Journal of Endocrinology, Metabolism and Diabetes of South Africa 2020; 25(2):44–50
https://doi.org/10.1080/16089677.2020.1782007

JEMDSA
ISSN 1608-9677 EISSN 2220-1009

ORIGINAL RESEARCH

Counting the cost of preventable diabetes-related lower limb amputations at a single district hospital in KwaZulu-Natal: what does this mean, what can be done?

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Background: Healthcare policy decisions are driven by many factors, including cost, hence the need to show costs of diabetes mellitus-related lower limb amputations (DMLLA) to inform amendments to health care. Substantial decreases in amputation rates are associated with specialised podiatry foot clinics and ongoing foot education, as per national guidelines on the multidisciplinary team approach (MDTA) to diabetes health care. There are only two podiatry posts in KwaZulu-Natal (KZN) state health department (DoH).
Objectives: Aims were to draft the medical costs for 660 DMLLA at Greys Hospital for the period 2013–2017; to extrapolate costs on annual DMLLA in KZN; to outline socio-economic costs for future investigation; to present evidence that podiatry in the MDTA can decrease numbers of DMLLA.
Methods: A retrospective review on clinical data captured in real time and maintained by the Pietermaritzburg Metropolitan Trauma Service (PMTS) and Surgical Service (PMSS) was performed. Costs were analysed on data for 660 patients' DMLLA at Greys Hospital between 2013 and 2017, and psychological and socio-economic costs via literature review.
Results: Medical care at Greys Hospital for 660 DMLLA in the five years cost in excess of ZAR 213 million. Extrapolated to the 1 231 diabetic amputations (2014) equals an annual cost to KZN DoH in excess of ZAR 398 million. Personal, family loss and socio-economic costs are estimated in excess of ZAR five million per amputee, resulting in further cost of ZAR 6.155 billion per annum to KZN. Extrapolation across 11 provinces signifies a national cost of at least ZAR 68 billion.
Conclusions: We present a gauge of the cost of DMLLA to KZN and national health. Substantial possible socio-economic losses compound these. The role of podiatrists within MDTA teams has an evidence base to prevent DMLLA.

Keywords: diabetes mellitus, public health, podiatry, prevention of foot and limb loss, socio-economic cost

Background

In resource-limited environments in low- and middle-income countries, lower limb amputations due to the complications of diabetes are costly to fiscus. It is important to note that there is a marked decrease in amputation rates associated with specialised podiatry foot clinics and ongoing patient foot education.[1] Albeit that the thrust of primary care is prevention, provision of such primary prevention care for diabetic foot complications is difficult to implement in the face of other demands for hospital and trauma care. Cost calculations of preventable diabetes-related amputations in South Africa are required in order to inform policy-makers regarding the importance of training and placement of podiatrists throughout the healthcare system. Podiatrists are needed in the primary health care sector for screening, assessment, semi-surgical and other treatment in the management of diabetic foot health, as well as the provision of in-depth patient foot education.

A study in 2015 noted that KwaZulu-Natal (KZN) had 1.28 million people registered with diabetes in the public sector, which translates into a mean diabetes prevalence of 12.5%, although some districts exceeded 35%.[1] The same study found that the District Health Information System (DHIS) registered 2 323 diabetic lower limb amputations carried out in state health facilities in KZN during the period 2013–2014.

Several research outcomes have led to the International Diabetes Federation's statement that all people with diabetes should have a foot assessment that places them in the appropriate risk stratification to indicate the clinical pathway for foot disease prevention and treatment. A multidisciplinary team approach, with the inclusion of podiatry in treating the diabetic foot, is central for good outcomes, to protect the diabetic foot from breakdown, preventing foot ulceration and lower limb amputations. Podiatry takes preventive measures early in the disease process such that treating the foot in the early risk categories prevents patients from becoming high risk.[2] Although the value of podiatry and the approach of a multidisciplinary team in diabetes care has been widely acknowledged,[3–20] very few such teams that include podiatry are in place in state health. Healthcare policy decisions are driven by many factors, including cost, hence the need to begin the process of calculating the costs of diabetes-related lower limb amputations. Since lower limb amputations in diabetes are largely preventable, they are a measure of inadequate care on the part of any healthcare service.

The study aimed to produce a draft cost calculation in respect of patients with diabetes-related complications who were referred to the surgical service at Greys Hospital, Pietermaritzburg for lower limb surgery such as amputation, stenting, skin grafting or revisionary amputation of a previous amputation. These costs are extrapolated across the total number of annual amputations in KZN province. An outline of the socio-economic costs or so-called 'hidden costs' is added, based on a review of psychology and legal literature. For the purposes of a draft calculation, comparable costs and amputations are assumed equally across all 11 provinces.

Ethical approval was granted by the Biomedical Research Ethics committee under the reference BCA058/17.

Methods and materials

A retrospective review of data captured on a prospectively entered electronic registry was performed. Clinical data are captured in real time and maintained by the Pietermaritzburg Metropolitan Trauma Service (PMTS) and the Pietermaritzburg Surgical Service (PMSS) in KwaZulu-Natal province, South Africa. All patients who underwent diabetes-related lower limb surgery or amputation at Greys Hospital in the calendar years 2013–2017 were identified and selected for analysis. Clinical data for a total of 660 digital records were exported from the databases to spreadsheets. Since compound clinical data were in descriptive text form, 'unpacking' or manual conversion of the textual data into numerical coding was carried out to facilitate quantitative analysis.

Tables were prepared of cost driver formulae, after the methods developed in previous studies that have used data from the PMTS.[21–23] Costs were obtained from the radiology manager and hospital financial management (see Tables 2 and 3). In addition, in-hospital ward costs were estimated, based on the average of medical aid rates across two of the largest private hospital groups in KwaZulu-Natal and as per Allied Health tariffs published by the Discovery Health Medical Scheme.[24]

'Hidden costs' are the socio-economic costs of diabetes-related lower limb amputations, which form a backdrop of concern to the overall mental health of health workers; to amputees themselves and their families; and to the social and economic welfare of individuals, affected communities, industry and national fiscus. These were sourced from review of the literature that included the quantum of typical legal settlements in respect of personal injury claims involving loss of the lower limb.[25]

Results

Calculations across cost drivers resulted in a total cost of ZAR 213.456 million (albeit incomplete) for 660 diabetic amputations, broken down by categories of costs. Costs were calculated from data on types of diagnostic imaging, laboratory tests requested, transportation to and from the referring facility, theatre time, post-surgery instructions, prognosis, outcome, ward type and ward stay duration. This total is incomplete as it does not include items such as food, dietitian consultations, nursing consumables and all hospital staff remuneration. While the amounts for podiatry foot care and podiatry orthotics or shoe modifications are shown, they do not form part of the total estimates since only two podiatrists are deployed in state health in KZN.[1] However, the relevance of the podiatry cost estimates will be covered in the discussion.

The data revealed that patients who underwent diabetes-related lower limb amputations are often sent to the PMSS by ambulance from as many as 20 other state hospitals in the province. It was noted that patients are often returned to their base facility for nursing once they have been stabilised after surgery due to crowding and lack of ward beds at Greys Hospital. Running costs for ambulance vehicles are available from the Automobile Association of South Africa[26] and are presented below.

Transportation

Table 1 outlines only the running costs for such transportation. The vehicle running cost consists of maintenance and fuel for an example Volkswagen Crafter 2.0 L diesel ambulance[26] and excludes costs of staffing, personal protective equipment (PPE), mobile and telecom communications, vehicle purchase/lease, vehicle depreciation, vehicle insurance, signwriting, training, medical liability insurance, medical equipment, medical equipment depreciation, medical consumables, security tracking, management overheads and any other aggregate costs, which will need to form part of an internal audit not included in the present study. Also excluded from the transportation costs are costs incurred by those 110 patients (in Table 1) who used other transportation (referring health facility: GP private, Greys Hospital, Private transport, Unknown, Walk-in) for whom transportation costs were not available or not recorded.

Table 1 lists the ambulance running costs as per the Automobile Association[26] of return trips from referring health facilities, in descending order of cost, for diabetes amputation patients at Greys hospital for the five years from 2013 to 2017.

Diagnostic imaging

Diagnostic imaging forms a large segment of costs for amputation surgery, including leg, cardiovascular and other systems imaging since morbidity of the entire patient is assessed before surgery (Table 2).

Standard and routine diagnostic laboratory investigations

The cost of standard and routine laboratory tests (full blood count, electrolytes, kidney function, liver function, blood gas, etc.) was obtained from the hospital laboratory and estimated as a total of ZAR 2 650, applied across all diabetic amputation patients, per surgical encounter.

As may be seen in Table 3, base tariffs were used to estimate post-surgical costs such as hospital care back at the referring facility, physiotherapy, rehabilitation, podiatry care and podiatry orthotics for the contralateral foot, prosthetic limbs and mobility aids.

The calculations across the cost driver formulae (as per Table 3) resulted in the line totals presented in Table 4.

Hidden costs to Department of Health

A decline in quality health care has caused the public to lose trust in the healthcare system.[27] The medical response is thus compromised by delays in treatment due to ignorance and mistrust.[27] Patients with compromised limbs who are referred to Greys Hospital inevitably lose those limbs, which all too often reinforces patients' beliefs due to so many patients presenting late with limbs that cannot be salvaged. Patients do not have foot care intervention or in-depth foot education from podiatrists carried out early enough to effect prevention.[1]

Table 1: Running cost estimate of transporting diabetes patients for amputation and amputation-related surgery (n = 660) to and from Greys PMSS between 2013 and 2017

Referring base health facility ranked by cost	Category	Km to Greys	AA cost at ZAR 7/km per round trip	No. of patients	ZAR total
Newcastle Hospital	Regional	265	3710.00	116	430 360.00
Church of Scotland Hospital Tugela Ferry	District	121	1 694.00	98	166 012.00
Vryheid Hospital	District	301	4 214.00	37	155 918.00
Greytown Hospital	District	75	1 050.00	89	93 450.00
Emmaus Hospital, Winterton	District	149	2 086.00	39	81 354.00
Appelbosch Hospital, Ozwatini	District	69	966.00	68	65 688.00
Estcourt Hospital	District	144	2 016.00	22	44 352.00
Montebello Hospital, Ozwatini	District	68	952.00	21	19 992.00
Ladysmith Hospital	Regional	157	2 198.00	9	19 782.00
Madadeni Hospital, Newcastle	Regional	268	3 752.00	4	15 008.00
Inkosi Albert Luthuli Hospital	Central	77	1 078.00	13	14 014.00
Dundee Hospital	District	226	3 164.00	2	6 328.00
Nkonjeni Hospital, Mahlabathini	District	318	4 452.00	1	4 452.00
Christ the King Hospital, Ixopo	District	122	1 708.00	2	3 416.00
EG Usher Hospital, Kokstad	District	237	3 318.00	1	3 318.00
Edendale Hospital	Regional	11	154.00	11	1 694.00
St Apollinaris Hospital, Makholweni	District	120	1 680.00	1	1 680.00
Addington Hospital	Regional	84	1 176.00	1	1 176.00
Life Entabeni	Private	79	1 106.00	1	1 106.00
King Edward VII Hospital	Tertiary	79	1 106.00	1	1 106.00
St Augustine Netcare Hospital	Private	79	1 106.00	1	1 106.00
Clinic local	Clinic	10	140.00	3	420.00
Mediclinic Howick	Private	26	364.00	1	364.00
Northdale Hospital	District	5	70.00	5	350.00
Greys Pain Clinic	Clinic	5	70.00	1	70.00
Orthopaedic centre	Tertiary	5	70.00	1	70.00
St Anne's Netcare Hospital	Private	4	56.00	1	56.00
GP private *	Private	0	0.00	25	0.00
Greys Hospital *	Tertiary	0	0.00	31	0.00
Private transport *	Private	0	0.00	22	0.00
Unknown *	Private	0	0.00	30	0.00
Walk in *	Private	0	0.00	2	0.00
Sub-total running and fuel costs only				660	ZAR 1 132 642.00

Note: * Cost of transportation missing for 110 patients. It is unknown why a regional hospital with its own surgeons, for example in Newcastle, would need to send surgical cases to Greys Hospital.

Another hidden loss is that of medical personnel's loss of morale and loss of sense of purpose. The vast load of amputations has negative psychological consequences for surgeons since it is demoralising and energy draining to be removing limbs that cannot be salvaged, in the full knowledge that the amputation could have been prevented. Mental fatigue is experienced since staff feel that they are constantly 'swimming upstream'.

Table 2: Individual diagnostic imaging cost drivers

Imaging cost drivers	ZAR per investigation (2019 values)
Radiograph: chest	650
Radiograph: per lower limb	470
CT scan: pelvis un-contrasted	2 750
CT scan: pelvis pre- and post-contrast	7 200
CT scan: lower limbs to feet	6 200
CT angiogram: lower limb	13 000
Ultrasound: lower limb	1 300
Ultrasound: Doppler echo per lower limb	2 300

Hidden indirect socio-economic costs

In conducting a review of personal accident legal cases in which there was a loss of limb, loss descriptions are listed below and suggest a framework for future quantitative and qualitative investigations. A typical possible amount awarded in legal settlement for loss of limb in comparable personal injury cases is ZAR 5 million,[25] which does not factor in losses to society or to national fiscus.

Losses to the individual:

- Emotional aspects in addition to pain and suffering.[28]
- Loss of body image and body image dissatisfaction.[29,30]

Table 3: Summary of individual hospital cost driver formulae

Cost drivers	Formulae
Cost of EMS transportation	Total costs of EMS transportation as per Table 1
Cost of analgesia	ZAR 75 per day × number of days for the number of patients
Cost of antibiosis	ZAR 700 per day × number of days for the number of patients
Cost of imaging studies	ZAR costs as per drivers in Table 2 × applicable patients
Cost of laboratory tests	ZAR 2 650 per patient × number of patients
Cost of an operating theatre	Cost per minute (225 ZAR) × time (minutes)
Cost of surgical ICU	ZAR 18 000 per day × number of applicable days
Cost of acute/high care	ZAR 10 500 per day × number of applicable days
Cost of surgical ward stay	ZAR 3 800 per day × number of applicable days
Estimated ward stay on return to the referring facility	ZAR 3 800 per day × average 14 days × number of patients
Estimated postoperative physiotherapy at Greys Hospital	ZAR 325 per day × 6 047 ward days for 660 patients
Estimated physiotherapy/occupational therapy rehabilitation at the referring facility, including crutches	ZAR 325 average per day × 14 ward days for 660 patients
	ZAR 280 for a pair of crutches × 660 patients
Cost of (absent) podiatry care and ongoing assessment as per SEMDSA guidelines (in this case, all 660 were high-risk patients)	ZAR 614 every 3 months × 660 patients over the 5 years
Cost of (absent) podiatry orthotics/shoe modification to save the contralateral limb, prevent future ulceration	ZAR 3 600 per patient × 660 patients
Cost of prosthetic limbs, estimated for 50% of patients	ZAR 160 000 × 330 patients, plus ZAR 140 000 for revisions
Cost of mobility aids (wheelchair) for rehabilitation	ZAR 9 000 per wheelchair × 660 patients
Cost of qualified counselling	ZAR 508 per 60-minute session × 20 sessions × 660 patients

- Grief and anger, often directed inwards with changes in self-identity.[31]
- Loss of income due to loss of employment or decreased working life.
- Depression and the consequences of depression such as poor coping.[29]
- Lack of adequate readjustment.[28]
- Loss of perceived status to other individuals, stigma.[31]
- Loss of quality of life; home care often unaffordable.[28]
- Increased risk of second amputation.[32]
- Increased risk of earlier mortality.[32]
- Loss of trust in health care system.[27]

Losses to the family unit:

- Disruption of family life.[33]
- Financial and physical cost of home care.[33]
- Negative impact on family member who becomes caregiver.[33]
- Loss of income and quality of life.[34]

Table 4: Total ZAR costs for Greys Hospital as per cost driver formulae in Table 3

Greys Hospital – costs for 6 047 ward days, 660 amputations (five years 2013–2017)	Total ZAR at 2019 values
EMS patient transportation*	1 132 642
Analgesia (IV and oral)	453 525
Antibiosis (IV and oral)	4 232 900
Imaging studies	1 156 630
Laboratory tests	1 754 300
Operating theatre time (32 322 minutes)[†]	7 272 450
Cost of surgical ICU[₮]	15 264 000
Cost of acute/high care[₮]	18 354 000
Cost of surgical ward stay[₮]	11 924 400
Estimated cost of return stay at referring hospital (average 14 days)	35 112 000
Estimated cost of physiotherapy at Greys Hospital over total ward days	1 965 275
Estimated cost of physiotherapy/occupational therapy rehabilitation at referring facility	3 003 000
Cost of crutches for 660 patients	184 800
Estimated cost of podiatry treatment over 5 years for 660 patients (care not provided)[§]	**(8 104 800)**
Estimated cost of podiatric orthotics/shoe modifications (care not provided)[§]	**(2 376 000)**
Cost of wheelchairs for 660 patients	5 940 000
Cost of prosthetic limbs for 50% of patients	99 000 000
Estimated cost of counselling for 660 patients	6 705 600
Total Greys Hospital costs for 660 diabetes amputations[§] (excluding podiatry not provided)	213 455 522

Notes: *Transportation excludes costs of staffing, personal protective equipment (PPE), mobile and telecom communications, vehicle purchase/lease, vehicle depreciation, vehicle insurance, signwriting, training, medical liability insurance, medical equipment, medical equipment depreciation, medical consumables, security tracking, management overheads and any other aggregate costs. [†]Operating theatre cost excludes the cost of stock, consumables and staff remuneration. [₮]ICU, acute/high care and general ward stay duration are not indicative of actual needed days due to crowding and lack of beds; the patient is often transported after surgery back to a hospital ward at the referring facility. [§]Food, dietitian consultations, nursing consumables and all hospital staff remuneration is excluded, as is podiatry, which level of care was not provided.

- Psychological losses such as depression, hopelessness.[31]
- Anxiety, grief and suffering by family members.[35]
- Loss of trust and anger against healthcare system.[27]

Losses to society:

- Decreased working life.
- Loss of skills and knowledge.
- Cost of replacement skills training.
- Loss of production.
- Loss of mentorship capacity.
- Loss of continuity.
- Anger against healthcare system.[27]
- Loss of trust in healthcare system.[27]
- Early deaths.[32,36–38]

Losses to fiscus:

- Direct healthcare costs of amputation.
- Future healthcare costs.
- Increase in disability grants.

- Cost of replacement skills training.
- Loss of PAYE.
- Loss of taxable production.
- Loss of VAT on lost production.

Discussion

The quantum of ZAR 213.456 million (albeit incomplete) for 660 diabetic amputations and amputation-related surgeries at a single surgical and tertiary hospital unit in KwaZulu-Natal (between 2013 and 2017) is alarming. This represents an average (incomplete) hospital cost of ZAR 323,418 per diabetes-related amputation. If this figure is multiplied by the 1 231 diabetes-related amputations in 2014 as reported in 2015,[1] this brings the cost to ZAR 398 million in one year for KZN – on preventable lower limb complications of this non-infectious disease.

The possible indirect costs to individuals, society and the national fiscus are incalculable. Socio-economic costs include losses to the individual, to the family, the community, the economy and fiscus through lost production and lost taxation. Legal settlements in cases of personal injury from comparable lower limb loss are typically calculated in the region of ZAR 5 million each and this is only in respect of projected medical costs, loss of income, reduced life span, pain and suffering.[25] Legal settlement calculations do not take into consideration the loss to society or to fiscus that diabetes-related amputations cause.

Ignorance and neglect precede diabetes lower limb amputations. In 2019, a foot assessment study was carried out by a podiatrist researcher on a cohort of 301 patients attending the Edendale chronic outpatient diabetes clinic.[28] Patients expressed anger on discovering that an entire medical discipline exists to prevent foot complications in diabetes but is not available to them.[28] Their anger was directed at lack of care and information so that, 'if they had known earlier', complication outcomes may have been prevented.[28] A random survey of 18 community health centres in the Western Cape in 2008 found that only 11.3% of patients with diabetes had a recorded foot examination.[29] Five years later, a study in KZN reported that the recording of foot examinations in patient records was only 6%.[30] A further study in 2013 assessed the awareness and performance of prescribed diabetic foot care practices in a Gauteng Hospital.[31] It was found that not only were the practices inadequate, but 94% of patients had never been referred to or made use of a podiatrist. In 2016, a study set out to determine the awareness of diabetic foot disease among patients with type II diabetes mellitus at a regional hospital in Durban. It found that more than 90% of participants had not received any previous form of diabetic foot care education from any source.[32] Yet national guidelines for diabetes care are clear on the role of in-depth foot care to assess risk and direct the pathways of care to prevent amputations.[33]

Given the high mortality rate after amputations, there is a moral imperative to prevent amputations, not only because of the enormous one-way drain on finances but because the whole fabric of society is affected.

The psychological value to the patient of an immediate in-depth foot assessment, with identification of the at-risk foot, with foot care education, footwear examination and education, cannot be over-emphasized. Podiatrists, as specialised diabetic foot health practitioners, impart a medical identity and mission that promotes the importance of the feet in diabetes. While medical staff who treat diabetes according to national guidelines are aware of the value of podiatry, there remains an insufficient number of state health podiatry posts across KZN.

Currently, there are only two podiatry posts in state health in KZN for a registered diabetes population of close on 1.3 million patients. The authors of the 2015 audit postulated that at least 350 podiatrists were needed to assess and educate the numbers of diabetes state health patients in KZN.[1] As far back as 2005, it was highlighted that a major barrier to addressing the skills shortage of such practitioners is the lack of additional training institutions for podiatric medicine on the African continent.[34] This paper makes a further call for expanded training of the discipline of podiatric medicine at medical schools, particularly within KwaZulu-Natal where it is absent.

Podiatry as a discipline needs to be firmly positioned within the healthcare system in order to reduce the number of diabetes-related amputations. A recent systematic review and meta-analysis states that 'healthcare systems can expect a 39–56% amputation rate reduction after implementing a multidisciplinary amputation prevention programme that includes podiatry'. The costing exercise in this paper showed some ZAR 10 million that should have been used for podiatric care. Applying the percentages given by the systematic review and meta-analysis means that if podiatric care and devices had been implemented for the 660 patients in this study, 39% to 56% of the amputation costs of ZAR 213.456 million, i.e. between ZAR 83 million and ZAR 119 million, could have been saved for Pietermaritzburg alone.

By counting the rising numbers of diabetes-related amputations at a single hospital over a period of five years, and applying those data for the province, we have provided a gauge of what diabetes-related amputations mean in terms of annual costs to KZN and National Health. At a second level and compounding these costs are substantial possible socio-economic losses. The role of podiatrists within multidisciplinary diabetes teams is an evidence-based means of decreasing diabetes-related amputations.[35–46]

Author contributions

ATT conceptualised, conducted the literature reviews, converted data to code to perform data analysis and wrote the manuscript; JLB extracted and facilitated the raw clinical text data from the registry databases and provided insight into the state of surgical staff morale; VYK provided cost driver design and analysis framework; DLC provided pertinent stylistic edits and directional encouragement; CA supplied critical revision and approved the version to be published.

Disclosure statement – No potential conflict of interest was reported by the author(s).

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Received: 20-03-2020 Accepted: 10-06-2020