Newcastle University

Newcastle University ePrints

Walker RW, Jusabani A, Aris E, Gray WK, Whiting D, Kabadi G, Mugusi F, Swai M, Alberti G, Unwin N. Post-stroke case fatality within an incident population in rural Tanzania. *Journal of Neurology, Neurosurgery and Psychiatry* 2011, 82(9), 1001-1005.

Copyright:

This article has been accepted for publication in the *Journal of Neurology, Neurosurgery and Psychiatry* following peer review. The definitive copyedited, typeset version [*J Neurol Neurosurg Psychiatry* 2011;**82**:1001-1005 doi:10.1136/jnnp.2010.231944] is available online at:

http://dx.doi.org/10.1136/jnnp.2010.231944

Always use the definitive version when citing.

Further information on publisher website: http://jnnp.bmj.com

Date deposited: 6th November 2013

Version of file: Author final

This work is licensed under a Creative Commons Attribution-NonCommercial 3.0 Unported License

ePrints – Newcastle University ePrints
http://eprint.ncl.ac.uk

Post-stroke case-fatality within an incident population in rural Tanzania

Richard W. Walker MD,[1,2] Ahmed Jusabani MD,[3] Eric Aris MD,[4] William K. Gray PhD,[1] David Whiting PhD,[5] Gregory Kabadi MSc,[6] Ferdinand Mugusi MD,[4] Mark Swai MD,[3] George Alberti MD[7] and Nigel Unwin DM[2,8]

1. North Tyneside General Hospital, Rake Lane, North Shields, Tyne and Wear, NE29 8NH, UK
2. Institute of Health and Society, University of Newcastle-upon-Tyne, UK
3. Kilimanjaro Christian Medical Centre, Moshi, Tanzania
4. Department of Neurology, Muhimbili University Hospital, Dar-es-Salaam, Tanzania
5. International Diabetes Federation, Brussels, Belgium
6. Ifakara Health Institute, Dar-es-Salaam, Tanzania
7. Department of Endocrinology and Metabolism, St Mary's Hospital Campus, Imperial College, London, UK
8. Faculty of Medical Sciences, Cave Hill Campus, University of the West Indies, Barbados

Correspondence to: Richard Walker, Department of Medicine, North Tyneside General Hospital, Rake Lane, North Shields, Tyne and Wear, NE29 8NH, UK; telephone and fax: 0191 293 2709

Richard.walker@nhct.nhs.uk

Cover Title: Post-stroke case-fatality in Tanzania

Word count: Abstract 232, Text 2512, Tables 4, Figures 1, References 35

Key words: Stroke, Tanzania, Mortality, Case-fatality, sub-Saharan Africa

Table 1. Three-year case-fatality rates for the Hai DSS

Table 2. Age- and sex-specific case fatality rates at 28 days post-stroke

Table 3. Age- and sex-specific case fatality rates at 3 years post-stroke

Table 4. Comparison with other studies

Figure 1. Kaplan-Meier cumulative survival function for 3-6 year follow-up

ABSTRACT

Background and purpose: To establish post-stroke case-fatality rates within a community based incident stroke population in rural Tanzania.

Methods: Incident stroke cases were identified by the Tanzanian Stroke Incidence Project (TSIP), and followed up over the next 3 to 6 years. In order to provide a more complete picture we also used verbal autopsy (VA) to identify all stroke deaths occurring within the same community and time period, and identified a date of stroke by interview with a relative or friend.

Results: Over 3 years TSIP identified 130 cases of incident stroke, of which 31 (23.8%, 95% CI 16.5 to 31.2) died within 28 days and 78 (60.0%, 95% CI 51.6 to 68.4) within 3 years of incident stroke. Over the same time period, an additional 223 deaths from stroke were identified by VA, 64 (28.7%, 95% CI 20.9 to 36.5) had died within 28 days of stroke and188 (84.3%, 95% CI 78.1 to 90.6) within 3 years.

Conclusions: This is the first published study of post-stroke mortality in sub-Saharan Africa (SSA) from an incident stroke population. The 28-day case-fatality rate is at the lower end of rates reported for other low and middle income countries, even when including those identified by VA, although confidence intervals are wide. Three-year case-fatality rates are notably higher than seen in most developed world studies. Improving post-stroke care may help to reduce stroke case-fatality in SSA.

INTRODUCTION

Stroke is a major cause of death worldwide accounting for nearly 10% of all deaths, with 85% of all stroke deaths occur in the developing world.[1] Stroke incidence and case-fatality vary widely from country to country, but recent research, based on best available evidence, has supported the view that both are closely linked to measures of a country's wealth, such as gross domestic product.[2-3] Eastern Europe, north Asia, south Pacific and central Africa had the highest stroke mortality rates. There was a 3.5-fold increase in stroke mortality in low-income countries compared to middle- and high-income countries. Furthermore, stroke mortality has been shown to increase as economic conditions deteriorate; this increase is thought to be linked to increased case-fatality, rather than increased incidence.[4-5]

The World Health Organisation's MONICA study from the period 1980-1995 demonstrated mean 28-day case-fatality rates of 18% in Sweden, 19% in Denmark, 21% in Finland, 28% in Beijing, China, 33% in Italy, 40% in Russia and 45% in Poland.[5] A 2009 systematic review of 56 population-based stroke incidence studies from 1970-2008 revealed a mean decrease in 1-month case-fatality between 1980-89 and 2000-08 from 21.5% to 19.8% in high income countries and from 35.2% to 26.6% in low to middle income countries.[3] This decrease has occurred against a background of demographic changes leading to an increasingly elderly population, and is almost certainly due to improved management of stroke survivors.[6,7] Declines in 1-year case-fatality have also been reported recently.[8] In contrast, a long-term study in Oxfordshire, UK saw no significant change in incident stroke case-fatality from 1981 to 2004 (17.2% vs. 17.8%), despite a dramatic fall in overall incidence.[9] Results from long-term follow-up of stoke cases are more variable, in part due to varying exclusion and inclusion criteria.[10-13] However, recent studies from the

developed world suggest 3- and 5-year case-fatality rates of 43-54% and 53-60% respectively.[14-18]

Reports of post-stroke deaths in sub-Sahara Africa (SSA) are, however, unreliable due to factors such as, the small number of deaths occurring in hospitals, limited death certification and lack of coverage of primary health care services.[19-20] Previous studies looking at mortality amongst those admitted to hospital have demonstrated a one month case-fatality of between 27% and 46%.[21-23]

We are not aware of any previous studies of case-fatality of incident stroke cases in SSA.[19] The aim of this study was to establish case-fatality over 3 years post-stroke within an incident population. Such data are needed to help inform clinicians, government agencies and other healthcare providers in SSA.[2-3]

PARTICIPANTS AND METHODS

Participants were part of a stroke incidence study, details of which have been described previously.[24] A favourable ethical opinion was obtained from the National Institute of Medical Research in Tanzania and from the Newcastle and Northumberland Joint Ethics Committee, UK.

Recruitment

During the incidence phase of our study we used two methods of case ascertainment.[24] The Tanzanian Stroke Incidence Project (TSIP) combined with verbal autopsy (VA) recruited cases from 15th June 2003 until 15th June 2006 and was conducted in two demographic surveillance sites (DSS); 52 villages in the Hai district of northern Tanzania and 8

geographical divisions of the city of Dar-es-Salaam. The study described here is based on data from the Hai DSS. Due to poorer coverage of primary healthcare services in the Dar-es-Salaam DSS we were unable to follow-up all these cases. The Hai DSS has been described previously as part of the Adult Morbidity and Mortality Project (AMMP).[25] From within a population of 159,814, a total of 453 strokes were recorded in Hai during this time period, 132 identified by TSIP and 346 by VA, with 25 cases identified by both systems. The age-adjusted incidence was 108.6 per 100,000 (95% CI 89.0 to 130.9).

Tanzanian Stroke Incidence Project

All 132 patients were followed-up prospectively after recruitment by a network of key informants within the DSS. The names and addresses of the deceased were communicated to clinical officers who established the likely cause, place and date of death by discussion with relatives. The results reported here relate to follow-up until 15th June 2009 (3-6 years post stroke depending on date of recruitment).

Verbal autopsy

The system of VA used has been well described and validated previously.[25-26] It is described briefly here. All deaths occurring in the study site were picked up as part of a long established system for VA and those identified as being due to stroke within the study period were included in the study. Deaths are coded independently by two coders and in case of disagreement a third coder's opinion is sought and the majority diagnosis recorded. To avoid double-counting we linked deaths within the study period occurring in patients identified by TSIP, with VA data using a variety of characteristics, including name and age, to determine the matches. All data were double entered into an EPI INFO data entry system. Fifteen percent of VAs from the study period had no cause of death ascribed, due to loss of forms.

For these we imputed a cause of death by randomly selecting (without replacement) from a pool of deaths from the same age, sex and area group as the missing deaths from one year before and one year after the year of the missing death. This process left the cause-specific mortality structure unchanged. Cause of death was assigned by applying the International Classification of Diseases 10 (ICD-10) to determine the underlying cause of death.[27] Stroke deaths in the VA system were defined as those where the probable cause of death was a cardiovascular disorder (cerebrovascular disease and hypertension) excluding unspecified cardiovascular disorders, congestive cardiac failure and ischaemic heart disease.

The date of the occurrence of the stroke was recorded as part of the VA, enabling fatality after 28 days and 3 years to be computed.

Statistics

Confidence intervals (CIs) for percentages are based on the normal approximation to the binomial distribution. A Kaplan-Meier survival curve is presented. All cases still alive at the end of the study period are censored. This means that data for the entire 6 years of the study can be considered, with data for those dying at greater than the minimum 3 years follow-up used.

RESULTS

Tanzanian Stroke Incidence project

Only one case of subarachnoid haemorrhage was identified by CT head scan. This patient, who died after 10 days, is excluded from further analysis because it was felt that the difference aetiology and prognosis of SAH would make this patient un-representative of the cohort as a whole.

By 15th June 2009, 87 cases, from 131, (66.4%, 95% CI 58.3 to 74.5) had died. For 79 cause of death was recorded as stroke, or complications of stroke, including all cases that died within the first four weeks post-stroke. One died from tumour, 3 from pneumonia and 3 from sepsis. Fifty-one cases (58.6%) died at home, 21 (24.1%) at the local referral hospital, Kilimanjaro Christian Medical Centre (KCMC), 12 (13.8%) at Machame hospital and 3 (3.4%) at other local hospitals.

For one patient date of death was not known and this patient was excluded from further analysis. For those in whom date of death was known (n = 86), the median time to death was 101 days (range 0-1765). Case-fatality rates are presented in **Table 1** and the mean ages of those dead and alive at 28 days and 3 years in **Table 2**. A Kaplan-Meier survival curve is shown in **Figure 1**.

Of those identified by TSIP, 63 cases had a CT scan carried out within 15 days of incident stroke. Eleven (17·5%) had evidence of a haemorrhagic stroke and 52 (82·5%) were normal or had evidence of cerebral infarct. Although there was a difference in case-fatality between stroke sub-types at 28 days, with 3 deaths after haemorrhagic stroke (27.3%) and 10 subsequent to cerebral infarct (19.2%) this did not reach statistical significance (95% CI for difference in percentage -20.3 to 36.5). Three-year case-fatalities were 4 (36.4%) for haemorrhage and 26 (50.0%) for infarct (95% CI for the difference -17.9 to 45.1).

Verbal Autopsy

Excluding cases also identified by TSIP (n = 25), 321 stroke cases were identified by VA during the study period. As previously reported, for some cases a cause of death had to be

imputed due to loss of VA forms.[24] These cases (n = 29) are excluded from further analysis. Furthermore, no reliable date of stroke could be established in 69 cases. In some cases identified by the VA system, the stroke occurred before the start of the study period, but these cases should be balanced by those who had a stroke within the study period, but who died after the end of the study, and were therefore not include in the final figures. For the remaining 223 cases for which a date of stroke was available (69.5% of all unique VA cases), the timing of death, worst case scenario (as by definition all these cases died eventually) 28-day and 3-year 'case-fatality rates', are presented in **Table 1** and age- and sex-specific case-fatality rates at 28 days and 3 years in **Table 2** and **Table 3** respectively.

Case-fatality rates for our cohort are compared to those from other studies in SSA (primarily based on hospital-ascertained cohorts) and Europe in **Table 4**.

Table 1. Three-year case-fatality rates for Hai DSS

	Case-fatality rates for 130 cases (69 male, 53.1%) identified by TSIP		**Timing of death for the 223 cases (114 male, 51.1%) identified by VA (95% CI)**		**Combined 'Case-fatality rates' for 353 cases (183 male, 51.8%) identified by TSIP and VA (95% CI)**	
	Deaths	Percentage (95% CI)	Deaths	Percentage (95% CI)	Deaths	Percentage (95% CI)
7 days	16 (5 males)	12.3 (6.6 to 18.0)	51 (23 males)	22.9 (15.7 to 30.1)	67 (28 males)	19.0 (12.2 to 25.7)
28 days	31 (15 males)	23.8 (16.5 to 31.2)	64 (31 males)	28.7 (20.9 to 36.5)	95 (46 males)	26.9 (19.3 to 34.5)
6 months	48 (25 males)	36.9 (28.6 to 45.2)	117 (61 males)	52.5 (43.9 to 61.1)	165 (86 males)	46.7 (38.2 to 55.3)
1 year	59 (32 males)	45.4 (36.8 to 53.9)	143 (75 males)	64.1 (55.9 to 72.4)	202 (107 males)	57.2 (48.7 to 65.7)
2 years	73 (39 males)	56.2 (47.6 to 64.7)	167 (87 males)	74.9 (67.4 to 82.3)	240 (126 males)	68.0 (60.0 to 76.0)
3 years	78 (42 males)	60.0 (51.6 to 68.4)	188 (99 males)	84.3 (78.1 to 90.6)	266 (141 males)	75.4 (67.9 to 82.8)

Table 2. Age- and sex-specific case fatality rates at 28 days post-stroke

	Cases identified by TSIP		**Cases identified by VA**	
	Males	Females	Males	Females
	Number of deaths/total cases (%)	Number of deaths (%)	Number of deaths (%)	Number of deaths (%)
0-44 years	0/3 (0%)	1/6 (16.7%)	2/4 (50.0%)	3/13 (23.1%)
45-54 years	2/6 (33.3%)	0/5 (0%)	2/8 (25.5%)	4/11 (36.4%)
55-64 years	4/10 (40.0%)	3/11 (27.3%)	2/14 (14.3%)	2/11 (18.2%)
65-74 years	3/22 (13.6%)	5/18 (27.8%)	5/35 (14.3%)	8/24 (33.3%)
75-84 years	5/21 (23.8%)	3/8 (37.5%)	15/42 (35.7%)	9/32 (28.1%)
≥ 85 years	1/7 (14.3%)	4/13 (30.8%)	5/11 (45.5%)	7/18 (38.9%)
Overall	15/69 (21.7%)	16/61 (26.2%)	31/114 (27.2%)	33/109 (30.3%)
Mean age (years) at stroke of those dead	70.5 (95% CI 65.8 to 75.2)		71.3 (95% CI 67.0 to 75.6)	
Mean age (years) at stroke of those alive	68.2 (95% CI 65.1 to 71.2)		69.7 (95% CI 67.5 to 72.0)	

* Ages given are at time of stroke.

Table 3. Age- and sex-specific case fatality rates at 3 years post-stroke

	Cases identified by TSIP		**Cases identified by VA**	
	Males	Females	Males	Females
	Number of deaths/total cases (%)	Number of deaths (%)	Number of deaths (%)	Number of deaths (%)
0-44 years	1/3 (33.3%)	2/6 (33.3%)	4/4 (100.0%)	8/13 (61.5%)
45-54 years	4/6 (66.7%)	2/5 (40.0%)	6/8 (75.5%)	7/11 (63.6%)
55-64 years	5/10 (50.0%)	6/11 (54.5%)	11/14 (78.6%)	8/11 (72.7%)
65-74 years	10/22 (45.5%)	12/18 (66.7%)	29/35 (82.9%)	20/24 (83.3%)
75-84 years	16/21 (76.2%)	5/8 (62.5%)	40/42 (95.2%)	30/32 (93.8%)
≥ 85 years	6/7 (85.7%)	9/13 (69.2%)	9/11 (81.8%)	16/18 (88.9%)
Overall	42/69 (60.9%)	36/61 (26.2%)	99/114 (86.8%)	89/109 (81.7%)
Mean age (years) at stroke of those dead	71.2 (95% CI 68.0 to 74.3)		71.6 (95% CI 69.5 to 73.7)	
Mean age (years) at stroke of those alive	65.0 (95% CI 60.7 to 69.4)		62.5 (95% CI 57.1 to 67.9)	

* Ages given are at time of stroke.

Table 4. Reported case-fatality rates in other populations

	Number of participants	Mean age in years (std dev.)	Males (%)	City or area	Participants	Case fatalities		
						≤ 1 month	1 year	> 1 year
Walker, *et al* 2003[21]	106	58 (16)	70 (66.0)	Banjul, Gambia	Hospital based	27% (1 month)	44% (6 months)	73.5% (3 years)
Garbusinski, *et al* 2005[23]	148	Median 64	73 (49.3)	Banjul, Gambia	Hospital based	46% (1 month)	58% (6 months) 62% (1 year)	-
Rosman, *et al* 1986[22]	116	-	65 (56.0)	Pretoria, South Africa	Hospital based	33.6% (1 month)	-	-
Komolafe, *et al* 2007[34]	293	-	-	Ile-Ife, Nigeria	Hospital based	27.5% (7 days) 45% (1 month)	-	-
Osuntokum, *et al* 1979[28]	318	-	229 (72.0)	Ibadan, Nigeria	Hospital and nursing home based	34.9% (3 weeks)	-	-
Bamford, *et al* 1990[35]	675	-	318 (47.1)	Oxford, UK	Incident cases	19% (30 days)	31%	-
Brønnum-Hansen, *et al* 2001[17]	4162	-	2187 (52.5)	Copenhagen, Denmark	Incident cases	28% (28 days)	41%	60% (5 years)
Hankey *et al* 2000[16]	362	73 (13)	194 (53.6)	Perth, Australia	Incident cases	23% (30 days)	36%	58% (5 years)
Mohan *et al* 2009[18]	2874	-	1427 (49.7)	London, UK	Incident cases	-	36%	53% (5 years)
Loor *et al* 1999[15]	221	-	-	Amsterdam, The Netherlands	Community-based cohort	26% (1 month)	37%	54% (3 years)
Elneihoum *et al* 1998[14]	2290	76 (11)	1051 (45.9%)	Malmö, Sweden	Stroke register	-	-	43% (3 years)

Figure 1. Kaplan-Meier cumulative survival function for 3-6 years follow-up.

DISCUSSION

This is the first study in SSA of post-stroke case-fatality in an incident stroke population. Previous studies of stroke mortality in SSA have tended to be hospital-based and have reported higher death rates (see **Table 4**), although long-term follow-up is often hampered by the inability to trace patients.[28] It is notable that almost 60% of deaths within the TSIP identified cohort were at home, rather than in hospital. Our lower case-fatality may reflect the fact that many cases of stroke in SSA are not reported. This may be due to a number of reasons, both economic and cultural.[29] Some strokes resulting in death soon after onset may not be recorded as stroke whilst some strokes will occur without formal diagnosis, with those with the more severe symptoms more likely to be admitted to hospital. Moreover, many people may choose to visit traditional pharmacies and healers for advice rather than seeking help from more formal healthcare services.[29] However, within TSIP efforts were made to identify stroke cases within the community and the project paid for transport to hospital, admission and investigative tests.

Tanzania is one of the poorest countries in the world and there is limited access to rehabilitation services.[30] However, post-stroke mortality for the combined TSIP and VA data at one month post-stroke in the Hai DSS bear comparison with those from many studies from the developed world.[3,5] However, mortality rates at 3-years post-stroke, with over three-quarters of all cases having died, are noticeably higher.[14-15] This is also apparent when considering the case-fatality rates from the TSIP data only. Indeed, follow-up of incident stroke cases from 4 independent studies in the UK and Australia report lower 5-year case-fatality rates than seen at 3 years post-stroke in our study.[12,16,18,31] This may suggest that case-fatality rates at one month post-stroke are governed to a large extent by the nature of the stroke itself. Although death rates at 3 years may be influenced, in part, by the

life expectancy of the background population, they may also suggest that long-term mortality may be reduced by more effective post-stroke care.

At 28 days, of those recruited to TSIP who underwent CT head scan at less than 15 days post-stroke, haemorrhagic stroke was associated with a greater case-fatality rate than cerebral infarct, although the numbers were small and the difference did not reach statistical significance. These findings support previous hospital-based studies in SSA.[32] They are also broadly similar to those reported by Feigin *et al* in a systematic review of population-based incidence studies.[3]

The data in **Table 2** reveal no significant difference in ages between those who had died, and those who were still alive, at 28 days post-stroke. At 3 years post-stroke (**Table 3**), those who were dead were older at the time of stroke than those still alive, though this is only significant in those identified by VA. Clearly for many of those dying some time after the incident stroke, the stroke itself is less likely to have been the direct cause of death than complications of the stroke or other co-morbidity. However, this study was designed to estimate post-stroke mortality, regardless of the primary cause of death. Without a suitable control population we are unable to comment on how many deaths may have been unrelated to the incident stroke.

It would be inappropriate to consider the VA data as representing a direct measure of case-fatality rates; rather it is the distribution of the duration between stroke and death. Nevertheless, it provides a 'worst case scenario' as these figures are based only on stroke deaths, and we have no way of knowing how many incident cases of stroke, which were not picked up by TSIP, survived, though this is likely to be very few. Inclusion of the VA data

therefore provides a sensitivity analysis, giving extremes based on the experience within the community for the case-fatality rates.

We acknowledge that the VA system is not ideal for identifying time from stroke to death. The system was designed to identify the cause of death by interview with close family members, friends or carers. Where stroke was thought to be the primary cause of death, questions were asked about the date of onset of symptoms, weakness and paralysis to try to identify the date of stroke. We recognise that this information, gathered retrospectively, relies heavily on the recall of those interviewed for the VA, and, therefore, may be inaccurate. Nevertheless, we feel that the inclusion of these data adds substantially to the external validity of our findings, and provides a valuable sensitivity analysis – providing an estimate of the worst case scenario for 28-day and 3-year case-fatality rates.

Given the lack of previous comparable data from SSA we are unable to comment on long-term trends in post-stroke mortality. Globally, case-fatality rates from stroke and cardiovascular disease appear to be linked to measures of prosperity, with recent research indicating an increase in rates in Eastern Europe in the last 20 years.[2-5, 33]

Our results reveal that one-month case-fatality rates for the Hai district of Tanzania are similar to those reported for many low and middle income countries. Further research is needed to establish whether this is representative of Tanzania, and SSA, as a whole. In those surviving beyond one month post-stroke, effective management may help to reduce long-term mortality, but it is not clear how this should best be provided in a resource poor environment. For example, with the lack of sufficiently trained therapists, programmes which involve the training of relatives to provide therapy may be appropriate. In this area, where there is no access to institutional care, the relatives already provide the day-to-day 'nursing' care for

even the most disabled stroke patients. Currently in SSA there is a focus of effort in combating communicable diseases, such as HIV/AIDS. However, as the epidemiological transition continues in such countries the burden of non-communicable diseases, such as stroke, is likely to greatly increase.[19]

Acknowledgements: We wish to acknowledge all patients, relatives and carers who participated in this study and also the staff in the medical and radiology departments at KCMC who assisted with the study.

Competing interests: None

Funding: This work was funded by a grant from the Wellcome Trust (grant number 066939).

Copyright licence statement: The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, an exclusive licence (or non exclusive for government employees) on a worldwide basis to the BMJ Publishing Group Ltd and its Licensees to permit this article (if accepted) to be published in the Journal of Neurology, Neurosurgery & Psychiatry editions and any other BMJPGL products to exploit all subsidiary rights, as set out in our licence (**http://jnnp** .bmjjournals.com/ifora/licence.pdf)."

References

1. Lopez AD, Mathers CD, Ezzati M, et al. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet* 2006;367:1747-1757.

2. Johnston SC, Mendis S, Mathers CD. Global variation in stroke burden and mortality: estimates from monitoring, surveillance, and modelling. *Lancet Neurol* 2009;8:345-354.

3. Feigin VL, Lawes CM, Bennett DA, et al. Worldwide stroke incidence and early case-fatality reported in 56 population-based studies: a systematic review. *Lancet Neurol* 2009;8:355-369.

4. Sarti C, Rastenyte D, Cepaitis Z, et al. International trends in mortality from stroke, 1968 to 1994. *Stroke* 2000;31:1588-1601.

5. Sarti C, Stegmayr B, Tolonen H, et al. Are changes in mortality from stroke caused by changes in stroke event rates or case-fatality? Results from the WHO MONICA Project. *Stroke* 2003;34:1833-1840.

6. Benatru I, Rouaud O, Durier J, et al. Stable stroke incidence rates but improved case-fatality in Dijon, France, from 1985 to 2004. *Stroke* 2006;37:1674-1679.

7. Hallstrom B, Jonsson AC, Nerbrand C, et al. Stroke incidence and survival in the beginning of the 21st century in southern Sweden: comparisons with the late 20th century and projections into the future. *Stroke* 2008;39:10-15.

8. Gulliford MC, Charlton J, Rudd A, et al. Declining 1-year case-fatality of stroke and increasing coverage of vascular risk management: population-based cohort study. *J Neurol Neurosurg Psychiatry* 2010;81:416-422.

9. Rothwell PM, Coull AJ, Giles MF, et al. Change in stroke incidence, mortality, case-fatality, severity, and risk factors in Oxfordshire, UK from 1981 to 2004 (Oxford Vascular Study). *Lancet* 2004;363:1925-1933.

10. Scmidt E, Smirnov V, Ryabova V. Results of the seven-year prospective study of stroke patients. *Stroke* 1988;19:942-949.

11. Sacco RL, Wolf PA, Kannel WB, et al. Survival and recurrence following stroke. The Framingham study. *Stroke* 1982;13:290-295.

12. Dennis MS, Burn JPS, Sandercock PAG, et al. Long-term survival after first-ever stroke: the Oxfordshire Community Stroke Project. *Stroke* 1993;24:796-800.

13. Petty GW, Brown RD, Whisnant JP, et al. Survival and recurrence after first cerebral infarction: a population-based study in Rochester, Minnesota, 1975 through 1989. *Neurology* 1998;50:208-216.

14. Elneihoum AM, Goransson M, Falke P, et al. Three-year survival and recurrence after stroke in Malmo, Sweden: an analysis of stroke registry data. *Stroke* 1998;29:2114-117.

15. Loor HI, Groenier KH, Limburg M, et al. Risks and causes of death in a community-based stroke population: 1 month and 3 years after stroke. *Neuroepidemiology* 1999;18:75-84.

16. Hankey GJ, Jamrozik K, Broadhurst RJ, et al. Five-year survival after first-ever stroke and related prognostic factors in the Perth Community Stroke Study. *Stroke* 2000;31:2080-2086.

17. Bronnum-Hansen H, Davidsen M, Thorvaldsen P. Long-term survival and causes of death after stroke. *Stroke* 2001;32:2131-2136.

18. Mohan KM, Crichton SL, Grieve AP, et al. Frequency and predictors for the risk of stroke recurrence up to 10 years after stroke: the South London Stroke Register. *J Neurol Neurosurg Psychiatry* 2009;80:1012-8.

19. Connor MD, Walker R, Modi G, et al. Burden of stroke in black populations in sub-Saharan Africa. *Lancet Neurol* 2007;6:269-278.

20. Walker RW, McLarty DG, Kitange HM, et al. Stroke mortality in urban and rural Tanzania. *Lancet* 2000;355:1684-1687.

21. Walker RW, Rolfe M, Kelly PJ, et al. Mortality and recovery after stroke in the Gambia. *Stroke* 2003;34:1604-1609.

22. Rosman KD. The epidemiology of stroke in an urban black population. *Stroke* 1986;17:667-669.

23. Garbusinski JM, van der Sande MAB, Bartholome EJ, et al. Stroke presentation and outcome in developing countries - A prospective study in The Gambia. *Stroke* 2005;36:1388-1393.

24. Walker R, Whiting D, Unwin N, et al. Stroke incidence in rural and urban Tanzania: a prospective, community-based study. *Lancet Neurol* 2010;9:786-792.

25. Policy Implications of Adult Morbidity and Mortality; final report. Tanzanian Ministry of Health, 2004. (Accessed at http://research.ncl.ac.uk/ammp/finrep/.)

26. Setel PW, Whiting DR, Hemed Y, et al. Validity of verbal autopsy procedures for determining cause of death in Tanzania. *Trop Med Int Health* 2006;11:681-696.

27. WHO. International statistical classification of disease and related health problems, tenth revision, volume 2. Geneva, Switzerland: World Health Organization; 1993.

28. Osuntokun BO, Bademosi O, Akinkugbe OO, et al. Incidence of Stroke in an African City - Results from the Stroke Registry at Ibadan, Nigeria, 1973-1975. *Stroke* 1979;10:205-207.

29. Mshana G, Hampshire K, Panter-Brick C, et al. Urban-rural contrasts in explanatory models and treatment-seeking behaviours for stroke in Tanzania. *J Biosoc Sci* 2008;40:35-52.

30. Unwin N, Setel P, Rashid S, et al. Noncommunicable diseases in sub-Saharan Africa: where do they feature in the health research agenda? *Bull World Health Organ* 2001;79:947-953.

31. Wolfe CDA, Smeeton NC, Coshall C, et al. Survival differences after stroke in a multiethnic population: follow-up study with the South London stroke register. *BMJ* 2005;331:431-435.

32. Owolabi MO, Ugoya S, Platz T. Racial disparity in stroke risk factors: the Berlin-Ibadan experience; a retrospective study. *Acta Neurol Scand* 2009;119:81-87.

33. Levi F, Chatenoud L, Bertuccio P, et al. Mortality from cardiovascular and cerebrovascular diseases in Europe and other areas of the world: an update. *Eur J Cardiovasc Prev Rehabil* 2009;16:333-350.

34. Komolafe MA, Ogunlade O, Komolafe EO. Stroke mortality in a teaching hospital in South Western Nigeria. *Trop Doct* 2007;37:186-188.

35. Bamford J, Sandercock P, Dennis M, et al. A prospective study of acute cerebrovascular disease in the community: the Oxfordshire Community Stroke Project, 1981-1986. 2. Incidence, case-fatality rates and overall outcome at one year of cerebral infarction, primary intracerebral and subarachnoid haemorrhage. *J Neurol Neurosurg Psychiatry* 1990;53:16-22.