Estimating cause-specific mortality from community- and facility-based data sources in the United Republic of Tanzania: options and implications for mortality burden estimates

David R Whiting,[a] Philip W Setel,[b] Daniel Chandramohan,[c] Lara J Wolfson,[d] Yusuf Hemed,[b] & Alan D Lopez[e]

Objective To compare mortality burden estimates based on direct measurement of levels and causes in communities with indirect estimates based on combining health facility cause-specific mortality structures with community measurement of mortality levels.
Methods Data from sentinel vital registration (SVR) with verbal autopsy (VA) were used to determine the cause-specific mortality burden at the community level in two areas of the United Republic of Tanzania. Proportional cause-specific mortality structures from health facilities were applied to counts of deaths obtained by SVR to produce modelled estimates. The burden was expressed in years of life lost.
Findings A total of 2884 deaths were recorded from health facilities and 2167 recorded from SVR/VAs. In the perinatal and neonatal age group cause-specific mortality rates were dominated by perinatal conditions and stillbirths in both the community and the facility data. The modelled estimates for chronic causes were very similar to those from SVR/VA. Acute febrile illnesses were coded more specifically in the facility data than in the VA. Injuries were more prevalent in the SVR/VA data than in that from the facilities.
Conclusion In this setting, improved *International classification of diseases and health related problems*, tenth revision (ICD-10) coding practices and applying facility-based cause structures to counts of deaths from communities, derived from SVR, appears to produce reasonable estimates of the cause-specific mortality burden in those aged 5 years and older determined directly from VA. For the perinatal and neonatal age group, VA appears to be required. Use of this approach in a nationally representative sample of facilities may produce reliable national estimates of the cause-specific mortality burden for leading causes of death in adults.

Bulletin of the World Health Organization 2006;84:940-948.

Voir page 946 le résumé en français. En la página 947 figura un resumen en español. يمكن الاطلاع على الملخص بالعربية في صفحة 947.

Introduction

Accurate information on the levels and causes of death should be central to setting policy priorities in the health sector. However, few countries in the developing world have such basic demographic knowledge about their own populations. Growing interest has recently been shown in ways to assess and improve the quality of sources of routine mortality data,[1–3] and to make maximum use of existing non-routine sources for estimating mortality burdens, particularly among children.[4-8]

Given the lack of reliable vital statistics, the options for estimating mortality burden are extremely limited in resource-constrained settings. They include:

- household surveys for estimates of total child and, occasionally, maternal mortality;
- facility-based death statistics from routine health management information systems;
- community-based mortality statistics derived from the application of "verbal autopsy" (VA) in demographic surveillance systems (DSS) and sentinel/sample vital registration (SVR) systems.

Although each of these options has its limitations,[3] two of them, routine health service statistics and VA-derived mortality statistics, allow the attribution of causes of death at all ages; to date, household surveys have not provided this information.[6,9]

Within this context, we examine two ways of deriving the cause-specific mortality structure of populations in resource-constrained settings. The first is through the application of "indirect" measures of cause-specific mortality fractions from health facility statistics, to directly measured levels of mortality derived from community-based surveillance and reporting. The second is through the direct measurement of both the causes and levels of mortality, with causes of death derived from the application of a well-validated VA instrument.[10,11] This paper draws upon SVR data from the Tanzanian Ministry of Health,[12] and health-facility-based data collected during a study to validate the VA procedures used in the Tanzanian system.[11] We report the findings for three age groups in one urban and one rural setting. Subsequently the term "community-based" will be used interchangeably with "SVR".

[a] MEASURE Evaluation, Carolina Population Center, University of North Carolina at Chapel Hill, United States of America; and Department of Medicine, School of Population and Health Sciences, Newcastle University, England. Correspondence to this author at the latter address (email: david.whiting@ncl.ac.uk).
[b] MEASURE Evaluation, Carolina Population Center, and Department of Epidemiology School of Public Health, University of North Carolina at Chapel Hill, NC, United States of America.
[c] Department of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, London, England.
[d] Initiative for Vaccine Research, Vaccines, and Biologicals, World Health Organization, Geneva, Switzerland.
[e] School of Population Health, University of Queensland, Queensland, Australia.

Ref No. **05-028910**
(*Submitted: 9 December 2005 – Final revised version received: 9 May 2006 – Accepted: 11 May 2006*)

The purpose of this paper is to consider the options for providing accurate and readily obtainable estimates of mortality burden for use in policy planning, monitoring and evaluation. As such, we do not claim to validate either method, but to look at whether and how a re-analysis of facility-based records might produce estimates of mortality burden that differ substantially from those derived from direct community measurement through SVR, a technique which preliminary investigations have established as having a reasonable level of cost-effectiveness.[13]

Data and methods

The community-based mortality data were obtained from one urban (Dar es Salaam) and one rural (Hai, Kilimanjaro region) site during 2002. This entailed the regular enumeration of resident populations, vital events and migrations in defined geographical locations, as well as a continuous, active mortality surveillance system in which VA procedures were applied to all incident deaths.[14-16] For VAs three-line death certificates were completed, and cause of death was coded as a single underlying cause using a 39-item tabulation list (available on request) based on the *International classification of diseases and health related problems*, tenth revision (ICD-10).[17] Each VA was coded independently by two physicians and discrepancies were resolved by taking the majority verdict after independent coding by a third physician; if all three disagreed the cause was recorded as "undetermined". First and second coders agreed on all three lines of the VA death certificate 42.5% of the time for communicable, maternal, perinatal and nutritional conditions and for noncommunicable conditions. For injuries, agreement was 60%. Details of the field methods have been previously documented.[14,16,18] Community surveillance included all deaths that occurred in residents of households in the study areas regardless of place of death — home, health facility or elsewhere (e.g. on roads as a result of traffic fatalities) — VA was the source of the cause of death determination in all cases.

The cause structure of mortality in health facilities in Dar es Salaam was obtained from seven health facilities (three facilities adjacent to the SVR area) and for Kilimanjaro from six facilities (four situated within the SVR area).[18] All deaths from 2001 to 2003 were included, except for those among individuals resident outside a specified geographical radius around the facility, and cases in which surviving family members declined to participate in the study.

Physicians trained in ICD-10 coding rules reviewed all medical records.[17,19,20] Two physicians prepared independent death certificates that included underlying, immediate and associated causes of death; any disagreements were then resolved by consensus. The death certificates were coded according to ICD-10, and underlying causes were validated using TRANSAX software.[21] Each death was assigned to one of the groups in the mortality tabulation list.

It should be noted that the causes of death for the facility-based data used in this paper were not taken directly from hospital records or routine facility statistics, but were derived from a rigorous independent review of the records. Routine health service statistics in the United Republic of Tanzania only disaggregate age according to two groups (younger than five years and older than five years), are not coded according to ICD-10, and are not disaggregated by sex. Furthermore, previous assessment has shown that important causes of death including human immunodeficiency virus/acquired human immunodeficiency syndrome (HIV/AIDS) and tuberculosis are either grossly undercounted or absent.[22]

Years of life lost (YLLs) due to premature mortality were calculated in 5-year intervals using the Coale and Demeny West Model Level 26 life table[23] and summed (for ages 5 years and above). Denominators were generated from the SVR data as follows:

- perinatal and neonatal period: total number of live births recorded by the sentinel system for each area;
- age 29 days to 5 years: potential YLLs of children younger than 5 years minus one-twelfth of those aged 1 year;
- age 5 years and above: potential YLLs of resident population (aged 5 years and older calculated on current age in 5-year intervals) in the surveillance areas.

Mortality structures and rates derived from the community-based data were calculated as follows:

$$\sum_{x=\text{Cause}} YLL_x^{ra} \Big/ \sum_{P=\text{Population}} PYLL_P^{ra}$$

The modelled structures were calculated by applying the proportion of deaths due to each cause in each age group from the facility-based data to the number of deaths in the same age groups in the community-based data and then summing the YLLs by cause and age group:

$$\hat{p}_x = \frac{\sum_j p_x^{ra=j} \times n^{ra=j} \times YLL^{ra=j}}{\sum_i PYLL^{ra=i}}$$

Where:

r = region;
a = age group;
x = cause;
n = deaths counted by SVR;
p_x^{ra} = proportion of deaths due to cause "x" derived from medical record review in region r, age group a;
YLL = years of life lost;
$PYLLs_p$ = potential years of life lost of resident population derived from SVR (life expectancy values were those used by Murray & Lopez[23] — 80.0 years for males and 82.5 years for females).

Non-parametric bootstrap 95% confidence intervals were calculated.[24]

Three criteria for "good performance" of VA were established:[11]

- $\text{Sensitivity}_{VA} > 0.50$;
- $\text{Specificity}_{VA} > (1 - \text{CSMF})$ (cause-specific mortality fractions);
- Relative difference between CSMF_{VA} and $\text{CSMF}_{MR} < 0.20$ (where "MR" = cause according to reference medical record-based death certificate).

Causes meeting these criteria are indicated in the analysis.

Ethical approval

Ethical approval for this secondary analysis study was obtained from the University of North Carolina at Chapel Hill Institutional Review Board. Clearance for the verbal autopsy validation study was obtained from the Harvard University Human Subjects Protection Committee, the University of Newcastle upon Tyne Ethics Committee and the Tanzanian National Institute for Medical Research. The study was also implemented as part of the aims and objectives of the Tanzanian Ministry of Health under its Adult Morbidity and Mortality Project (AMMP).

Table 1. **Number and proportion of deaths, by cause, in children younger than 1 month**

	Dar es Salaam				Kilimanjaro			
	Community		Modelled		Community		Modelled	
Cause	*n*	%	*n*	%	*n*	%	*n*	%
Abdominal pain					1	0.5		
All other external causes; falls; accidental drowning and submersion; exposure to smoke, fire and flames	2	2.9						
Anaemias	1	1.4			1	0.5		
Congenital malformations of the central nervous system			1	1.5	2	1.1	3	2.5
Human immunodeficiency virus	1	1.4			5	2.7		
Hypertensive diseases	1	1.4						
Intestinal infectious diseases					6	3.2		
Malaria	5	7.1			6	3.2		
Malnutrition					2	1.1		
Other causes	2	2.9			3	1.6		
Perinatal conditions[a]	25	35.7	26	37.7	48	25.4	75	63.6
Pneumonia[a]	2	2.9			18	9.5	5	4.2
Prematurity and low birth weight	9	12.9	2	2.9	25	13.2	9	7.6
Remaining noncommunicable diseases					1	0.5		
Remaining respiratory diseases (infections)					1	0.5		
Stillbirths[a]	21	30.0	40	58.0	55	29.1	26	22.0
Transport accidents					1	0.5		
Unspecified acute febrile illness and other infectious causes	1	1.4			14	7.4		

[a] Sensitivity >0.50, and specificity >(1–$CSMF_{VA}$).

Results

Samples

Two thousand eight hundred and eighty-four deaths were recorded from health facilities in Kilimanjaro and Dar es Salaam combined, from 2001 to 2003. During 2002, the SVR system recorded 2167 deaths in the two areas. In Dar es Salaam, data on almost three times more facility deaths than SVR deaths were available for the study, whereas in Kilimanjaro records of 1.7 times more deaths were available from SVR than from the facilities. The age distributions of deaths in the community and facilities were significantly different in Dar es Salaam, where the community had a far greater proportion of deaths occurring at age 5 years and older. Many more of the facility deaths were among children, especially in the perinatal and neonatal age group. The age patterns of mortality in Kilimanjaro were similar in the facility and the community. In Dar es Salaam, 98.5% of facility deaths were reported from three large hospitals (n = 2004). Six per cent of these deaths were of residents of the surveillance area. In Kilimanjaro there were six participating facilities, of which four accounted for 93% (n = 791) of deaths; 59.5% of these deaths were of residents of the surveillance area.

Perinatal and neonatal mortality

The comparison between cause-specific mortality fractions (CSMFs) derived from the community and modelled from the facilites for all perinatal and neonatal deaths and causes is shown in Table 1, and the comparisons of mortality rates for the leading causes of perinatal and neonatal death are shown in Fig. 1. In Dar es Salaam, the community-based cause structure comprised 11 causes. The health-facility cause structure comprised four causes. No deaths due to malaria in this age group appear to have been recorded in the facility data from the urban setting. Cause-specific mortality rates based on direct measurement in the community in Dar es Salaam were dominated by perinatal conditions and stillbirth followed by: prematurity and low birth weight; malaria; and pneumonia. The facility-based mortality rates were also dominated by perinatal causes and stillbirth, followed by prematurity and low birth weight. There were no significant differences between the facility-derived and the community-based rates for the four causes occurring in the facility data.

In Kilimanjaro, 16 cause groups were assigned in the community-based mortality cause structure (n = 192), compared to five causes for the facility-based mortality structure (n = 91). Significant causes in the community-based mortality structure that were absent from the facility-based data included: unspecified acute febrile illness and other infectious causes; HIV; intestinal infectious diseases; and malaria. Significantly higher rates of stillbirth were noted in the Kilimanjaro community-based data than in the data derived from health facilities. This was the only cause for which statistically significant differences in mortality rates were found.

Age 29 days to 5 years

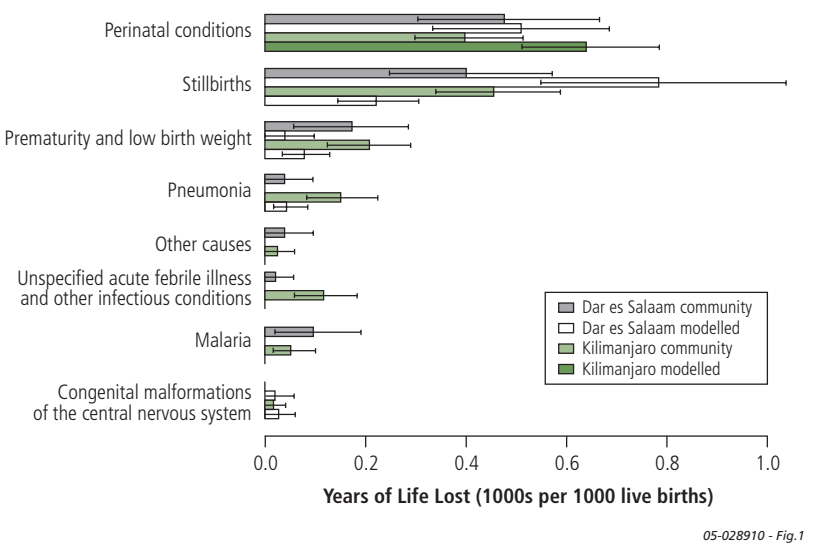
CSMFs for children aged 29 days to 5 years are shown in Table 2 and mortality rates are shown in Fig. 2. For Dar es Salaam, community surveillance produced a cause structure based on fewer than 100 deaths attributed to 10 causes, led by "unspecified acute febrile illness" and malaria. These causes accounted for 25% and 37% of deaths, respectively. The facility-derived cause structure (n = 449) identified nine causes of death, with malaria, pneumonia, intestinal infectious diseases and HIV predominating. There were significant differences between community-based and facility-based mortality rates for unspecified acute febrile illness and pneumonia.

In Kilimanjaro, 15 causes comprised the community-derived mortality structure (n = 88) whereas there were 14 different causes in the facility-based cause structure (n = 91). Deaths due to conditions including malnutrition and injuries were considerably more common in the community data, whereas more mortality from malaria and pneumonia was recorded in the facility-derived data. Nevertheless, with the exception of malnutrition, mortality rate estimates from the two sources did not differ significantly for any of the leading causes.

Age 5 years and above

Table 3 and Fig. 3 show findings for the population aged 5 years and older. The community-level mortality structure in Dar es Salaam included 24 different causes (n = 554); the facility data (n = 1090) included 20 causes. HIV/AIDS was by far the most prominent cause of death in both the community and facility-based data. In the community data, HIV/AIDS was followed by "unspecified acute febrile illness and other infectious causes", noncommunicable diseases (NCDs), malaria and tuberculosis. In the health facilities, the leading causes after HIV/AIDS were malaria, tuberculosis, NCDs and pneumonia.

Fig. 1. **Comparison of reference and modelled mortality rates in a perinatal and neonatal group**



Unspecified acute febrile illness and malaria were the most discrepant between the community and facility-based datasets. In Dar es Salaam, this discrepancy was also seen in the mortality rate estimates. Facility and community data estimated virtually identical proportions and rates of mortality due to HIV/AIDS, NCDs and neoplasms. Death rates from malaria, tuberculosis and pneumonia were higher in the facility-based data than in the community-based data.

In Kilimanjaro, the community mortality structure (n = 1169) consisted of 33 causes, compared to 25 causes in the facility-based data (n = 668). In the community-based VA mortality structure, HIV/AIDS was most prevalent, followed by NCDs; unspecified acute febrile illness and other infectious

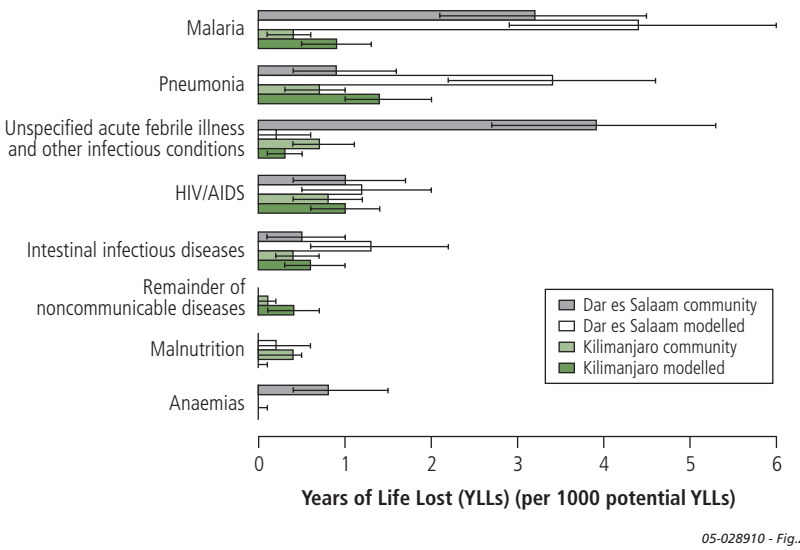
Table 2. **Number and proportion of deaths, by cause, in children aged from 29 days to 5 years**

	Dar es Salaam				Kilimanjaro			
	Community		Modelled		Community		Modelled	
Cause	*n*	%	*n*	%	*n*	%	*n*	%
All other external causes[a]	4	4.3			5	5.7	1	0.9
Anaemias	7	7.5			1	1.1		
Congenital malformations of the central nervous system	1	1.1			5	5.7	4	3.5
Disorders of the kidney	1	1.1						
Human immunodeficiency virus	8	8.5	10	10.6	16	18.2	21	18.1
Hypertensive diseases							1	0.9
Intestinal infectious diseases	4	4.3	11	11.7	9	10.2	13	11.2
Malaria[b]	27	28.7	37	39.4	8	9.1	19	16.4
Malnutrition			2	2.1	6	6.8	1	0.9
Meningitis			1	1.1	1	1.1	6	5.2
Other causes	1	1.1	1	1.1	2	2.3	4	3.5
Perinatal conditions					2	2.3	1	0.9
Pneumonia[a]	8	8.5	28	29.8	14	15.9	30	25.9
Prematurity and low birth weight					1	1.1		
Remaining noncommunicable diseases					2	2.3	8	6.9
Remaining respiratory diseases (infections)					1	1.1		
Tuberculosis			2	2.1			1	0.9
Unspecified acute febrile illness and other infectious causes	33	35.1	2	2.1	15	17.1	6	5.2

[a] Sensitivity >0.50, and specificity >(1–$CSMF_{VA}$).
[b] Sensitivity >0.50, specificity >(1–$CSMF_{VA}$), and ($CSMF_{VA}$ – $CSMF_{MR}$) <0.20.

causes; cancers; and pneumonia. In the facility-based data HIV/AIDS was most prevalent followed by NCDs, malaria, tuberculosis, neoplasms, hypertensive diseases, all other external causes, pneumonia, other causes, and diabetes mellitus. There was no significant difference in the rates for chronic diseases, whereas the rates for infectious diseases such as malaria and tuberculosis were higher in the facility-based estimates and the rate of unspecified acute febrile illness and other infectious causes was higher in the community-based estimates.

Fig. 2. **Comparison of reference and modelled mortality rates in children aged 29 days to 5 years**



05-028910 - Fig.2

Discussion

Limitations and implications for mortality burden measurement

We have presented mortality burdens calculated by: direct estimation from an SVR system with VA, and indirect estimates obtained by applying the cause structure in adjacent or nearby health facilities to sentinel counts of deaths.

It is notable that, in general, many more causes were coded in the community than in the facility-based data. There are several possible explanations for this. For example, for causes occurring infrequently in the facility data, the modelling process may have rounded them to zero. Identifying the precise reasons for this finding, however, would require further investigation.

Some implications from this comparison of data sources for calculation of mortality burden should be noted. For newborns and children, stillbirths are often excluded from demographic statistics, yet they account for a significant proportion of the mortality burden in the perinatal and neonatal age group. In Dar es Salaam the stillbirth rate was substantially higher in the modelled results than in the community, whereas in the rural area the opposite was true. This could be due to the not uncommon practice of recording early neonatal deaths as stillbirths in health facilities.[25] For example, a review of the VA data showed that according to parents and caregivers, 10% of "stillborn" children (as determined from the medical records) breathed after birth, and half of these cried before dying.

The community estimates of the burden due to prematurity and low birth weight are significantly higher than the facility-based estimates. There are various possible reasons for this. For instance, premature birth may occur when there is insufficient time to access health services and low birth weight might be more common in the poor who are known to access health services less often.[12] Alternatively, those who do reach health services may be less likely to die.

Among deaths of those aged 5 years and older, community and facility-derived estimates were remarkably similar for most chronic conditions including HIV/AIDS, NCDs and neoplasms. These conditions accounted for a substantial proportion of the total mortality burden and are causes for which the VA tool performed well.[11] The facility-based model estimates for most chronic conditions therefore appear to accurately represent the community burden in these two areas.

Estimates for specific acute febrile illnesses, such as malaria and pneumonia obtained from the facility-based model were higher than the community estimates. However, the mortality rates from unspecified acute febrile illness and other infectious conditions were higher in the community estimates. In these situations, medical records are more likely to contain information such as blood slide results, whereas VA data are likely to have far less specific information. This could well have inclined coders to select "unspecified acute febrile illness" over "malaria" or "pneumonia" when coding VA. For acute infectious conditions, therefore, the modelled estimates appear to be more specific than the community estimates. Although one-third of "malaria" deaths among children occurred in those aged less than 6 months (who might have been protected by maternal immunity), the proportion of deaths due to malaria did not change when these children were excluded.

Finally, there were few injuries in children younger than 5 years overall, and only one from the health facility data. Combining all injuries and accidents in those aged 5 years and above, the proportion of deaths is higher (significantly in Dar es Salaam) in the community-based figures than in the modelled estimates. This may be due to injuries that prove fatal before a health facility can be reached; alternatively if health care is effective, those who do obtain treatment may be less likely to die.

Conclusions

Study limitations

There are several factors that may affect the conclusions drawn from the data. First, the distribution of deaths was skewed towards a few leading causes in each age group; sample sizes for less common causes were small and confidence intervals for estimates of these causes were consequently large. Second, it is possible that the geographical criterion used to select deaths for inclusion in the validation was not sufficient to ensure that those included from outside the SVR areas had similar characteristics to those that were included. Analysis of the facility cause structure excluding those who were resident in the surveillance area, however, did not result in a substantially different cause structure in the health facility. We believe that those

Table 3. **Number and proportion of deaths, by cause, in subjects aged 5 years and older**

	Dar es Salaam				Kilimanjaro			
	Community		Modelled		Community		Modelled	
Cause	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Abdominal pain	7	1.3	2	0.4	19	1.6		
Accidental poisoning by and exposure to noxious substances					11	1.0		
All other external causes[a]	11	2.0	4	0.7	24	2.1	30	2.9
Anaemias	2	0.4			3	0.3	1	0.1
Assault[b]	4	0.7			10	0.9	1	0.1
Chronic obstructive pulmonary diseases	1	0.2	3	0.6	18	1.6	16	1.6
Cirrhosis of the liver					8	0.7	7	0.7
Congenital malformations of the central nervous system					2	0.2	5	0.5
Diabetes mellitus	9	1.6	7	1.3	23	2.0	37	3.6
Disorders of the kidney	8	1.5	5	0.9	23	2.0	17	1.7
Human immunodeficiency virus[a]	204	37.0	200	36.8	275	23.8	214	20.9
Hypertensive diseases	13	2.4	12	2.2	29	2.5	78	7.6
Intentional self-harm[b]					17	1.5	4	0.4
Intestinal infectious diseases[a]	13	2.4	10	1.8	20	1.7	15	1.5
Malaria[a]	40	7.3	124	22.8	21	1.8	84	8.2
Malignant neoplasm of breast[b]	3	0.5	1	0.2	6	0.5		
Malignant neoplasm of liver and intrahepatic bile ducts					8	0.7	15	1.5
Malignant neoplasm of trachea, bronchus and lung	1	0.2			1	0.1		
Malnutrition					2	0.2		
Meningitis			2	0.4			3	0.3
Other causes	40	7.3	19	3.5	155	13.4	26	2.5
Pneumonia	7	1.3	27	5.0	57	4.9	38	3.7
Prematurity and low birth weight					2	0.2		
Remaining disorders of the liver			1	0.2	1	0.1	9	0.9
Remaining noncommunicable diseases[b]	43	7.8	52	9.6	185	16.0	218	21.3
Remaining neoplasms[a]	12	2.2	6	1.1	83	7.2	115	11.2
Remaining respiratory diseases (infections)	1	0.2			13	1.1		
Tetanus[b]	1	0.2			3	0.3	5	0.5
Transport accidents	18	3.3	2	0.4	14	1.2	4	0.4
Tuberculosis[a]	29	5.3	54	9.9	24	2.1	62	6.1
Unspecified acute febrile illness and other infectious causes	76	13.8	1	0.2	97	8.4	15	1.5
Viral hepatitis					1	0.1		
In women of child-bearing age (15–49 years)								
Maternal (except pregnancy with abortive outcome)[a]	8	4.6	10	5.9	1	0.4	6	3.3
Pregnancy with abortive outcome	1	0.6			1	0.4		

[a] Sensitivity >0.50, and specificity >(1–$CSMF_{VA}$).
[b] Sensitivity >0.50, specificity >(1–$CSMF_{VA}$), and ($CSMF_{VA}$ – $CSMF_{MR}$) <0.20.

included in the validation study were similar to those from the surveillance area and were unlikely to have experienced significantly different mortality patterns or risks.

Considerations for application to other countries

"Routine" sources of data, such as vital registration and facility-based statistics are unreliable for measuring mortality levels and rates in most lower-income countries, and in some situations (such as areas experiencing protracted conflict) even facility-based data are absent or extremely patchy. Even in areas where coverage is thought to be fairly good, such as Kenya, the usefulness of routine administrative sources for estimation of demographic characteristics may be very limited.[2]

In a setting where *no* facility-based statistics exist, or where facility-based monitoring has collapsed, it is unlikely that sufficient data sources would exist to permit any reliable estimates of mortality levels or cause structures for national populations. In such circumstances it is plausible that social and political insecurity, or severely constrained resources, would make a sustained investment in any long-term mortality monitoring system a dubious undertaking.

However, most countries do have some form of routine health information system. With improved ICD coding practices, the comparison undertaken here shows that applying facility-based cause structures to counts of deaths from communities derived from sentinel or SVR in the United Republic of Tanzania may produce reasonable estimates of the directly measured cause-specific mortality (as determined by VA) burden in those aged 5 years and older for leading

causes of death. It would, nevertheless, be necessary to run an active system of SVR with VA in parallel to any facility-based system for a fixed period of time to provide a basis for any later comparison. For the perinatal and neonatal age group, VA appears to be required. VA-derived mortality burden estimates are assumed to be preferable because they provide direct, if crude, measurements of the community mortality experience.

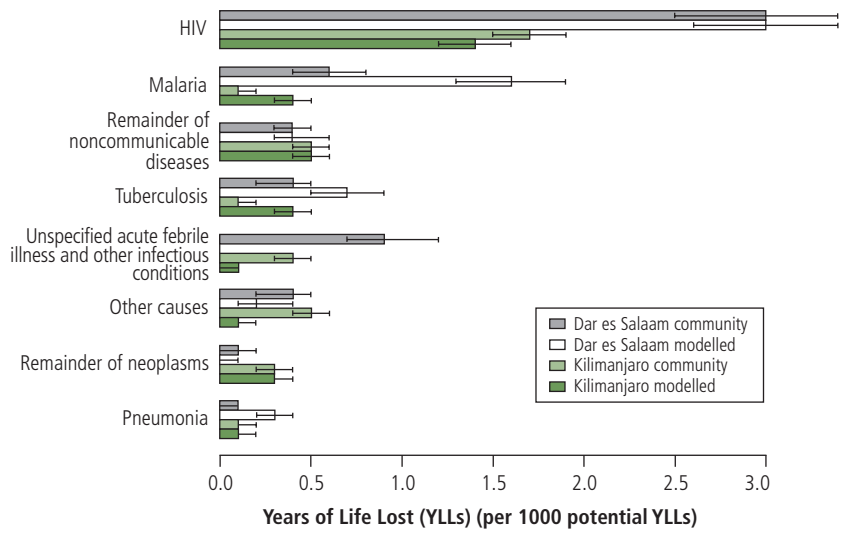
To estimate the burden of disease in Africa, the Global Burden of Disease study[23] included extrapolations from a relatively small number of DSS sites, including those included in this study. This paper suggests that use of health facility data, combined with community levels of mortality might have resulted in similar estimates of the burden for a number of important causes, but only if the following four conditions had been met:

- the similarities in cause structure shown here also apply to hospitals and their neighbouring communities in other parts of Africa;
- a reliable alternative source of accurate mortality levels was available;
- death certificates had been completed and coded using correct ICD-10 procedures; and
- the mortality burden in the DSS sites they had used was similar to the burden in other African countries.

Countries that lack complete vital registration might apply a phased approach to obtain estimates of the community mortality burden in the most cost-effective manner. Initially, VAs could be conducted as part of a sentinel or SVR system or in conjunction with a large household survey or national census so that comparisons, similar to those presented here, could be made of the mortality burdens estimated directly and those derived from the facility-based model. Comparisons stratified by socioeconomic status measured at the household level would also be desirable. In addition, "catchment areas" of populations and communities actually using nearby facilities would have to be well understood so that characteristics of denominator populations could be accurately worked out.

If it can be established that the estimates for any or all age groups are congruent, the VA component may no longer be required. Use of this approach in a nationally representative sample of facilities could thereby be demonstrated to produce national estimates of the cause-specific mortality burden for leading causes of death; these will have been demonstrated to be consistent with VA-derived estimates — the only other systematic source of such data likely to be practical and available. ■

Fig. 3. **Comparison of reference and modelled mortality rates in population aged 5 years and older**



05-028910 - Fig.

Acknowledgements

The authors wish to acknowledge the Adult Morbidity and Mortality Project, Phase2 (AMMP) and the people resident in the AMMP surveillance sites in Dar es Salaam and Hai. The views expressed are not necessarily those of the NIH, NIA or USAID.

Funding: Funding for the preparation of this article was provided through MEASURE Evaluation, Phase 2, a United States Agency for International Development (USAID) Cooperative Agreement (# GPO-A-00-03-00003-00) implemented by the Carolina Population Center, University of North Carolina at Chapel Hill. Research funding and publication support was also provided by grant P10462-109/9903GLOB-2, The Global Burden of Disease 2000 in Aging Populations, US National Institutes of Health (NIH), National Institute on Ageing (NIA). AMMP was a project of the Tanzanian Ministry of Health funded by the UK Department for International Development and implemented in partnership with the University of Newcastle upon Tyne.

Competing interests: none declared.

Résumé

Estimation de la mortalité par cause à partir des données de la communauté et des établissements de santé en République-Unie de Tanzanie : options et incidences sur les estimations du poids de la mortalité

Objectif Comparer les estimations du poids de la mortalité obtenues en mesurant directement les niveaux et les causes dans les communautés aux estimations indirectes obtenues en associant la structure de mortalité par cause dans les établissements de santé à la mesure des niveaux de mortalité dans la communauté.

Méthodes On a utilisé les données des registres d'état civil sentinelles avec autopsie verbale pour déterminer le poids de la mortalité par cause au niveau communautaire dans deux régions de la République-Unie de Tanzanie. La structure proportionnelle de la mortalité par cause obtenue dans les établissements de santé a été appliquée aux chiffres des décès obtenus par les registres sentinelles afin d'obtenir des estimations modélisées. Le poids a été exprimé en années de vie perdues.

Résultats Au total, les établissements de santé ont enregistré

2884 décès et les registres sentinelles/autopsies verbales 2167. Dans la classe d'âge des nouveau-nés et très jeunes nourrissons, les taux de mortalité par cause sont dominés par les affections périnatales et la mortinatalité aussi bien pour les données communautaires que les données des établissements. Les estimations modélisées relatives aux causes chroniques sont très semblables à celles des registres sentinelles/autopsies verbales. Les maladies fébriles aiguës sont codées de manière plus spécifique dans les données des établissements que dans les autopsies verbales. Les traumatismes sont plus répandus dans les données provenant des registres sentinelles/autopsies verbales que dans celles provenant des établissements.

Conclusion Dans cette situation, les meilleures pratiques de codage de la Classification internationale des Maladies et des Problèmes de Santé connexes, Dixième Révision (CIM-10) et l'application de la structure par causes de la mortalité des établissements aux chiffres des décès relevés dans les communautés à partir des registres sentinelles semblent donner des estimations raisonnables du poids de la mortalité par cause chez les sujets de cinq ans et plus, déterminée directement à partir de l'autopsie verbale. Pour la classe d'âge des nouveau-nés et très jeunes nourrissons, il semble nécessaire d'utiliser les autopsies verbales. L'utilisation de cette approche dans un échantillon d'établissements représentatif au plan national peut fournir des estimations nationales fiables du poids de la mortalité par cause pour les principales causes de décès chez l'adulte.

Resumen

Estimación de la mortalidad por causas específicas a partir de fuentes de datos de la comunidad y de los establecimientos sanitarios en la República Unida de Tanzanía: opciones y repercusiones en las estimaciones de la carga de mortalidad

Objetivo Comparar las estimaciones de la carga de mortalidad basadas en mediciones de su magnitud y sus causas realizadas directamente en la comunidad con las estimaciones indirectas basadas en la combinación de la estructura de la mortalidad por causas específicas registrada en los establecimientos sanitarios y la magnitud de la mortalidad medida en la comunidad.

Métodos Se utilizaron datos del sistema de registro civil centinela (RCC) con autopsia verbal (AV) para determinar la carga de mortalidad por causas específicas a nivel comunitario en dos zonas de la República Unida de Tanzanía. A las cifras de muertes obtenidas en los RCC se les aplicaron las estructuras proporcionales de mortalidad por causas específicas registradas en los establecimientos sanitarios, con el fin de obtener estimaciones derivadas de modelos. La carga se expresó en años de vida perdidos.

Resultados Se registraron 2884 muertes en los establecimientos sanitarios y 2167 en los RCC/AV. En el grupo de edad perinatal y neonatal, las tasas de mortalidad por causas específicas mostraron un predominio de las afecciones perinatales y las muertes intrauterinas, tanto en los datos obtenidos en la comunidad como en los obtenidos en los establecimientos sanitarios. Las estimaciones de las causas crónicas derivadas de modelos fueron muy similares a las obtenidas en los RCC/AV. Las enfermedades febriles agudas se codificaron de forma más específica en los datos de los establecimientos sanitarios que en la AV. Los traumatismos fueron más prevalentes en los datos de los RCC/AV que en los de los establecimientos sanitarios.

Conclusiones En este entorno, la mejora de las prácticas de codificación de la 10ª revisión de la *Clasificación Internacional de enfermedades y problemas relacionados con la salud* (CIE 10) y la aplicación de las estructuras etiológicas obtenidas en los establecimientos sanitarios a las cifras de muertes registradas en la comunidad, derivadas de los RCC, parecen proporcionar estimaciones razonables de la carga de mortalidad por causas específicas en mayores de 5 años determinada directamente a partir de las AV. En los grupos de edad perinatal y neonatal parecen ser necesarias AV. El empleo de este método en una muestra de establecimientos representativa del país puede proporcionar estimaciones nacionales fiables de la carga de mortalidad por las principales causas específicas de muerte de los adultos.

ملخص

تقدير معدلات الوفيات الناجمة عن سبب معين بالاعتماد على معطيات ترتكز على المجتمع وعلى المرافق في جمهورية تنزانيا المتحدة: الاختيارات والتأثيرات على التقديرات لعبء الوفيات

الهدف: مقارنة تقديرات عبء الوفيات المرتكزة على قياس مباشر للمستويات وللأسباب في المجتمعات مع تقديرات مرتكزة على ترافق المكوِّنات الخاصة بمعدلات الوفيات الناجمة عن سبب معين في المرافق الصحية مع قياس مستويات الوفيات.

الطريقة: استخدمنا المعطيات التي تتيحها السجلات المدنية (الحياتية) الخافرة مع الصفة التشريحية اللفظية للتعرف على عبء الوفيات الناجمة عن سبب معيَّن في مستوى المجتمع في منطقتَيْن في جمهورية تنزانيا المتحدة. وقد طبقت مكوِّنات المعدلات النسبية التي استمدت من السجلات المدنية (الحياتية) الخافرة لإنتاج تقديرات مستمدة من النماذج. وقد عُبِّر عن العبء بالسنوات الضائعة من الحياة.

الموجودات: سُجِّلت 2884 وفاة في المرافق الصحية و2167 وفاة في السجلات المدنية (الحياتية) الخافرة والصفة التشريحية اللفظية. وقد سادت وفيات الفترة المحيطة بالولادة وموت الأجنة داخل الرحم على معدلات الوفيات الناجمة عن سبب معيَّن في المجموعة العمرية المحيطة بفترة الولادة والولدان، وذلك في المعطيات المستمدة من كل من المجتمع ومن المرافق الصحية. وقد كانت التقديرات المستمدة من النماذج للأسباب المزمنة مشابهة إلى حدٍ بعيد للتقديرات المستمدة من السجلات (الحياتية) الخافرة ومن الصفة التشريحية اللفظية. وقد ورد ترميز الأمراض الحُمَّوية الحادة بشكل أكثر نوعية في المعطيات المستمدة من المرافق الصحية منه في الصفة التشريحية اللفظية، وقد كانت الأذيات أكثر انتشاراً في المعطيات المستمدة من السجلات المدنية (الحياتية) الخافرة ومن الصفة التشريحية اللفظية منه في المعطيات المستمدة من المرافق الصحية.

الاستنتاج: يبدو أن ممارسات الترميز في المراجعة العاشرة المُحَسَّنة للتصنيف الدولي للأمراض وللمشكلات الصحية المتعلقة بها، وتطبيق المكوِّنات للأسباب المرتكزة على المرافق عند تعداد الوفيات المستمدة من المجتمعات والمشتقة من السجلات المدنية (الحياتية) الخافرة، سينتج تقديرات معقولة لعبء

الوفيات الخاصة بسبب معيَّن لدى من تزيد أعمارهم عن 5 سنوات والتي استمدت بشكل مباشر من الصفة التشريحية اللفظية. ويبدو أن الصفة التشريحية اللفظية ضرورية للمجموعات العمرية في الفترة المحيطة بالولدان وللولدان. ويمكن لاستخدام هذا الأسلوب ضمن نموذج ممثِّل للمرافق الصحية على الصعيد الوطني أن يؤدي إلى تقديرات وطنية موثوقة لعبء الوفيات الناجمة عن سبب معيَّن، وذلك بالنسبة للأسباب الرئيسية للوفيات لدى البالغين.

References

1. Mathers C, Inoue M, Lopez A, Shibuya K. *Overview of global mortality data sources*. Geneva: Evidence and Information for Policy, World Health Organization; 2003.
2. Arudo J, Gimnig JE, ter Kuile FO, Kachur SP, Slutsker L, Kolczak MS, et al. Comparison of government statistics and demographic surveillance to monitor mortality in children less than five years old in rural western Kenya. *Am J Trop Med Hygiene* 2003;68(4 Suppl):30-7.
3. Setel PW, Sankoh O, Mathers C, Velkoff VA, Rao C, Gonghuan Y, et al. Sample registration of vital events with verbal autopsy: innovative approaches to measuring and monitoring vital statistics. *Bull World Health Organ* 2005;83:611-7.
4. Morris SS, Black RE, Tomaskovic L. Predicting the distribution of under-five deaths by cause in countries without adequate vital registration systems. *Int J Epidemiol* 2003;32:1041-51.
5. Korenromp EL, Williams BG, Gouws E, Dye C, Snow RW. Measurement of trends in childhood malaria mortality in Africa: an assessment of progress toward targets based on verbal autopsy. *Lancet Infect Dis* 2003;3:349-58.
6. Korenromp EL, Arnold F, Williams BG, Nahlen BL, Snow RW. Monitoring trends in under-5 mortality rates through national birth history surveys. *Int J Epidemiol* 2004;33:1-9.
7. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? *Lancet* 2003;361:2226-34.
8. Williams BG, Gouws E, Boschi-Pinto C, Bryce J, Dye C. Estimates of world-wide distribution of child deaths from acute respiratory infections. *Lancet Infect Dis* 2002;2:25-32.
9. Timaeus IM, Jasseh M. Adult mortality in sub-Saharan Africa: evidence from Demographic and Health Surveys. *Demography* 2004;41:757-72.
10. Yang G, Rao C, Ma J, Wang L, Wan X, Dubrovsky G, et al. Validation of verbal autopsy procedures for adult deaths in China. *Int J Epidemiol* 2005;35:741-8.
11. Setel PW, Whiting DR, Hemed Y, Chandramohan D, Wolfson LJ, Rao C, et al. Validity of verbal autopsy procedures for determining cause of death in Tanzania. *Trop Med Internat Health* 2006;11:608-703.
12. Ministry of Health. *The policy implications of Tanzania's mortality burden: a ten-year community-based perspective. AMMP-2 final report*. Vol. 1. Dar es Salaam: Adult Morbidity and Mortality Project, Tanzania Ministry of Health/University of Newcastle upon Tyne/UK Department for International Development; 2004.
13. Rommelmann V, Setel PW, Hemed Y, Mponezya H, Angeles G, Boerma T. Costs and results of information systems for poverty and health indicators in the United Republic of Tanzania. *Bull World Health Organ* 2005;83:569-77.
14. Mswia R, Whiting D, Kabadi G, Masanja H, Setel P, for the AMMP Team. Hai District Demographic Surveillance System. In: The INDEPTH Network, editor. *Population and health in developing countries. Volume 1: Population, health, and survival in INDEPTH Sites*. Ottawa: International Development Research Centre; 2002:151-8.
15. Mswia R, Whiting D, Kabadi G, Masanja H, Setel P, for the AMMP Team. Morogoro Rural Demographic Surveillance System. In: The INDEPTH Network, editor. *Population and health in developing countries. Volume 1: Population, health, and survival in INDEPTH Sites*. Ottawa: International Development Research Centre; 2002:165-72.
16. Mswia R, Whiting D, Kabadi G, Masanja H, Setel P, for the AMMP Team. Dar es Salaam Demographic Surveillance System. In: The INDEPTH Network, editor. *Population and health in developing countries. Volume 1: Population, health, and survival in INDEPTH Sites*. Ottawa: International Development Research Centre; 2002:143-50.
17. World Health Organization. *International statistical classification of diseases and related health problems*. Tenth Revision. Volume 1. Geneva: World Health Organization; 1993.
18. Ministry of Health. *The policy implications of Tanzania's mortality burden: field operations and validation studies. AMMP-2 Final Report Volume 3*. Dar es Salaam: Adult Morbidity and Mortality Project/Tanzania Ministry of Health, University of Newcastle upon Tyne/UK Department for International Development; 2004.
19. World Health Organization. *International statistical classification of diseases and related health problems*. Tenth Revision. Volume 2. Geneva: WHO; 1993.
20. World Health Organization. *International statistical classification of diseases and related health problems*. Tenth Revision. Volume 3. Geneva: WHO; 1993.
21. Chamblee RF, Evans MC. TRANSAX: The NCHS system for producing multiple cause-of-death statistics 1968-78. *Vital Health Statistics* 1986;20:1-83.
22. Mkusa V, Hemed Y, Masuki G, Setel PW. Setting priorities in health care: use of diverse information perspectives at the district level in Tanzania. In: *4th International Conference on Priorities in Health Care*; 2002 18–22 September. Oslo, Norway; 2002.
23. Murray CJL, Lopez AD, editors. *The global burden of disease*. Cambridge (MA), Harvard School of Public Health on behalf of the World Health Organization and the World Bank; 1996.
24. Carpenter J, Bithell J. Bootstrap confidence intervals: when, which, what? A practical guide for medical statisticians. *Stat Med* 2000;19:1141-64.
25. Lawn J, McCarthy B. *Improving vital registration of births and perinatal deaths in the developing world: recommendations from a survey of countries and a literature review*. Geneva: World Health Organization; 1998.