Indians has been shown to reflect that of more developed countries, while the profile for blacks and coloureds is closer to that of developing nations[2] (Wyndham 1984a,b,c; Botha & Bradshaw 1985; Rip *et al.* 1987; Yach & Buthelezi 1995). This dichotomous interpretation is no longer adequate. The profile of deaths in Agincourt reflects a mixed picture: the 'unfinished agenda' of communicable and nutritional disease dominates death in young children, accidents are prominent in youth, while the 'emerging agenda' of violence and chronic degenerative disease is pronounced among the middle-aged and elderly. This profile reflects the profound social and demographic transition underway in South Africa (Bradshaw & Buthelezi 1996), and shows it to be well established within a rural, underdeveloped population. Findings of note include:

High death rate from kwashiorkor

During the past 10 years, several community-based anthropometric studies in South Africa have shown a high prevalence of stunting yet relatively little wasting or acute nutritional stress (First RHOSA Nutrition Survey 1987; Solarsh *et al.*

[2]See footnote 1.

1994; South African Vitamin A consultative group 1995). Poverty and underdevelopment alone therefore are unlikely to fully explain the high rates in Agincourt. Local understanding of social disruption and its consequences at family and household level is needed.

Prominence of violent death

While trauma has been shown to be the leading cause of death between 5 and 64 years in the country as a whole (Bradshaw *et al.* 1992; Yach & Buthelezi 1995), and violence is an all too common feature of urban South Africa (Byarugaba & Kielkowski 1994; Lehrer *et al.* 1995), the major contribution of violence as a cause of death in an essentially peaceful area of rural South Africa was unexpected.

Emerging AIDS and related diseases, particularly pulmonary tuberculosis

Marked increases in deaths from AIDS, PTB and chronic diarrhoea are apparent in Agincourt from mid-1993. (Tollman *et al.* 1999).This emphasizes the imperative that communities, nongovernmental organizations, health services and social welfare agencies prepare for the impact of these diseases.

Circulatory deaths in the middle-aged and young elderly

Disability, following nonfatal cerebrovascular events, is as yet unmeasured. This highlights the need to understand the contributing risk factors of lifestyle, to develop innovative, culturally appropriate health promoting initiatives, and to improve health care provision.

Given its widespread use among adults of this community, alcohol plays a likely role of predisposing factor for accidents, homicide and suicide; and as a factor contributing to the pathogenesis of liver disease, upper gastrointestinal bleed, and certain circulatory diseases. The pattern of death provides some insight into the quality of care at primary level. The relative under-representation of acute respiratory infection (ARI) and vaccine-preventable diseases may result from an annual mass immunization campaign, and the widespread use of antibiotics in clinics. However, 89% of children who died from diarrhoea received medical treatment during their terminal illness. This may indicate a combination of late presentation and poor case management and underline the need for more effective promotive and preventive efforts. The low death rate from malaria is in keeping with the sporadic cases of clinical disease seen in the area during the study period, and with the few notified malaria deaths in South Africa (Uyirwoth 1994). Misclassification with ARI, reported by Todd *et al.* (1994), is unlikely to explain the low rate, as ARI is also seldom documented as a cause of death. The finding may reflect the effect of a relatively well-organized vertical malaria control programme.

Despite the high level of 'undetermined' deaths in Agincourt (consequent on the limitations of the VA approach and the rigour of physician assessment), this is more or less at the national level if deaths over age 75 are excluded (26% of deaths). Based on 1990 data, 23% of all reported deaths in South Africa are in the category 'Signs, Symptoms and Ill-defined'. In Northern Province, however, 57% of deaths fall into this category, followed by Mpumalanga with 38% of deaths ill-defined (Bradshaw *et al.* 1995). Both provinces are largely rural with a minority of deaths occurring in hospital. Geographically, Agincourt lies on the boundary of these two provinces.

Verbal autopsy approach: reliability and validity of findings

Comparison of VA findings with data from the adjacent provinces should be interpreted with caution since misclassification error, due to the limitations of the VA approach, can result in over-or underestimates of cause-specific mortality rates and proportions (Anker 1997; Maude & Ross 1997). However, the verbal autopsy approach has proved vital in determining the ranking of causes of death in Agincourt, rural South Africa – information crucial to district level priority-setting and planning. The technique is acceptable to community members and, with adequate training, lay fieldworkers are able to elicit the salient historical and clinical information. Training and supervision, though, are crucial. The quality of interviews differed between fieldworkers, and each fieldworker has improved over time. Shared language and culture between fieldworkers and study community has also proved critical. This must be enhanced by careful attention to culturally accepted terminology, and an understanding of the relationship between local linguistic phrases and western signs and symptoms (Snow & Marsh 1992).

Clinician assessment was the method used to determine VA diagnoses. In other studies predefined algorithms have been applied (Kalter *et al.* 1990; Chandramohan 1994). However, experience with validation of VAs for adult deaths shows results from clinician assessment to be more valid (have higher sensitivities and specificities) than those produced by algorithm (Chandramohan *et al.* 1998). In Agincourt, internal validity was measured by the third assessor reviewing blind a sample of VAs which had been assigned the same diagnosis by both first and second assessors. This demonstrated 90% congruence, 8% minor and 2% major differences (Kalter *et al.* 1990). In Agincourt, VA diagnoses were validated by comparison with hospital reference diagnoses and sensitivity and specificity calculated for each cause of death. Forty percent of the deaths occurred in hospital and only a third of these had hospital records of sufficiently high quality to be used as gold standards. Although the age and sex distribution of the validated VAs were similar to those of

all deaths, hospital deaths do not represent all deaths in the community, with accidents and violence typically underrepresented. Of the 127 VAs used for validation 8% were due to accidents and violence, 27% to communicable and 55% to noncommunicable causes, compared to 14, 16 and 34% among all deaths. The remaining deaths were undetermined.

The frequency distribution of causes of death based on VAs closely approximates that of the hospital records used for validation. Validation results showed a sensitivity of 82% and specificity of 93% for communicable diseases overall, and 88% and 98%, respectively, for accidents and violence. These were lower for noncomunicable diseases (65% and 66%, respectively). Accuracy of the VA estimate is dependent on the cause-specific mortality fraction, sensitivity and specificity, particularly the latter (Anker 1997). However, for the purposes of priority-setting and programme-planning, the noncommunicable disease diagnoses are arguably more useful than the sensitivity and specificity suggest. Most misclassification occurs within the noncommunicable disease category itself, and the specific diseases tend to share risk factors. Consequently, interventions directed at these factors will address a number of diseases simultaneously (Kahn *et al.* unpublished observation).

Implications of findings

Many articles reporting on mortality in South Africa conclude with the need for strengthening primary health care services and the need for better routine recording of data. (Wyndham 1984a; Botha & Bradshaw 1985; Herman & Wyndham 1985; Bradshaw *et al.* 1992). While the pattern of mortality in Agincourt reinforces this, it calls for a third crucial approach: a deeper understanding of the causal factors underlying critical health problems to strengthen policy and better target interventions. Greater understanding is likely to be found in the interactions of social, behavioural, biological, economic and environmental characteristics of families, and consequently best studied using a multidisciplinary approach and the combined efforts of quantitative and qualitative scientists (Mosley 1989; Chen & Bell 1994).

As the importance of noncommunicable disease in developing settings gains acceptance internationally (Murray & Lopez 1996), so resources must be diverted towards its research, policy and practice. However, caution must be exercised to avoid overinvesting too rapidly in this area at the expense of the 'unfinished agenda' which continues to afflict the youngest, poorest and most disenfranchised. (Gwatkin & Heuveline 1997).

Acknowledgements

This work could not have been conducted without the support of the study communities, and the interest of health providers to respond to findings. Ethical clearance was granted by the University of the Witwatersrand's Committee for Research on Human Subjects [Medical] (No. M960720). We acknowledge the roles of Obed Mokoena, Susan Khosa, the field team, and the Northern Province Department of Health. The European Union and Kagiso Trust, Henry J. Kaiser Family Foundation and Trust for Health Systems Planning and Evaluation have all taken an interest in this work. Kathleen Kahn was supported by the British Council, and Stephen Tollman by the British Council and a Wellcome Trust Travelling Research Fellowship (049336/Z/96/Z) during the analysis and write-up of this work.

References

Anker M (1997) The effect of misclassification error on reported cause-specific mortality fractions from verbal autopsy. *International Journal of Epidemiology* 26, 1090–1096.

Bang AT, Bang RA & the SEARCH Team (1992) Diagnosis of causes of childhood deaths in developing countries by verbal autopsy: suggested criteria. *Bulletin of the World Health Organization* 70, 499–507.

Botha JL & Bradshaw D (1985) African vital statistics – a black hole? *South African Medical Journal* 67, 977–981.

Bradshaw D & Buthelezi G (1996) Health status. In: *South African Health Review 1996.* Health Systems Trust and the Henry J Kaiser Family Foundation, Durban.

Bradshaw D, Dorrington RE & Sitas F (1992) The level of mortality in South African in 1985 – what does it tell us about health? *South African Medical Journal* 82, 237–240.

Bradshaw D, Laubscher R & Schneider M (1995) *Estimated Cause of Death Profiles for the nine new provinces based on 1990 data.* CERSA, Medical Research Council, South Africa.

Byarugaba J & Kielkowski D (1994) Reflections on trauma and violence-related deaths in Soweto, June 1990 – June 1991. *South African Medical Journal* 84, 610–614.

Chandramohan D, Maude G, Rodrigues L & Hayes R (1994) Verbal autopsies for adult deaths: Issues in their development and validation. *International Journal of Epidemiology* 23, 213–222.

Chandramohan D, Maude G, Rodrigues L & Hayes R (1998) Verbal autopsies for adult deaths: their development and validation in a multicentre study. *Tropical Medicine and International Health* 3, 436–446.

Chen LC & Bell DE (1994) Responding to health transitions: from research to action. In *Health Social Change in International Perspective* (eds. LC Chen, A Kleinman & NC Ware), Harvard Series on Population and International Health, Harvard University Press, Boston, pp. 491–501.

Datta N, Mand M & Kumar V (1988) Validation of causes of infant death in the community by verbal autopsy. *Indian Journal of Pediatrics* 55, 599–604.

Dowell SF, Davis HL, Holt EA *et al.* (1993) The utility of verbal autopsies for identifying HIV-1-related deaths in Haitian children. *AIDS* 7, 1255–1259.

First RHOSA Nutrition Survey (1987) Anthropometric assessment of nutritional status in black under-fives in rural South Africa. *Epidemiological Comments* **14**, 2–37.

Fortney JA, Susanti I, Gadalla S *et al.* (1986) Reproductive mortality in two developing countries. *American Journal of Public Health* **76**, 134–138.

Garenne M & Fontaine O (1990) Assessing probable causes of death using a standardized questionnaire: A study in rural Senegal. In *Measurement and Analysis of Mortality. New Approaches* (eds. J Vallin, S D'Souza & A Palloni), Clarendon Press, Oxford, pp. 123–142.

Gray RH, Smith G & Barss P (1990) *The use of verbal autopsy methods to determine selected causes of death in children.* Occasional Paper no. 10. The Johns Hopkins University School of Hygiene and Public Health, Baltimore.

Greenwood BM, Greenwood AM, Bradley AK *et al.* (1987) Deaths in infancy and early childhood in a well-vaccinated, rural West African population. *Annals of Tropical Paediatrics* **7**, 91–99.

Gwatkin DR & Heuveline P (1997) Improving the health of the world's poor. *British Medical Journal* **315**, 497–498.

Herman AAB & Wyndham CH (1985) Changes in infant mortality rates among whites, coloureds and urban blacks in the RSA over the period 1970–83. *South African Medical Journal* **68**, 215–218.

International Classification of Diseases (1978) *Manual of the international statistical classification of diseases, injuries and causes of death.* Based on the recommendations of the Ninth Revision Conference, 1975. World Health Organization, Geneva.

Kalter HD, Gray RH, Black RE & Gultiano SA (1990) Validation of postmortem interviews to ascertain selected causes of death in children. *International Journal of Epidemiology* **19**, 380–386.

Kielmann AA, Taylor CE, Faruqee R *et al.* (1983) Child and maternal health services in rural India. In *The Narangwal Experiment, Vols 1 and 2.* The Johns Hopkins University Press, Baltimore.

Lehrer LB, Matzopoulos R & Bradshaw D (1995) *A profile of violence and injury mortality in the Cape Town metropole 1994.* South African Medical Research Council, Tygerberg.

Maude GH & Ross DA (1997). The effect of different sensitivity, specificity and cuase-specific mortality fractions on the estimation of differences in cause-specific mortality rates in children from studies using verbal autopsy. *International Journal of Epidemiology* **26**, 1097–1106.

Mirza NM, Macharia WM, Wafula EM, Agwanda RO & Onyango FE (1990) Verbal autopsy: a tool for determining cause of death in a community. *East African Medical Journal* **67**, 693–698.

Mosley WH (1989) *Population laboratories for community health research.* Department of Population Dynamics, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore.

Murray CJL & Lopez AD (1996) Causes of death: New methods and global and regional applications for 1990. In *The Global Burden of Disease: a Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020, Vol 1* (eds CJL Murray & AD Lopez), The Harvard School of Public Health, on behalf of the World Health Organization and the World Bank, Boston, pp. 117–200.

Rip MR, Epstein L, Disler PB *et al.* (1987) Variations in mortality of the coloured, white and Asian population groups in the RSA. 1978–82. *South African Medical Journal* **72**, 405–407.

Ross DA (1992) *Monitoring cause-specific infant and child mortality rates in areas where death certification systems are weak. WHO/UNICEF consultation on the measurement of overall and cause-specific mortality in infants and children.* World Health Organisation, Geneva.

Snow RW, Armstrong JRM, Forster D *et al.* (1992) Childhood deaths in Africa: Uses and limitations of verbal autopsies. *Lancet* **340**, 351–355.

Snow RW, Basto de Azevedo I, Forster D *et al.* (1993) Maternal recall of symptoms associated with childhood deaths in rural East Africa. *International Journal of Epidemiology* **22**, 677–683.

Snow B & Marsh K (1992) How useful are verbal autopsies to estimate childhood causes of death? *Health Policy and Planning* **7**, 22–29.

Solarsh GC, Sanders DM, Gibson CA & Gouws E (1994) Community-based survey versus sentinel site sampling in determining the nutritional status of rural children. *South African Medical Journal* **84**, 747–752.

South African Vitamin A Consultative Group (1995) Children aged 6–71 months in South Africa, 1994: their anthropometric, vitamin A, iron and immunisation coverage status. *Epidemiological Comments* **22**, 185–214.

Todd J, De Francisco A, O'Dempsey T & Greenwood B (1994) The limitations of verbal autopsy in a malaria-endemic region. *Annals of Tropical Paediatrics* **14**, 31–36.

Tollman S, Herbst K, Garenne M, Gear J & Kahn K (1999) The Agincourt Demographic and Health Study: Site description, baseline findings and implications. *South African Medical Journal* in press.

Tollman SM, Kahn K, Garenne M & Gear JSS (1999) Reversal in mortality trends: Evidence from the Agincourt field site, South Africa, 1992–1995. *AIDS*, in press.

Uyirwoth GC (1994) Malaria in South Africa 1984–93. *Epidemiological Comments* **21**, 110–117.

Wyndham CH (1984a) Trends in the mortality rates for the ten leading causes of death among White, Coloured and Asian children under 5 years of age in the RSA, 1968–77. *South African Medical Journal* **66**, 719–725.

Wyndham CH (1984b) Leading causes of death among children under 5 years of age in the various population groups of the RSA in 1970. *South African Medical Journal* **66**, 717–718.

Wyndham CH (1984c) Mortality trends in the populations of the RSA from causes commonly observed in developing communities. 1968–77. *South African Medical Journal* **66**, 945–950.

Wyon JB & Gordon JE (1971) The Khanna Study. In *Population Problems in the Rural Punjab* Harvard University Press, Cambridge, Ma.

Yach D & Buthelezi G (1995) Health status. In *South African Health Review 1995.* Health Systems Trust and the Henry J. Kaiser Family Foundation, Durban.

Zimicki S (1990) Approaches to assessment of the cause structure of mortality: a case-study from Bangladesh. In *Measurement and Analysis of Mortality. New Approaches* (eds. J Vallin, S D'Souza & A Palloni), Clarendon Press, Oxford, pp. 99–122.