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Research Article

Impact of neurosurgical site infections on patient expenditure at a national referral hospital in Kenya: a cost of illness study

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Background: Neurosurgical site infections result in prolonged hospitalisation and increased treatment costs. Cost of illness studies are important in computing the total costs of treatment of disease, as they quantify the burden of disease in terms of direct costs, productivity losses and intangible costs. Neurosurgical site infections do not occur at a high rate in most clinical settings. Their economic impact has been assumed to be minimal, and most studies have not exclusively studied their economic impact.

Objective: To assess the economic burden of treatment of surgical site infections among trauma patients admitted at the neurosurgical ward of Kenyatta National Hospital.

Methods: A prospective cost of illness study was conducted between April 2015 and June 2015 as part of a larger prospective cohort study. The patient perspective was adopted. The time horizon was the hospitalization period of the patients, which was a median of ten days. No discounting was done because the study was done within a year. A micro costing approach was used to compute direct costs on medication, laboratory and radiologic tests, cost of surgical procedures and nursing care, and direct non-medical costs incurred by patients for the average 10 day hospitalisation period. Productivity losses were also computed.

Results: The total median cost of treating patients with neurosurgical site infections was higher, at USD 203.95 than that of patients without infection at USD 141.20. The median cost on antibiotics was USD 18.70 while that of non-antibiotic drugs was USD 33.03. The total median cost on laboratory and radiologic tests was USD 20 and USD 55 respectively. The key cost drivers were expenditures on meropenem, phenytoin, urea, electrolyte and creatinine tests and CT scans. With regards to costs of services, care-giver costs accounted for the highest median expenditure, followed by costs of surgery and nursing care.

Conclusion: Neurosurgical site infections increase hospitalisation duration and costs. Prevention of these will reduce patient expenditure.

Key words: cost of illness, neurosurgical site infection, productivity losses

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1. Introduction

Surgical site infections occur at and beyond the site of surgical incision after surgery. Neurosurgical site infections generally have a low incidence, but when they occur, they are associated with high morbidity and mortality rates, prolonged hospital stay and increased costs (Chiang et al, 2014). The cost of surgical site infections per year has been estimated to range from 1 to 10 billion US dollars and its monetary equivalents in direct costs and productivity losses (Perencevich et al, 2003; Shepard et al, 2013). The average cost of treatment of a single surgical site infection in America has been estimated to be 2,734 US dollars (Shepard et al, 2013).

The cost of treatment of surgical site infection depends on the site of the infection. The estimated cost of treating a superficial SSI is 400 US dollars per case, while that of treating an organ/space infection has been estimated to be 30,000 US dollars per case (Urban, 2006). There is paucity of data on the cost of treatment of neurosurgical site infections in both high and low income countries. Costs of illness studies are important as they quantify the direct costs and productivity losses incurred with specific diseases and provide data for planning and resource allocation to governments and health institutions. Generally, since neurosurgical site infections are of low incidence, their economic impact has not been studied. This study will provide data that will aid hospitals in developing countries in allocating resources that would be used in treatment and prevention of neurosurgical site infections.

This study sought to compute the expenditure on antibiotics and other medications, diagnostic tests and productivity losses incurred due to hospitalization; compare the expenditure in patients with surgical site infections and those without and identify the key cost drivers.

2. Methods

2.1 Study Design and Population

A prospective cost of illness cohort study of adult trauma patients admitted at the neurosurgical unit between April and June 2015 was conducted.

2.2 Eligibility criteria

Patients who met the following criteria were included in the study: adult patients over 18 years old, those who sustained traumatic injury through road traffic accidents, assault, falls or any other cause, those who had contaminated to dirty wounds and were admitted at the KNH neuro-intensive care unit and ward 4C for elective and emergency neurosurgery in the study period. Paediatric patients, those with clean wounds and those who underwent neurosurgery for reasons other than trauma were excluded.

2.3 Sampling Strategies and Sample Size

The investigator perused through patient files in the neurosurgical ward to identify patients who had been admitted due to trauma. Universal sampling was used such that all patients who met the inclusion criteria were included in the study. Consent was sought from patients and/or caregivers before recruitment into the study. A sample size of 100 patients was estimated using the formula for incidence (Daniel, 2010).

2.4 Data Collection

The investigator perused through patient files and documented the types of drugs prescribed to the patients and the laboratory and radiological tests they had undergone. The costs of each item were obtained from the Kenyatta National patient charge sheets for the surgical division and the acquisition lists for drugs. Where the patients underwent tests or obtained drugs outside the hospital, the information was obtained by history taking from the patients and/or caregivers.

2.5 Data Analysis

The patient perspective was adopted and this included all costs incurred by the patients during treatment. The time horizon was defined as the time between admission and discharge. No discounting of costs was done because the study was done in less than one year.

A micro costing approach was used to compute direct costs. Most of the quantities and prices of resources consumed were obtained from the participant files. We computed the direct costs which included the following categories of expenditure: surgery, bed occupancy, nursing care, medicines, laboratory and diagnostic tests. For the direct non-medical costs, we computed costs incurred on food and transport for patients and their caregivers during the hospitalization period.

To compute the expenditure on medicines, the 2014 acquisition price lists of Kenyatta National Hospital were used to obtain unit prices of the medicines. The final price was computed as a product of the price of unit dose, number of unit doses, frequency of administration and duration of administration. Where there was missing data on the dose, duration, frequency and route of administration, imputation was done by replacing the missing data with the median dose, frequency, route and duration of use. To calculate the costs incurred by the patients, we used a mark -up of 30%.

To obtain prices of laboratory and radiological tests, expenditure on transport and food, we inquired from patients as these were not recorded in their files.

Productivity losses were calculated using the human capital approach, as a product of daily income and the hospitalization days, with 30 days allowed for recuperation. The estimated daily income was obtained by participant interview. Overhead costs such as administrative charges, utilities such as water and electricity were ignored.

2.6 Ethical Considerations

Approval to carry out this study was sought from the Kenyatta National Hospital/ University of Nairobi Ethics Review Committee, no **P76/02/2014**.

3. Results

Care-giver costs accounted for the highest median expenditure, followed by costs of surgery and nursing care. Expenditure on non-antibiotic drugs like anti-seizure drugs, drugs for raised intracranial pressure, haematinics and vitamin supplements accounted for the least expenditure, as presented in **Table 1**. One US dollar is equivalent to KES 100.

Table 1: Summary of all costs incurred

Type of costs	Median costs [IQ], KES.	Median costs, US Dollars (USD)
Antibiotics	3303.09 [1177.98, 8956.39]	33.03 [11.78, 89.56]
Non antibiotics	1870.05 [1539.41, 4805.11]	18.70 [15.39, 48.05]
Surgery and nursing care	42,200	422.00
Laboratory tests	2000 [1700, 5700]	20.00 [17.00, 57.00]
Radiologic tests	5500 [5500, 13000]	55.00 [55.00, 130.00]
Caregiver costs	81,900	819.00
Productivity losses	12,250 [0, 70,000]	12.25 [0, 700.00]

Comparison of expenditure in patients with and without surgical site infection

A comparison was made between the total costs of all the procedures for patients who developed surgical site infections and those who did not. Of note, the median total costs, for each type, were higher in the group which developed infection, as shown in Table 2. As expected, there was a statistically significant association between the total expenditure (p=0.028), total direct medical cost (p= 0.004), the total cost of medicine (p=0.026) and surgical site infection.

There was no statistically significant difference between the total costs of radiological tests, laboratory tests non-medical costs, and presence of surgical site infections. This is expected because radiologic and laboratory tests can be ordered for any other reason apart from diagnosis of infection. However, when individual laboratory tests were considered, there was a statistically significant difference between the expenditure on full blood count and surgical site infection (p=0.010). There was no association between direct medical costs and surgical site infection as presented in **Table 2**.

Table 2: Comparison of the total costs between those who developed surgical site infection and those who did not

Type of total cost	Median [IQR] Expenditure , No infection (KES)	Median [IQR] Expenditure, Infection (KES.)	P value
Total cost	14119.84 [11495.46,21280.0], n=49 USD 141.19[114.95, 212.80]	20394.61[14022.42, 28500, n=24 USD 203.94[140.22, 285.00]	**0.028**
Total direct medical cost	9800 [8166.9, 13362.6], n=51 USD 98.00[81.67, 133.62]	12483.52[9333.64, 26127.67], n=27 USD 124.83 [93.33, 261.27]	**0.004**
Total medicines cost	906.14 [0, 3150.76], n=53 USD 90.61[0, 31.50]	2483.185[502.58, 8616.65], n=28 USD 24.83[50.26, 86.17]	**0.026**
Total radiologic tests	5500[5500,7000], n=53 USD 55.00[55.00, 70.00]	5500[5500,8000], n=27 USD 55.00[55.00, 80.00]	0.574
Total lab tests	1800[1600, 2800], n=53 USD 18.00[16.00, 28.00]	2250 [1650, 2850], n=28 USD 22.50 [16.50, 28.50]	0.683
Total non- medical costs	2400[0,7600], n=51 USD 24.00[0. 76.00]	4200 [1750, 5940], n=25 USD 42.00[17.50, 59.40]	0.158

Key Cost Drivers for Medicines and Laboratory tests

We identified the key cost drivers among antibiotics, non-antibiotics, laboratory and radiologic tests. For antibiotics, meropenem was the key cost driver, accounting for 92.5 % of the total cost of antibiotics. Similarly, phenytoin accounted for 15% of the expenditure on non-antibiotics as the key cost driver. Urea, electrolyte and creatinine (UECs) tests accounted for a large proportion of expenditure on laboratory tests, because about 36.8% of all the patients underwent this test, with a maximum of about 41.1% (median 36.8%, IQ 25.0% to 41.1%). This was followed by liver function tests (median 25.9%, IQ 14.6% to 41.2%) and full blood count (median 12.0%, IQ 7.7% to 16.7%). All patients (100.0%) underwent at least one CT scan, making it a key cost driver for radiologic tests.

4.0 Discussion

Our study computed the costs of treatment of neurosurgical patients only. This is unlike other studies which computed the costs of treatment of patients undergoing different types of surgeries (Ulu- Kilic et al, 2015; Wang et al, 2015; Borzkut et al, 2013; Collins, 2013; Shepard et al, 2013, Sharma et al, 2012; Hanstein et al, 2011). There were no studies that computed the costs of treatment of neurosurgical patients alone. Most of these studies also computed costs across different hospitals, unlike our study which was a single centre study (Shepard et al, 2013, Wang et al, 2015; Ulu- Kilic et al, 2015; Collins, 2013; Sharma et al, 2012; Hanstein et al, 2011).

The costs in our study appear much lower than the expenditure quoted in similar studies, most of which have quoted prices amounting to thousands of US dollars (Ulu- Kilic et al, 2015; Collins, 2013; Sharma et al, 2012; Borzkut et al, 2013). This can be attributed to the short duration of hospital stay for our patients, which we used to calculate the costs, compared to other studies which computed costs of hospitalisation for months or years. The subsidised cost of antibiotics could also explain the relatively low costs of treatment. Kenyatta National Hospital mainly procures generic antibiotics for the patients in the general wards, which are much cheaper than their original versions. Our study also had a small sample size and estimated the costs in a small unit of a major hospital, compared to the other studies which estimated either costs of large populations of surgical patients in multiple hospitals (Wang et al, 2015; Borzkurt et al, 2013; Shepard et al, 2013; Sharma et al, 2012; Hanstein et al, 2011).

A very old study reported that in the recent years, the cost of radiologic tests has risen and forms a huge part of patient health expenditure. This is particularly so, considering the routine use of more sophisticated tests such as CT scans and MRI scans (Hofman et al, 2000). This can be mirrored in our study in which CT scans were mostly used for diagnosis. Radiologic tests were the fourth most costly intervention after surgical and nursing procedures and bed occupancy.

Another old study computed the costs of several radiologic examinations (Saini et al, 2000). The costs were a computation of labour and non-labour costs. The average cost radiography, CT scan and MRI was USD 41, 112 and 267 respectively. These charges are much higher than the costs of these tests in our study. This can be explained by the fact that after introduction of these tests, the costs have significantly gone down over the years. A newer study has advocated for the reduction in the number of radiological examinations done as they increase health care costs and expose patients to unnecessary radiation (Kendall and Quill, 2014). This however should not overlook the importance of radiological tests in informing diagnosis and guiding treatment (Hofman et al, 2000). Variations in the cost of radiologic and laboratory examinations were seen in our study, depending on the site where the patients underwent the test. This is also seen in studies which showed such variations (Spence et al, 2014; Chatterjee et al, 2013).

The median cost of antibiotics was KES. 1,870.05 (18.70 US dollars). In the study period, 50 patients were on antibiotics, and 22 of them developed infection. The total median cost therefore, of treating all the infected patients with antibiotics (n=22) was KES 41,141.10, as opposed to KES. 52,361.40 for those who did not develop infections (n=28). These findings are contrary to several studies which show that the cost of antibiotics increases with those who have developed infection (Bozkurt et al, 2013; Sharma et al, 2012; Ulu-Kilic et al, 2015). Looking at our antibiotic consumption data, it is clear that antibiotics were given equally to patients, regardless of whether they developed infection or not, suggesting indiscriminate antibiotic use or an increase in use of antibiotics for prophylaxis rather than for treatment. More patients without infections received multiple antibiotics, compared to those who developed infections, because those who developed infections were fewer than those who did not.

Although the cost on antibiotics was higher in the patients who did not develop infections, the overall cost of treating infected patients was higher than that of treating uninfected patients. This included the direct medical costs, productivity losses and direct non-medical costs. These findings agree with other studies (Shepard et al, 2013; Sharma et al, 2012).

Apart from direct medical costs, patients spent a median of KES. 100 and KES 200 on food and transport respectively, for the relatives who visited them in hospital. This is against a median daily income of KES. 300. This shows that these costs literally took up all the income for the day. Even though Kenyatta National hospital provides meals for all its patients, the relatives opted to supplement that with food bought from outside the hospital. This increased the household income spent on taking care of the ill.

The patients were employed in low paying jobs, with a median average daily income of KES 300. The productivity costs were very high, almost a third of the direct medical costs. This finding is contrary to that in other studies that have stated that productivity losses can be higher than direct medical costs (Changik, 2014). This is because such studies have been carried out in high income areas where patients are on high salaries and the cost of replacing them during the illness and recuperation period is high. Our patients worked menial jobs with no fixed salaries, so they could easily be replaced by other casual labourers at the time of illness.

In this study, the costs of medicines, diagnostic tests, surgery and nursing care, direct non-medical costs and productivity losses were computed. Care giver costs were the highest, followed by costs of surgical and nursing procedures and productivity losses. The cost on medicines was the lowest. They key cost drivers for laboratory, radiologic procedures and medicines were CT scans, UECs and meropenem respectively. The total expenditures were higher in patients who developed infection than patients who did not. Patients who underwent full blood count tests were likely to be infected. Productivity losses and cost of hiring caregivers was higher than the patients' income.

From our study, it is evident that the costs of treating a neurosurgical trauma patient were much higher than the patients' household incomes, assuming that the daily income is a reflection of household income. This is against the fact that the Kenyan healthcare system heavily relies on out of pocket payments for healthcare (Chuma and Okungu, 2011). The Ministry of health is underfunded and cannot take care of the costs of all patients. The National Health Insurance Fund (NHIF) pays for some inpatient costs of patients, but only caters for inpatient hospital stay. Some hospitals, Kenyatta National Hospital included, have adopted a waiver system to take care of the costs of extremely poor patients, but this still has challenges as they are not able to cover the costs of all patients (Kamanda et al, 2015). This calls for a revision in healthcare financing policies in Kenya, to meet the WHO standards for equity in healthcare (Chuma and Okungu, 2011).

The limitation for this study was that intangible costs were not computed. This is because we were unable to interview some of the patients with head trauma because of low Glasgow coma scores, confusional states and general disorientation which was associated with head injury.

5.0 Conclusion

Neurotrauma and associated surgical site infections affect the youth of productive age in developing countries. The direct costs of treatment, and household expenses incurred are a heavy burden to the patients and their families, most of whom cannot afford the out of pocket expenses. The productivity losses are also high, although the patients in this cohort were not employed in jobs with a steady income. Costs due to antibiotic use are higher in the patients who do not develop infections than those who develop infections. This points to irrational antibiotic use or increased use of antibiotics for prophylaxis, which is associated with unnecessary costs. The costs of diagnostic tests do not vary with infection rates, but vary with the site at which the tests are done. The acquisition costs of some medicines varied with the year.

Hospitals carrying out neurosurgical procedures and governments in developing countries at large should come up with comprehensive insurance schemes to cater for the healthcare costs of this group of patients. As discussed earlier, irrational antibiotic use contributed to an increase in medication costs. The neurosurgical units should develop antibiotic use guidelines for their patients to ensure rational and economic use of medicines. The hospital tender committees should evaluate yearly acquisition prices of all the medication to prevent the wide variations in prices seen in some medications. Finally, a study should be carried out to compute the intangible costs incurred by neurosurgical trauma patients in developing countries.

Conflict of Interest declaration

The authors declare no conflict of interest.

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References

Bozkurt F, Kaya S, Gulsun S (2013). Assessment of perioperative antimicrobial prophylaxis using ATC DDD Methods. *Int. J. Infect. Dis.* **17**: e1212-e1217.

Changik JO (2014). Cost of illness studies: concepts, scopes and methods. *Clin. Mol. Hepatol*. **20**: 327-337.

Chiang HY, Kamath AS, Pottinger JM and Greenlee JD (2014). Risk factors and outcomes associated with surgical site infections after craniotomy or craniectomy. *J. Neurosurg*. **120**:509-521.

Collins S (2013). SSI prevention: crossing environments of care, standardizing incision management. *Infect. Ctrl. Today*. www.infectioncontroltoday.com. Accessed 14/5/2016.

Drummond MF, Sculpher MJ, and Torrance GW (2005). Cost Analysis. In: Methods for the economic evaluation of health care programmes; 55-98. 3rd Edition. Oxford.

Hanstein TJ, and Gaiser G (2011). Economic burden of surgical site infections in hip and knee arthroplasty- a cost of illness study for Germany. Value in Health. *Value Health*. 14: A116.

Hofman PAM, Neleman P, Kemerink G and Wilmink JT (2000). Value of radiological diagnosis of skull fracture in the management of mild head injury: meta-analysis. *J Neurol. Neurosurg, Psychiatry*. **68**;416-422.

Jarvis WR (1996). Selected aspects of the socioeconomic impact of nosocomial infections: morbidity, mortality, cost and prevention. *Infect Ctrl. Epidem*. **17**: 552-557.

Junker T, Mujagic E, and Hoffmann H (2012). Prevention and control of surgical site infections: review of the Basel Cohort study. *Swiss Medical Weekly.* **142**:w13616.

Lee KY, Coleman K and Paech D (2011). The epidemiology and cost of surgical site infections in Korea: a systematic review. *J. Korean Surg. Society*. **8**: 295-307.

Perencevich EN, Sands KE and Platt R (2003). Health and economic impact of surgical site infections diagnosed after hospital discharge. *Emerg. Infect. Dis*. **9**: 196-203.

Sharma MS, Suri A and Chandra SP (2012). Cost and usage patterns of antibiotics in a tertiary care neurosurgical unit. *Indian J. Neurosurg*. **1**: 41-47.

Shepard J, Ward W, and Milstone A (2013). Financial impact of surgical site infections on hospitals. *JAMA Surg*. **148**: 907-914.

Tan J.T, Coleman K and Norris S (2010). Surgical site infection in India: A systematic review of the incidence and economic burden. *Value Health.* **13**:A546-A547.

Urban J (2006). Cost analysis of surgical site infections. *Surg. Infect*. **7**(S1): S19-S22.

Ulu- Kilic A, Alp E and Cevahir F (2015).Economic evaluation of appropriate duration of antimicrobial prophylaxis for prevention of neurosurgical infections in a middle income country. *Am. J. Infect. Ctrl*. **43**: 44-47.

Wang Q, Mi C and Zhang Y (2015). Impact of surgical site infections on cost of illness and length of stay in a teaching hospital. *J. Microbiol. Immunol. Infect*. **48**:S180