Stroke incidence in rural and urban Tanzania: a prospective, community-based study

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Summary

Background There are no methodologically rigorous studies of the incidence of stroke in sub-Saharan Africa. We aimed to provide reliable data on the incidence of stroke in rural and urban Tanzania.

Methods The Tanzania Stroke Incidence Project (TSIP) recorded stroke incidence in two well defined demographic surveillance sites (DSS) over a 3-year period from June, 2003. The Hai DSS (population 159,814) is rural and the Dar-es-Salaam DSS (population 56,517) is urban. Patients with stroke were identified by use of a system of community-based investigators and liaison with local hospital and medical centre staff. Patients who died from stroke before recruitment into the TSIP were identified via verbal autopsy, which was done on all those who died within the study areas.

Findings There were 636 strokes during the 3-year period (453 in Hai and 183 in Dar-es-Salaam). Overall crude yearly stroke incidence rates were 94·5 per 100,000 (95% CI 76·0–115·0) in Hai and 107·9 per 100,000 (88·1–129·8) in Dar-es-Salaam. When age-standardised to the WHO world population, yearly stroke incidence rates were 108·6 per 100,000 (95% CI 89·0–130·9) in Hai and 315·9 per 100,000 (281·6–352·3) in Dar-es-Salaam.

Interpretation Age-standardised stroke incidence rates in Hai were similar to those seen in developed countries. However, age-standardised incidence rates in Dar-es-Salaam were higher than seen in most studies in developed countries; this could be because of a difference in the prevalence of risk factors and emphasises the importance of health screening at a community level. Health policy makers must continue to monitor the incidence of stroke in sub-Saharan Africa and should base future funding decisions on such data.

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Introduction

Stroke is an increasing problem in developing countries, but data are limited, particularly for sub-Saharan Africa.1 Little is known about mortality and morbidity outcomes of stroke in sub-Saharan Africa, and we are not aware of any previously published population-based stroke incidence studies.2,3 In the 1970s, a stroke register was set up for Ibadan, Nigeria, that covered a population of 803,000.4 Over the 2-year study period, 318 patients with stroke were registered, and the crude yearly incidence of first-ever stroke was 25 per 100,000 for men and 13 per 100,000 for women. However, this figure is likely to be an underestimate because there were difficulties identifying patients with stroke: not all patients were seen by the investigators, there was a small number of study staff, and only those contacting so-called western style health services were traced.

In a study from Harare, Zimbabwe,5 first-ever strokes occurring in black Zimbabweans, who had been living in Harare for 6 months or more (denominator population 887,768), were identified through several methods: daily review of patients with stroke in medical wards in the four hospitals serving the population along with checking of emergency department records and a monthly inspection of the post-mortem register for any patients in whom stroke was found at autopsy. The attending physician diagnosed stroke and in difficult cases reviewed the diagnosis with the investigator. None of the patients had brain CT scans. The crude stroke incidence was 31 (95% CI 27–34) per 100,000 per year. Standardised to the world population, the incidence was 68 per 100,000.

Investigators from South Africa6 estimated the incidence of first-ever and recurrent stroke from figures relating to hospital admission of patients with stroke and found a crude incidence of stroke of 101 per 100,000 in a population aged 20 years and over (92 of 116 had CT scans). Both these studies showed a marked rise of incidence with age. Age-specific stroke incidence is higher in younger age groups in the sub-Saharan African studies than in the UK Oxford Vascular Study7 but lower than figures for black people from the Northern Manhattan Stroke Study.8

The Adult Morbidity and Mortality Project (AMMP)9 was done in the early 1990s and had three project areas: one urban (Dar-es-Salaam) and two rural (Hai and Morogoro). Censuses were done yearly in the two rural areas and every 6 months in Dar-es-Salaam. The age-standardised and age-specific mortality rates for the 10-year age bands up to age 65 years for all three areas for the 3-year period from July, 1992, were higher than comparable data from 1993 in England and Wales, and
most patients with stroke died outside of hospital care.6 The overall prevalence of impairment and disability relating to stroke in the Hai study population for those aged 15 years and over was 127 per 100 000 and for those aged 55 years and over was 566 per 100 000.7 These figures are lower than those from developed countries,8 perhaps because fatality from stroke is higher in sub-Saharan Africa than in developed countries.

To add to the previous data on prevalence and mortality of stroke in sub-Saharan Africa, we aimed to obtain accurate stroke incidence data for the Hai (rural) and Dar-es-Salaam (urban) study populations of the AMMP.

Methods

Patients

We used two systems to identify patients with stroke: the Tanzanian Stroke Incidence Project (TSIP), established by this study, identified patients with stroke within the community and at health facilities; and verbal autopsy was used to identify all deaths in the community caused by stroke during the study period. Only those who met the WHO criteria for stroke9 who had first-ever or recurrent stroke were included. Patients were excluded if the neurological deficit was thought to be caused by infection or a space-occupying lesion.

The TSIP enrolled patients from June 15, 2003, until June 15, 2006. All patients who had a stroke within this period in the Hai (population 159 814; 77 572 men) and Dar-es-Salaam (population 56 517; 27 863 men) demographic surveillance sites (DSS) were enrolled.

In Hai, most people own their homes and few rent, and there is very little migration into or out of the area. The areas under surveillance in Dar-es-Salaam are mixed: some are areas planned by the city council and rented by government officials whereas others are unplanned and provide a more basic form of shelter. There is more migration into and out of the Dar-es-Salaam DSS than for the Hai DSS.

Each of the eight geographical divisions of the Dar-es-Salaam DSS and each of the 52 villages of the Hai DSS had an enumerator; these were individuals, usually nurses, teachers, or community development workers, who received training to identify patients with stroke and who were responsible for data collection. The enumerators did the censuses and also reported any people who died during the study period so that verbal autopsies could be done on these people.10

Awareness about stroke and potential preventive and treatment measures were raised in the general population and within the community structures (eg, by community leaders) at the time of the censuses. Enumerators identified patients with possible stroke and passed information on to clinical officer supervisors as soon as possible so that patients could be assessed in their own homes. This was particularly important for those who were making a rapid recovery from stroke. Patients for whom the likely diagnosis of stroke was confirmed, and who gave informed consent, were transferred to the local referral hospital where the research associates (AJ, EA, and ML) did a structured interview and examination as soon as possible. Transport to hospital, hospital admission, clinical investigation, and treatment costs were paid for by the TSIP.

To maximise identification of patients with stroke, medical ward admission books and discharge lists were examined (by EA, AJ, or ML) every 2 weeks at the main hospitals to which patients in the area might be admitted (and large health centres where patients were occasionally admitted), and the doctors working within the hospitals kept a regular check on the wards for inpatients who had had a stroke, and provided information on patients with stroke who might initially have been misdiagnosed. Furthermore, each week we checked referrals to radiology departments for CT head scan and reviewed physiotherapy and occupational therapy records—both hospital and community based—to check for patients with stroke. Personnel who might come into contact with patients with stroke were told about the study so that information about potential patients could be passed on as soon as possible. Patients identified by these means were recruited, interviewed, and examined in the usual way. Patients in whom CT head scan showed a condition other than stroke were excluded from the study.

All deaths occurring in the two study sites were assessed as part of an established system for verbal autopsy and those identified as having died from a stroke within the study period were included in the study. Verbal autopsy interviews were done wherever possible with the carers or relatives of the deceased, usually within 1 month of the date of death. A structured form was used, with an open history section. Cause of death was assigned by applying the tenth revision of the International Classification of Diseases11 to identify the underlying cause of death. Stroke deaths were defined as those in which the probable cause of death was a cardiovascular disorder (cerebrovascular disease and hypertension) excluding unspecified cardiovascular disorders, congestive cardiac failure, and ischaemic heart disease. Each death was assigned a cause by independent physicians. If the physicians disagreed on the cause of death, the form was sent to a third physician for independent diagnosis. If any two of the three agreed, this diagnosis was taken as the cause of death. If all three disagreed then the cause was reported as undetermined. Full details of the methods and copies of the forms can be found in volume 3 of the AMMP final report.

To maximise resource use, patients who died during follow-up but who had already been identified as having had a stroke by the TSIP system were not recorded as part of the verbal autopsy system. To avoid double counting, we linked deaths within the study period that occurred in patients identified by TSIP with verbal autopsy data using several characteristics, including

For the AMMP final report see http://research.ncl.ac.uk/ammp/fnrep/
name and age, to identify any matches. All data were double entered into an EPI INFO data entry system. For verbal autopsies that had no cause of death because of the loss of the forms after entry into the data system and before coding, we imputed a cause of death by randomly selecting from a pool of all deaths in the study area 1 year before and 1 year after the study. Deaths were matched for age, sex, and geographical area.

The denominator population for stroke incidence was defined as those who were resident in the surveillance areas on Dec 15, 2004 (the midpoint of the study). The numerator for the 3-year incidence study consisted of all strokes detected by the TSIP reporting system except those in whom the CT scan revealed another diagnosis, and all those diagnosed as stroke from the verbal autopsy mortality surveillance system except those already identified by the TSIP reporting system. Collection of accurate information on patient age can be difficult in sub-Saharan Africa; age was calculated from birth year and confirmed using memory prompts if the year of birth was in doubt.

This study was approved by the National Institute of Medical Research, Dar-es-Salaam, Tanzania, and by the Newcastle and North Tyneside Joint Ethics Committee, UK.

Statistical analysis
Age-standardisation was done by use of the direct method, with standardisation to the WHO world standard. Confidence intervals were calculated based on the assumptions of the Poisson distribution.

Role of the funding source
The study sponsors had no role in the study design, data collection, data analysis, and interpretation of data, in the writing of the report, or in the decision to submit the paper for publication. All authors had full access to the data in the study and RW had the final responsibility for the decision to submit for publication.

Results
The age structure of the background census population is shown in table 1. There were 636 strokes during the 3-year period: 453 (237 in men) in Hai and 183 (100 in men) in Dar-es-Salaam. 201 strokes were detected by the TSIP system (132 in Hai and 69 in Dar-es-Salaam) and 460 deaths from stroke were identified by the verbal autopsy mortality surveillance system (346 in Hai and 114 in Dar-es-Salaam), of which 25 were already listed on the TSIP database and were therefore removed. 558 of 4290 verbal autopsy deaths from the Hai study area had no cause of death because of the loss of forms. Four of 1432 verbal autopsy deaths from the Dar-es-Salaam DSS area had no cause of death because of the loss of forms. 182 of 4290 deaths from the Hai DSS and 42 of 1432 from the Dar-es-Salaam DSS were coded as undetermined. All patients with stroke were identified in the community before hospital admission. Any patients who were identified by other sources (eg, radiology, physiotherapy, and occupational therapy staff) had already been identified by enumerators before hospital admission. All patients identified by TSIP consented to assessment and examination.

Diagnosis of stroke was confirmed by CT scan in 159 of 201 patients (102 of 132 from Hai and 57 of 69 from Dar-es-Salaam) identified by the TSIP system. 64 of 132 patients from Hai had a CT scan done within 15 days of stroke onset: 11 had evidence of a haemorrhagic stroke, 52 were normal or had evidence of stroke caused by cerebral infarct, and one had a subarachnoid haemorrhage. In Dar-es-Salaam, 17 of 69 patients had a CT scan done within 15 days: three had evidence of a haemorrhagic stroke and 14 were normal or had evidence of stroke caused by cerebral infarct.

The 42 patients who did not have a CT scan had stroke diagnosis confirmed clinically by a member of the study team (AJ, EA, or ML). 14 other patients identified by TSIP were assessed by the study team and were found not to have had a stroke: seven were thought to have an abscess or tumour, two had Parkinson’s disease, two had Bell’s palsy, two had encephalitis, and one patient was not given a formal diagnosis. Of the 201 patients with confirmed stroke, 22 had previously had a stroke (14 in Hai and eight in Dar-es-Salaam) and four patients had previously had two strokes (three in Hai and one in Dar-es-Salaam). Information on previous strokes was not available for strokes identified by the verbal autopsy system.

Overall crude yearly stroke incidence rates were 94·5 per 100 000 (95% CI 76·0–115·0) in Hai and 107·9 per 100 000 (88·1–129·8) in Dar-es-Salaam (table 2). Age-standardised yearly stroke incidence rates were 108·6 per 100 000 (95% CI 89·0–130·9) in Hai and 315·9 per 100 000 (281·6–352·3) in Dar-es-Salaam (difference between groups 207·3, 95% CI 166·9–247·7, relative risk 2·9). Table 3 shows the age-specific and sex-specific yearly stroke incidence rates for Hai and Dar-es-Salaam. Stroke incidence rates were markedly higher for men than women aged 55–64 years, 65–74 years, and 75–84 years in the Hai DSS. In the Dar-es-Salaam DSS, stroke incidence rates were higher for men than for women aged 65–74 years and 75–84 years. For all other age bands, the small number of cases identified within

| Age group | Hai DSS population | Dar-es-Salaam DSS population | World population* |
|-----------|--------------------|-----------------------------|-------------------|
| 0–44 years | 126598 (79·22%)    | 49678 (87·90%)              | 72·12%            |
| 45–54 years | 12872 (8·05%)     | 3764 (6·66%)               | 11·41%            |
| 55–64 years | 8907 (5·57%)      | 1905 (3·37%)               | 8·27%             |
| 65–74 years | 6812 (4·26%)      | 803 (1·42%)                | 5·17%             |
| 75–84 years | 3329 (2·08%)      | 282 (0·50%)                | 2·43%             |
| ≥85 years  | 1296 (0·81%)      | 85 (0·15%)                 | 0·63%             |

Data are number (%). Percentages might not add up to 100% because of rounding. DSS=demographic surveillance site.

Table 1: Age distribution of the background population in Hai and Dar-es-Salaam
each of the age groups made identification of a difference difficult. The figure shows comparative stroke incidence data for people in Hai, Dar-es-Salaam, and black people in the Northern Manhattan Stroke Study (1993–1996). Stroke incidence rates for the Hai DSS are comparable to those for black people from Northern Manhattan, whereas incidence rates in the Dar-es-Salaam DSS were higher than in black people from Northern Manhattan across all age bands, most notably in the 65–74 years and 75–84 years age bands.

Electrocardiogram (ECG) rhythm was recorded for patients with stroke who were identified by TSIP. Blood pressure was also recorded at least 7 days post-stroke to allow for the fact that blood pressure rises during the first few days after stroke. For blood pressure, a cutoff of greater than 160 mm Hg systolic or 90 mm Hg diastolic was taken as indicating hypertension. Of the 105 patients (57 men and 48 women) in Hai in whom blood pressure was measured at the appropriate time, 49 (23 men and 26 women) had hypertension and, of 93 who had an ECG, four had atrial fibrillation. In Dar-es-Salaam, of 61 patients (33 men and 28 women) who had their blood pressure measured at the appropriate time, 37 (23 men and 14 women) had hypertension, and three of 39 who had an ECG had atrial fibrillation. There was no marked difference in the proportion of patients with hypertension between the two study sites (p=0.082). Furthermore, there was no substantial difference in the proportion of men and women who had hypertension compared with those who did not within the Hai DSS (p=0.157) or the Dar-es-Salaam DSS (p=0.117).

**Discussion**

This is the first study of stroke incidence in sub-Saharan Africa to include community-based identification of patients with stroke. We found that age-standardised incidence rates were almost three times higher in urban Dar-es-Salaam than in rural Hai.

Several factors might have contributed to these differences in incidence rates. One reason might be the age structure of the denominator populations. The age structure in Hai is similar to the WHO world standard, with the main differences being higher proportions of people aged 0–44 years and aged 85 years and over. These differences might be a reflection of good coverage of primary health-care services within the Hai DSS. In Hai, there is a health centre with a primary health-care team in about half of the 52 villages within the study area. The Dar-es-Salaam DSS has a younger population than the Hai DSS: almost 88% of all inhabitants are younger than 45 years. Although there is also good coverage of primary health-care services, many people visit private pharmacies or traditional healers for advice, which can often lead to a delay in hospital admission.

Little is known about the major risk factors for stroke in sub-Saharan Africa. Hypertension seems to be the main modifiable risk factor: two-thirds of patients who died from stroke in Tanzania had a history of hypertension. In addition, incidence of hypertension, diabetes, and overweight are all higher in urban compared with rural areas. Thus, the higher incidence rate in Dar-es-Salaam might be explained in part by higher levels of hypertension and other modifiable risk factors.

The incidence rates reported here are higher than those seen in previous hospital-based studies of stroke incidence in sub-Saharan Africa. Such studies do not seem to be representative of the wider community, even in developed countries. Previous studies of stroke mortality in Tanzania have shown that only 56% of people in the Hai DSS and 30% in the Dar-es-Salaam DSS who die from stroke do so in hospital. Furthermore, many countries in sub-Saharan Africa do not have complete death certification and thus many stroke deaths go unreported.

**Table 3:** Age-specific and sex-specific yearly incidence rates per 100 000 people

| Age Group | Hai DSS | Dar-es-Salaam DSS |
|-----------|---------|------------------|
|          | Men     | Women            | Men     | Women            |
| 0–44 years | 80 (35–15) | 9 (4–17) | 195 (114–297) | 20 (12–31) |
| 45–54 years | 91 (73–111) | 7 (59–94) | 171 (146–199) | 324 (289–361) |
| 55–64 years | 240 (210–272) | 177 (152–205) | 580 (534–629) | 574 (529–622) |
| 65–74 years | 675 (625–727) | 470 (429–514) | 2592 (2494–2693) | 1904 (1820–1991) |
| 75–84 years | 1675 (1597–1758) | 1150 (1085–1218) | 4166 (4041–4294) | 3496 (3382–3613) |
| ≥85 years | 196 (1882–2055) | 1996 (1910–2085) | 2127 (2018–2219) | 2941 (2836–3049) |

Data are incidence (95% CI). DSS=demographic surveillance site.
The age-standardised incidence rates in the Hai DSS are similar to those seen in many methodologically rigorous studies of European and US populations.1 The Northern Manhattan Stroke study from 1993 to 1996 reported an incidence for those aged 20 years or older of 93 per 100 000 in white people and 223 per 100 000 for black people, which is 2·4 times higher. Assuming there are no strokes in people under age 20 years, these rates correspond to about 66 per 100 000 for whites and 158 per 100 000 for blacks across all ages. Incidence rates in Hai were lower for those aged 75 years and under than in Northern Manhattan.

CT head scan done more than 15 days post-stroke is thought to be unreliable because of the potential to misdiagnose haemorrhagic stroke.21 Within the subgroup of patients who had a CT scan within 15 days of stroke, we found a lower incidence of haemorrhagic stroke compared with ischaemic stroke than reported in previous studies of stroke in sub-Saharan Africa.22–24 The percentages of strokes caused by haemorrhage and infarct were similar to those seen in studies in the developed world.25–27 However, the number of patients who had a CT scan within 15 days of stroke was small and might not be representative of all patients with stroke. Patients who died soon after stroke (both within the TSIP and verbal autopsy systems), and therefore did not have a CT head scan, might have been more likely to have had a haemorrhage. However, because this was a community-based study of patients with stroke, a higher and more representative proportion of patients is likely to have been admitted to hospital, and thus had a CT scan, than in previous studies in sub-Saharan Africa.

People who live in urban areas in sub-Saharan Africa have a higher incidence of hypertension than those from rural communities, with a rise in blood pressure seen on migration from the countryside to cities.28,29 Previous studies have suggested age-standardised rates of hypertension of 13·1% in men and 13·3% in women within the Hai DSS and of 18·3% in men and 22·0% in women in the Dar-es-Salaam DSS using a cutoff of above 160/90 mm Hg.30 In our study, the prevalence of hypertension in patients with stroke seemed to be higher in Dar-es-Salaam than in Hai (p=0·082).

For stroke incidence studies to be comparable, they need to have the same inclusion criteria and methods of data collection and presentation. In a recent systematic review, incidence rates varied markedly, large areas of the world were not covered, and reliable information was particularly sparse for non-white populations.7 We aimed for complete, community-based, identification of patients, from several overlapping sources, and data collection for 3 years. Our study meets the ideal criteria for stroke incidence studies that were suggested by Sudlow and Warlow.11 Our study was prospective, with hot pursuit (prospective identification of cases when they occurred in the community) of patients in a large, already well defined, population in which we had an accurate and regularly updated measurement of the denominator population.

Worldwide, the incidence of stroke has been decreasing, but this decrease is mainly occurring in developed countries.1 The main reason for the decrease in developed countries has been improved preventive measures (eg, treatment for hypertension) and care after stroke—organised stroke care in stroke units decreased both mortality and morbidity at 6 months compared with standard care.32 Access to treatment from a full multidisciplinary team is limited in most of sub-Saharan Africa in both urban and rural settings. The cost-effectiveness of antihypertensive treatment for primary prevention of stroke in sub-Saharan Africa—taking into consideration the many other competing health priorities such as infectious diseases—has been the subject of debate. Patients in whom hypertension was identified in our study were given antihypertensive drugs and were followed up by a member of the study team (EA, AJ, or ML). Aspirin was also given to those without evidence of haemorrhage on CT scan, but aspirin is probably under-used in sub-Saharan Africa because most patients do not have a CT head scan after stroke.

In developed countries, 25–30% of patients remain severely disabled and dependent on others after a stroke.33 Data on fatality in stroke cohorts in sub-Saharan Africa are scarce and are limited to cohorts recruited from hospitals and to in-hospital fatality. In a study in The Gambia, all patients who presented with an acute stroke to the main referral hospital over a 1-year period were followed up for 3–4 years in the community to assess morbidity and mortality outcomes.11 Fatality rates were higher than in studies from developed countries, and this was also confirmed by a later follow-up study.34

Stroke seems to be an increasing problem in sub-Saharan Africa. A study from Accra that investigated stroke admissions from the early 1960s to the early 1990s...
found a large increase in both admissions and fatality in the early 1990s compared with the 1960s; in the 1990s, stroke was the leading cause of death, accounting for about 17% of deaths on medical wards, and fatality ranged from about 42% to 50% over this time period.35

This study has some limitations. Some patients died before they were seen, but these patients should have been identified by the verbal autopsy system. Other patients, particularly those who made an early full recovery, might not have been traced. Although all patients who were identified consented to be included in the study, not all patients consented to a full examination and assessment by a member of the study team. This was a particular problem in Dar-es-Salaam where, because of different beliefs about the causes of stroke, many individuals sought help from traditional healers in the first instance and some never went to hospital at all.22 In such cases, assessment was done in the community, but not all patients were included in the final incidence figures. Transport problems and large distances to hospital from some patients’ homes in the Hai district meant that not all patients from this region were admitted to hospital. Although the overall denominator population was similar to studies from developed countries, the urban population in our study was small, particularly in the higher age bands, and so the results are based on a small number of patients.

The TSIP system for early identification of stroke within the community was effective: no additional patients were identified from hospital records. The verbal autopsy system used within the AMMP has previously been validated, and there was a high sensitivity and specificity for stroke as a diagnosis.23,24 By counting all verbal autopsy deaths that occurred within the study period, we will have included some patients who had the stroke before the study period (ie, not incident within the study period) but unfortunately we cannot identify these from the verbal autopsy data collected. However, patients who survived a long time after stroke before dying are more likely to have been given another cause of death; thus, the number of patients included who had had a stroke before the start of the study is likely to have been low. Furthermore, these patients were probably balanced by those who had a stroke near the end of, but died after, the study period who were not picked up by the TSIP system. The large number of verbal autopsy deaths that were not picked up by the TSIP system probably reflects patients who died rapidly after their stroke.

Stroke incidence rates in rural Tanzania are comparable with previous data from blacks living in New York, but in urban Tanzania the incidence rate is substantially higher. Worldwide age-standardised stroke incidence rates are decreasing in developed countries, but without reliable incidence data from previous studies we do not know what is happening in sub-Saharan Africa. The reasons for the higher incidence of stroke in urban areas are not yet clear, although undiagnosed or inadequately treated hypertension is likely to be a major modifiable risk factor. Urbanisation in Africa, as in other parts of the developing world, is increasing rapidly, and the results from this study suggest that, in the absence of effective preventive measures, this is likely to lead to substantial increases in stroke incidence and mortality.

Contributors
RW and DW did the literature search. RW, NU, FM, MS, and GA designed the study. EA, AJ, GK, and ML collected the data. RW, DW, and WKG did the data analysis. All authors interpreted the results and wrote the paper.

Conflicts of interest
We have no conflicts of interest.

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