



## Economic burden of stroke in a rural South African setting



Mandy Maredza <sup>\*,a</sup>, Lumbwe Chola <sup>a,b</sup>

<sup>a</sup> MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt), School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

<sup>b</sup> Population Health, Health Systems and Innovation, Human Sciences Research Council, Pretoria, South Africa

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### ABSTRACT

**Background:** Stroke is the second leading cause of mortality and leading cause of disability in South Africa yet published data on the economic costs of stroke is lacking particularly in rural settings.

**Methods:** We estimate the total direct costs of stroke in 2012 from a health system perspective using a prevalence-based, bottom-up costing approach. Direct costs include diagnosis, inpatient and outpatient care. Analysis is based on the Agincourt health and socio-demographic surveillance system, which covers approximately 90,000 people. Published data from the SASPI study, Tintswalo Hospital Stroke register, and national cost databases were used. Sensitivity analysis was carried out to account for the variability in the data used.

**Results:** The total direct costs of stroke were estimated to be R2.5–R4.2 million (US\$283,500–US\$485,000) in 2012 or 1.6–3% of the sub-district health expenditure. Of this, 80% was attributed to inpatient costs. Total costs were most sensitive to the underlying incidence rates and to assumptions regarding service utilisation.

**Conclusions:** Our study provides a snapshot of costs incurred on stroke in rural South Africa. We show that stroke is a disease with high economic costs. Further studies that assess the lifetime costs of stroke are needed to better understand savings accrued from intervening at different stages of the disease.

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### 1. Introduction

Stroke is the second most common cause of death in South Africa, after HIV/AIDS and the leading cause of disability [1]. Recent estimates suggest that at least 30,000 strokes occur yearly in rural South Africa [2]. Globally, approximately 3% of total health care system resources are devoted to stroke indicating that stroke imposes a significant economic burden on countries [3]. Studies looking at the economic consequences of stroke in South Africa are few and somewhat dated. According to one such study, cardiovascular disease (CVD) including stroke consumed 4.1 billion to 5.0 billion South African rands (R) in 1991, excluding costs of rehabilitation or community care [4]. Adjusting the costs to 2014 values using the consumer price index, the current cost of CVD would be R19–24 billion annually. Other stroke related studies focussed on cost of medication for stroke prevention [5], or cost of inpatient care at tertiary facilities but did not estimate total cost of stroke [6]. Further, none of the studies considered the cost of stroke within a rural setting.

Economic data can be used to advocate for new interventions or the increased uptake of existing ones. Policy makers in South Africa are becoming increasingly aware of the need to justify health decisions on the basis of both effectiveness and costs; this is echoed strongly in the Department of Health's National Strategic Plan on non-communicable diseases [7]. Previous analyses on the economic implications of high sodium intake in South Africa led to a draft policy on salt reduction [8,9]. As such, documenting the economic implications of stroke could promote evidence based decision making, assist in priority setting and influence adequate budgeting and planning for the prevention and treatment of stroke.

The present study is designed to meet the need for up-to-date information on the cost of stroke by (i) estimating the cost of stroke care in rural South Africa for prevalent cases in 2012 based on the standard of care (treatment protocols, coverage of interventions) and (ii) estimating the costs of stroke cases in the same population when coverage of all essential treatment or service utilisation is scaled up to 90%.

We utilize a variety of data sources namely: published data on stroke from the Agincourt Health and Demographic Surveillance Site, clinic-linked data for the Agincourt population on health care utilization patterns and the Tintswalo Hospital Stroke Register (THSR) – a rural hospital-based stroke register. The results of this study could help to understand the resource implications of stroke in South Africa and similar settings in sub-Saharan Africa, as well as make a case for intensifying efforts for stroke prevention initiatives in the rural settings of South Africa.

\* Corresponding author at: MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt), School of Public Health, University of the Witwatersrand, Education Campus, St Andrews Road, Parktown, Johannesburg, South Africa.  
E-mail address: [rmtanya@gmail.com](mailto:rmtanya@gmail.com) (M. Maredza).

## 2. Methods

### 2.1. Setting and population

This analysis is based on a population of approximately 90,000 people residing in the Agincourt sub-district of Mpumalanga province, north-east of South Africa [10]. The area is completely covered by a health and demographic surveillance system (HDSS). Comprehensive data on mortality and causes of death, births, and inward and outward migration have been collected through a yearly census update since 1992 via verbal autopsies [10]. Additional data on labour participation and educational status have been collected at different time intervals to complement demographic data and provide contextual information.

Social infrastructure and utilities are quite limited in the Agincourt sub-district. There is no formal sanitation, piped water to communal standpipes is erratic and electricity is affordable to a minority. High unemployment results in temporary labour migration of men and women which was estimated at 50–70% amongst males and 25–35% amongst females in the 20–59 year age group [11]. There are two public health centres, one private health centre and seven satellite clinics in the site. The Agincourt community is served by three district hospitals that are approximately 25–60 km away.

The health profile of the Agincourt population is characterized by the persistent burden of TB and HIV/AIDS, high maternal and child morbidity and mortality, and increasing non-communicable diseases. Using 1994–97 as the base year, the probability of dying from non-communicable diseases trebled by 2005 within the sub-district [12]. Though a slower decline was observed from 2006 to 2009, the mortality rates have plateaued at high levels [13]. Similarly, deaths due to HIV/AIDS initially decreased, then plateaued at high levels [12,13]. Stroke, rather than ischaemic heart disease is the dominant manifestation of CVD within this population [14]. Between 2007 and 2011, stroke incidence and mortality rates were 244 and 144 per 100,000 person years respectively [14,2].

### 2.2. Cost-of-illness analysis

This study is predominantly a cost of illness (COI) analysis that utilizes a prevalence-based approach. Prevalence-based COI studies estimate the costs of all disease cases (new as well as pre-existing) in a given year [15]. They include all medical care costs and morbidity costs for a disease within the study year and nothing has to be known or assumed about the survival rate or course of the illness [16]. Because new disease cases that occur in that given year of analysis must be known, incidence data is required. The name prevalence-based should therefore not be confused to mean the exclusion of epidemiological incidence data.

### 2.3. Perspective

The perspective of the analysis is the health system, with the government as the payer of public health services. This was the most appropriate perspective to choose as the intent was to inform evidence-based priority setting within the public health care sector. Because the government perspective was chosen, only direct costs related to provision of health care were assessed. These costs included hospital inpatient stay, diagnostic costs, outpatient costs and secondary prevention costs. Direct costs of patient transport were not included. Productivity losses as a result of time off work due to illness or due to caring for a stroke patient were also not included as these are indirect costs and not borne by the government. All costs were adjusted to 2012 using the consumer price index and reported in local currency, South African Rand (R) and United States dollar (\$). We used an exchange rate of 1US\$ = R8.70 for the year 2012 based on the South African reserve bank historical exchange rates [17].

### 2.4. Costing approach

There are 2 main approaches to resource costing: top-down and bottom-up [18]. Top-down approach involves estimation of resource utilisation and costs by assigning a (national) average figure on non-patient specific bases such as using Diagnostic Related Groups (DRGs), or Healthcare Resource Groups (HRGs) [18]. DRGs are 'diagnosis-related' groups of patients that have similar resource consumption patterns [19]. It is not possible to use this method in South Africa where DRGs or similar classifications are not used in the public sector. The second approach, which is used in this study, is the bottom-up approach. This approach requires understanding the service delivery process for a patient (treatment pathway) and estimating relevant resource items and assigning costs to these items. Each of these processes requires detailed data and inventories. We use the Tintswalo hospital stroke register to understand the type of treatment a patient with stroke receives at a hospital in rural South Africa and the probability of receiving that treatment. The stroke register was established in 2001 to ascertain and assess rural stroke patients over 20 months [20]. We use the treatment pathway (Fig. 1) as a guide. We focus on the inpatient treatment pathway in the figure as the 'treatment' of stroke in the outpatient setting usually involves controlling risk factors, high blood pressure in particular and rehabilitation; the latter being largely unavailable in rural settings of South Africa. We do however calculate the outpatient costs. Clinic data linked to the Agincourt demographic surveillance system is used to determine health facility utilisation patterns by patients with stroke as well as the type of medication that stroke or hypertensive patients are on. We also use available data from published studies to estimate treatment coverage and adherence rates. Unit costs were abstracted from several national sources: (i) South African district health barometer for inpatient and outpatient care, (ii) South African medicines price registry for cost of medicines, and (iii) NHLS for costs of laboratory investigations.

### 2.5. Estimating prevalence and incidence of stroke in rural Agincourt sub-district

The Southern African Stroke Prevention Initiative (SASPI) study conducted in 2001 within the Agincourt population determined stroke prevalence through verbal autopsy with subsequent assessment of suspected stroke victims by a neurologist [22]. That study is the only "community-based" prevalence study of stroke in rural South Africa with a well-defined denominator. Trained fieldworkers used a previously validated questionnaire to interview each household informant. The key questions were: "Has (person) ever had weakness down one side of the body?" and "Has (person) ever had a stroke?" Clinical assessment of possible stroke victims was lowest amongst migrant males 25–44 years. To account for this noncontact, the investigators adjusted the stroke rates in each 10-year age stratum and assumed the same proportion of stroke survivors in employed men as amongst predominantly unemployed men. Thus the local population denominator included men who temporarily reside outside the sub-district as they consider the sub-district home and return to seek health care when too ill to work [22]. Based on this study, 103 cases of stroke were identified amongst 724 individuals visited, giving an adjusted stroke prevalence rate, adjusted for non-response of 290 per 100,000 person years.

To the best of our knowledge there is currently no other information on incidence of stroke from community-based studies in South Africa. A hospital based study conducted in 1986 estimated a crude stroke incidence of 101 per 100,000 per year in a population  $\geq 20$  years in suburban areas of Pretoria [23]. However, in developing countries, most people who suffer a stroke do not reach hospitals and the data is out-of-date. These figures are therefore likely an underestimate.

In our study, estimates of stroke incidence were derived from a study that combined primary data from Agincourt HDSS with modelling techniques [2]. In the study by Maredza, Bertram and Tollman [2], the

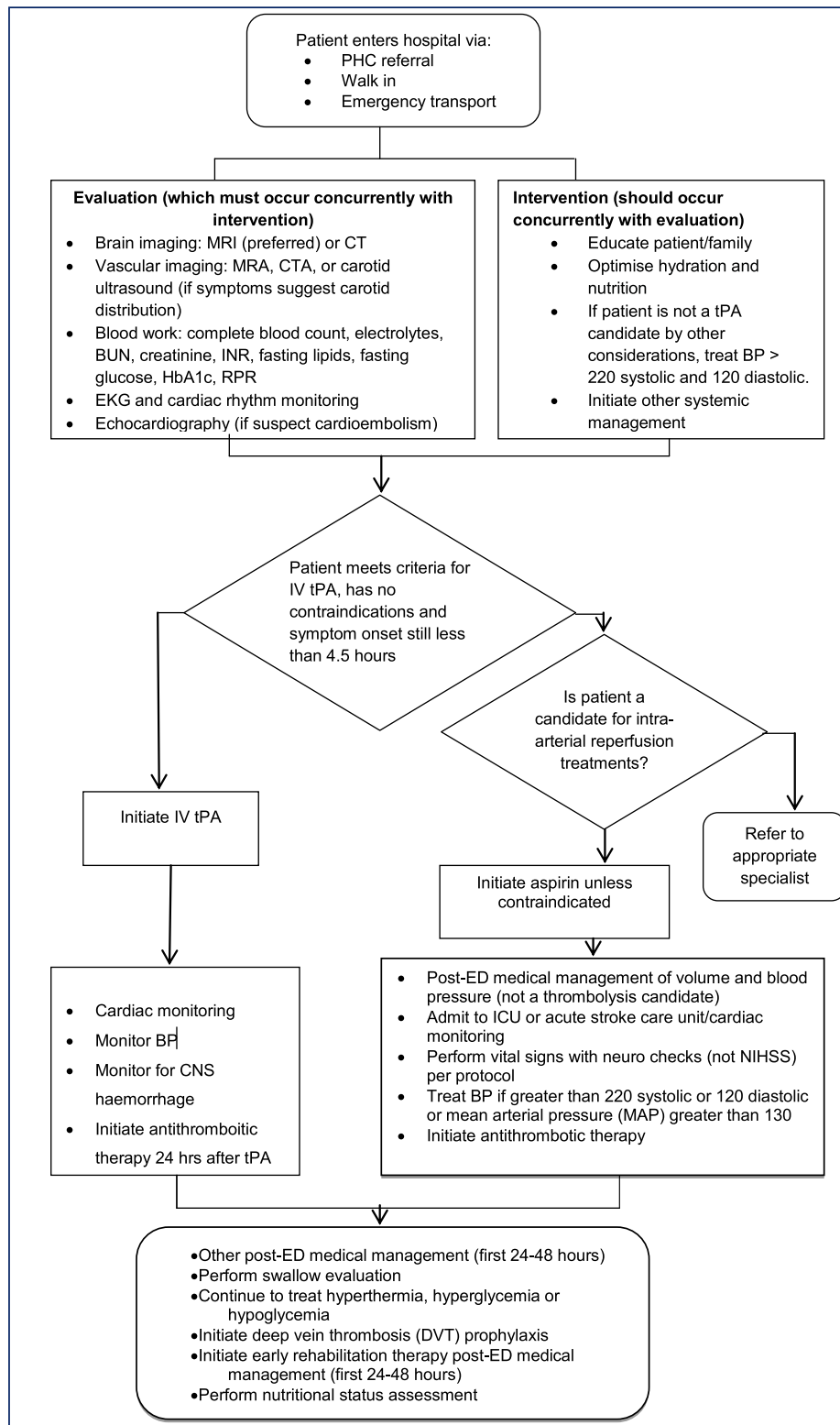


Fig. 1. Stroke treatment algorithm. Adapted from Anderson et al. [21].

incidence of stroke was estimated to be 244 per 100,000 persons. However, the stroke types (ischaemic and haemorrhagic) were not differentiated, but were all commonly categorised as 'stroke'. However, the treatment plan for ischaemic and haemorrhagic strokes is different, thus in our study, we estimate the proportion of ischaemic and haemorrhagic strokes in Agincourt sub-district using data from a

previously published study. The study indicated that 71% and 23% of stroke were ischaemic stroke and cerebral haemorrhages whilst 6% of strokes were undefined respectively [20]. We conduct a sensitivity analysis around the incidence estimates using rates obtained from a prospective based study in a rural Tanzanian HDSS and also vary the baseline input parameters by  $\pm 20\%$ .

## 2.6. Estimating direct costs

These included diagnostic costs, inpatient stay costs, outpatient visit costs and outpatient drug costs which were separately calculated to give total direct costs of care (Table 1). The inpatient care and diagnostic costs were calculated by multiplying the incidence of stroke by the related unit costs [24]. In the SASPI study, 80% of stroke patients indicated that they had sought care at a hospital/clinic following a stroke. We estimate that 50% of new stroke cases seek hospital inpatient care (are admitted) though the actual figure is likely to be much lower. Because of the uncertainty surrounding this figure we conduct sensitivity analysis around the point estimate, varying our baseline figure by  $\pm 20\%$ .

## 2.7. Diagnostic costs

Stroke diagnosis is based on signs and symptoms, a physical exam and test results and Fig. 1 shows the generic treatment pathway. We use this pathway and the THSR to estimate the proportion of stroke patients undergoing the various diagnostic tests. We assume that all patients undergo blood tests to check glucose and cholesterol, as well as routine tests for blood pressure and heart rate measurements. Computerized Tomography (CT) scans are conducted to determine the cause, part of the brain affected and severity of the stroke and because of the cost are only ever conducted in a certain proportion of patients. For this analysis, we assume that 7% of the stroke patients had a CT scan. This is based on the SASPI rural stroke register which showed that amongst all patients who were admitted to the Tintswalo district hospital, which is one of the district hospitals for the Agincourt community, 7% were referred for CT scans at the provincial capital as no CT scans are available at the district hospital.

## 2.8. Inpatient care costs

The average length of stay for stroke patients is multiplied by the inpatient day cost to estimate the cost of inpatient care. Average length of

**Table 2**

Total baseline costs of stroke in Agincourt sub-district, rural South Africa in 2012.

Cost items	Cost (rands)	Cost (US\$)
Diagnostic costs	R43,212	\$4967
CT scan	R18,788	\$2160
Cholesterol	R6710	\$771
Blood sugar (glucose testing strip)	R6710	\$771
Full blood count	R6710	\$771
Electrocardiogram	R4294	\$494
Inpatient care costs	R2164,000	\$248,736
Cost per inpatient day	R1,900,300	\$218,425
Thrombolysis	R263,720	\$30,313
Costs of outpatient care	R258,947	\$29,764
Cost per hospital outpatient visit	R126,703	\$14,564
Cost per PHC visit	R111,909	\$12,863
Outpatient drug costs (11 months)	R12,629	\$1452
Drug costs (1 months after stroke)	R7706	\$886
Total annual direct care cost	R2,466,159	\$283,465

stay of 8 days (95% CI, 7 to 9 days) was derived from the Tintswalo hospital stroke register [20]. We use a cost per patient day equivalent (PDE) as a proxy measure for the cost of an inpatient day at public sector hospitals. The cost per PDE is calculated by dividing the total expenditure of the hospital by the number of patient days. The PDE traditionally combines outpatient visits with inpatient days by assuming that the cost of one outpatient visit equals a third of the cost of an inpatient day. It is calculated by all public sector hospitals in South Africa. The cost per PDE for Tintswalo hospital was R1772 in 2012/13 [24]. We perform sensitivity analysis around the cost per inpatient day estimate since this figure also partly captures the cost of treating an outpatient.

The cost of thrombolysis was calculated separately. According to data collected through the THSR, 20% of stroke patients that sought hospital care arrived within 3 h of stroke onset [20]. Three hours is the time frame for administering thrombolysis. We therefore assume that of the 50% of patients who reach hospitals after a stroke 14.2% get thrombolytic therapy. The 14.2% is based on the assumption that 71% of those arriving

**Table 1**

Epidemiological, cost and coverage assumptions used in baseline cost analysis, Agincourt sub-district, South Africa.

Parameter	Base estimate used in analysis	Source
Prevalence	290 per 100,000	[22]
Incidence	244 per 100,000	[2]
Proportion ischaemic strokes	71%	[20]
Proportion haemorrhagic strokes	23%	[20]
Costs (in rands)		
<i>Diagnostic costs</i>		
CT scan	2000	2009 National Health Reference Price List
Cholesterol	50	2009 National Health Laboratory Services pricelist
Blood sugar (glucose testing strip)	50	2009 National Health Laboratory Services pricelist
Full blood count	50	2009 National Health Laboratory Services pricelist
Electrocardiogram	32	
Cost per outpatient visit	584	[24]
Cost per inpatient day	1770	[24]
Thrombolysis	6920	[26]
Outpatient hypertension drug costs/month	75	[26]
Secondary prevention (aspirin) per month	6.93	[26]
Cost per PHC visit (Provincial PHC expenditure per uninsured)	670	[24]
<i>Coverage and health care utilization assumptions</i>		
Proportion of incident strokes reaching hospital	50%	Conservative assumption
Proportion of stroke cases diagnosed by CT scan	7%	[20]
Proportion utilizing public sector	90%	[24]
Average length of stay in hospital	8 days (7–9)	[20]
Proportion receiving thrombolysis	20%	[20]
Proportion of patients on warfarin	0%	[22]
Proportion on secondary prevention on month 1	100%	[22]
Proportion on secondary prevention from month 2	7%	[22]
Proportion on antihypertensive medication	7%	[22]

**Table 3**  
Variation in inpatient, diagnostic and total costs under different incidence assumptions.

Cost items	Cost (rands)	Cost (US\$)	Difference from baseline estimates
Diagnostic costs	R19,126	\$2198	56%
Inpatient care costs	R957,831	\$110,096	56%
Drug costs (1 month after stroke)	R3411	\$392	–56%
Total annual direct care cost	R1,231,553	\$141,558	–50%

within 3 h have ischemic strokes and are eligible to receive thrombolytic therapy. Unit cost of alteplase was taken from the South African medicine price registry [26], along with all other medication costs.

### 2.9. Outpatient costs

In line with assumptions of other studies, we assumed that stroke victims who survive past 30-days visit the hospital at least once a year [25]. Whilst this may result in an under-estimate of costs, this is offset by the fact that patients with moderate to no-disability will rarely visit a specialist after the first year of stroke. Stroke prevalence estimates and cost of outpatient days were used to derive the estimate of total outpatient costs [22,24]. We conservatively assumed that the cost per outpatient day is one-third the cost an inpatient day. Outpatient care for stroke predominantly involves reducing risk factors for stroke namely hypertension and secondary prevention with drugs. We assume that all patients with ischaemic stroke (71%) were on secondary prevention (aspirin) therapy a month after the stroke. From month 2 onwards we assume that only 1% of the patients continue with the aspirin therapy and no patient is on warfarin [22]. Hypertension is the most common risk factor in stroke survivors therefore we assume that 70% of stroke survivors are prescribed hypertensive medication following the stroke. 70% was the prevalence of hypertension in the SASPI study. After month 2, we assume that only 7% continued with medication. Unit costs of drugs were obtained from the Medicines Pricing list of South Africa [26]. Since different hypertension drugs clusters (Beta Blockers, ACE inhibitors etc.) include various drugs (generics and brands) with different costs, the clinic data that is linked to the Agincourt health and demographic surveillance system was used to identify the most commonly prescribed drug in each drug cluster. There were no patients prescribed cholesterol lowering drug in the SASPI register, thus this was not included in the cost estimates.

### 2.10. Primary health care costs

We assumed that 90% of patients will utilize the public sector (based on the proportion of patients with medical insurance in the HDSS). The

cost per PHC visit [24] was used as the proxy measure for the cost of a clinic visit. We assumed that 7% of all stroke patients will visit the clinic once a month. This assumption was based on the SASPI study finding that 7% of stroke patients were on hypertensive medication [22].

## 3. Results

The total direct costs of stroke were R 2.5 million (US\$284,000) in 2012, with inpatient costs comprising 80% of the total costs (Table 2).

### 3.1. Costs when different incidence or prevalence rates were used

Using alternative incidence estimates from a rural HDSS in Tanzania, Hai district (108 per 100,000) [27], which were collected prospectively over a 3 year period, had a significant impact on the total costs. The incidence rates in that study were half the incidence estimates used in our analysis. Total annual direct costs change by 50% when these incidence estimates are used (Table 3).

Varying prevalence estimates by up to 50% had a lower effect on the total direct costs; increasing (or decreasing) the total direct costs by 5% of the baseline value.

### 3.2. Sensitivity analysis

A sensitivity analysis was conducted by simultaneously increasing or decreasing the unit costs by 20% from their current value. The result was total direct costs ranging between R2 million and R3 million. Varying the unit costs individually showed that inpatient day costs had the greatest effect on total costs, changing the baseline total costs by 16% (Table 4).

### 3.3. Total direct costs from base-case to best-case scenario

When the percentage use of all service items were increased simultaneously to 90% (i.e. proportion reaching hospitals, acute use of aspirin for secondary prevention in ischaemic strokes, use of blood pressure lowering drugs) then costs of stroke treatment increased by 70%. The total direct costs of care are therefore expected to be approximately R4.2 million if stroke victims have adequate access to care after stroke (Table 5).

## 4. Discussion

The present study gathered information on costs of treating stroke cases (both new and existing) in the year 2012 in Agincourt HDSS, adding valuable knowledge to current information on the known burden of stroke. To the best of our knowledge this is the first study to

**Table 4**  
Sensitivity analysis – effect on total direct costs of increasing or decreasing unit costs by 20%.

Parameter	Baseline	Total direct costs in South African rands (–20%; +20%)	Relative change in total costs
<i>Diagnostic costs</i>			
CT Scan	2000	(2,466,417; 2,473,933)	0.36%
Cholesterol	50	(2,468,832; 2,471,517)	0.03%
Blood sugar (glucose testing strip)	50	(2,468,832; 2,471,517)	0.05%
Full blood count	50	(2,471,517; 2,468,832)	0.03%
Electrocardiogram	32	(2,469,316; 2,471,034)	0.02%
Cost per outpatient visit	584	(2,444,834; 2,495,516)	0.61%
Cost per inpatient day	1770	(2,064,779; 2,875,570)	9.80%
Thrombolysis	6920	(2,417,431; 2,522,918)	1.27%
Outpatient hypertension drug costs/month	75	(2,466,260; 2,522,918)	8.16%
Secondary prevention (aspirin) per month	6.93	(2,470,022; 2,470,327)	0.00%
Cost per PHC visit (Provincial PHC expenditure per uninsured)	670	(2,447,793; 2,492,557)	0.54%
Total direct cost	2,470,175	(1,955,062; 2,993,661)	20.5%

**Table 5**  
From base case to best case scenario of increasing uptake of services to 90%.

Cost items	Cost – base case in rands (US\$)	Cost – best case in rands (US\$)
Diagnostic costs	R43,212 (\$4967)	R265,984 (\$30,572)
Inpatient care costs	R2,164,000 (\$248,736)	R3,684,200 (\$423,471)
Outpatient care costs	R126,700 (\$14,563)	R126 700 (\$14,563)
PHC costs	R111,910 (\$12,863)	R111 910 (\$12,863)
Outpatient drug costs (11 months)	R12,629 (\$1452)	R3,026,200 (\$347,839)
Drug costs (1 month after stroke)	R7706 (\$886)	R,13,342 (\$1534)
Total annual direct care cost	<b>R2,466,148</b> (\$283,465)	R4,215,780 (\$484,572)

estimate the costs of stroke in a rural setting of South Africa. The major strength of this study is its use of predominantly local data sources – both epidemiological and cost data. Previous studies on economic costs of stroke in sub-Saharan Africa are difficult to generalize as they vary with regards to cost categories included, number of patients assessed, duration of patient follow-up and unit costs of treatment procedures (Table 6) [6,28–33].

In this present study we found that total direct costs of stroke were between R2.5 million and R4.2 million (US\$283,000–US\$485,000) in Agincourt sub-district in 2012. Because total health system costs to a sub-district are not known it is difficult to precisely calculate the proportion of the expenditure that is consumed by stroke. Nonetheless, assuming that the overall sub-district health expenditure is the product of the population size and the health expenditure per capita in the district (R1413 in 2012/13) [24]; total sub district health expenditure equals R155 million (US\$18 million) in 2012. Total direct costs of stroke therefore account for approximately 1.6–3% of the sub-district health expenditure. Within an international context, Evers et al. report that stroke accounts for 2–4% of the health expenditure in developed countries [3]. Thus our study suggests that stroke has the same relative economic burden in rural South Africa as it does in developed country contexts.

What was clear from our analysis was that the high cost of stroke in Agincourt HDDS is a result of the high incidence of the disease. Intervening to reduce the onset of stroke is therefore a priority. Cost of illness studies that estimate the lifetime costs of the disease are urgently needed to understand the economics of stroke and its changing cost structure over a lifetime. This will allow policy makers to better understand how much resources can be saved by intervening at different stages of

the disease cycle. In addition, methodologically rigorous, follow-up studies on stroke incidence are needed within the country to permit such cost of illness analysis to be undertaken.

We have shown the immediate effect of changing the service utilisation of items on total costs and shown that under the best case scenario, the actual total costs of stroke will almost double the figures reported in the baseline analysis. However, one short-coming of the study is that it does not consider the impact of increased access to services (e.g. reduced risk of stroke recurrence and mortality) on future cost-savings. Previous analyses have shown that increasing access to health services can in fact reduce the lifetime costs of stroke even though the first year costs of treatment increase [25].

Information collected via the THSR was useful in providing basic, yet fundamental information on stroke types and treatment procedures within the rural sub-district population. Equally important was the study on stroke prevalence that was conducted in 2001. The THSR was designed for a specific research purpose, as such current data on strokes is not readily accessible from the hospital. Going forward it would be important to track stroke cases, so as to allow better estimation of current costs of stroke cases and understanding of the drivers of costly expenditures.

#### 4.1. Limitations

This study did not calculate a cost per stroke patient mainly because in the case of stroke there is a wide difference in the average costs of cases. In Tanzania, for example, costs of stroke cases ranged from USD75 to USD150 in rural Hai district, whilst in Dar es Salaam the differences were even larger (USD282 to USD674). Unlike incidence-based COI studies which can estimate the lifetime costs of a disease from its onset to its termination, prevalence-based studies (such as ours) can only provide a snapshot of costs at a particular point in time. We did not consider the impact of differing disabilities on our cost calculations but instead assumed that all stroke patients access hospitals only once a year. This assumption could have underestimated the total costs we reported as stroke victims in Africa generally report greater disability and need for care [22] than developed country counterparts. There is significant disability associated with stroke which results in loss of income to individuals and families. These productivity losses are highest in developing countries where people delay seeking care and studies from other settings have indicated that productivity losses make up a significant part in total costs of care [31]. This study did not attempt to estimate

**Table 6**  
Cost of stroke studies from sub-Saharan Africa.

Study (year)	Setting	No. of stroke patients	Length of follow up	Costs included	Costs per patient	Comment
[29]	Congo	90	6 months	Direct costs (diagnosis, inpatient care, medication)	158 ± 10 euros	Only 1st day of hospitalization included (article in French)
[30]	Togo	412	12 months	Direct costs (diagnosis, inpatient care, medication)	430 ± 190 euros for ischaemic stroke; 940 ± 40 euros haemorrhagic stroke	Article in French
[32]	Senegal	383	12 months	Direct costs (diagnosis, inpatient care, medication)	USD160	Article in French
[33]	Nigeria	240	Cross-sectional/ folder review	Direct costs (diagnosis, inpatient care, medication)	USD600 in public facility; USD5,000 in private facility	
[31]	Tanzania	16	6 months	Direct costs (diagnosis, inpatient care, medication), transport, indirect costs (productivity losses),	USD 107 in rural Hai; USD 420 in urban Dar es Salaam (excluding productivity losses) USD137 in rural Hai vs. USD380 in urban Dar es Salaam (productivity losses)	Included productivity losses Unit costs shown for some cost parameters
[6]	South Africa	261	12 months (retrospective folder review)	Inpatient costs	USD2240	Only inpatient costs included
[28]	Burkina Faso	122	7 months	Direct costs; transport cost to designated hospitals, physiotherapy and out-of-pocket payments to other points of care.	USD145–USD940	

such costs; as such the findings underestimate the total costs of stroke in 2012.

## 5. Conclusions

Stroke is a disease with high economic costs and rural settings of South Africa are no exception. It costs health services 2–3% of their expenditure. In light of competing health priorities, reducing this burden is critical in resource constrained settings. Whilst our study provides a snapshot of costs incurred in a particular year, incidence-based studies coupled with modelling techniques are urgently needed to estimate lifetime costs. Such studies will give a more accurate understanding of the lifetime costs of stroke, and the savings accrued from intervening at different stages of disease. Demographic surveillance sites could act as platforms through which such studies are implemented as systems for following up individuals are already in place.

## Author contributions

MM and LC contributed towards the conceptualization of the study. MM carried out all the initial analysis and drafted the manuscript. LC critically appraised the manuscript for intellectual content and assisted with interpretation of data. Both authors edited subsequent drafts and approved the final manuscript.

## Competing interests

The authors declare that they have no competing interests.

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