

Diabetes-related amputations in the public healthcare sector in KwaZulu-Natal: a five-year perspective. Are we winning?

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Background: Diabetes-related complications in the form of lower limb amputations (LLA) remain a major concern globally in the form of both human suffering and increased fiscal burden. Studies conducted in developed countries have demonstrated that the burden of diabetes-related amputations is on the decrease. These decreasing trends in developed countries provide an insight (a surrogate marker) into overall diabetes control achieved in these countries. Similar data from studies conducted in South Africa and Africa itself are scarce.

Methods: The data collected by Department of Health Information Systems (DHIS) for all patients with diabetes seen at public healthcare facilities within KwaZulu-Natal from 2013 to 2017 inclusive were assessed. The DHIS data element used for this study was 'diabetes-related amputations'. The location of the hospital was used to classify them as urban or rural. Data relating to type of housing, access to piped water, electricity and sanitation were obtained from the South African mid-year population estimates from 2016.

Results: This study demonstrated that a strong positive correlation existed between amputation rate and the increasing years of the study ($r = 0.70$). The trend in diabetes-related LLA in 5 of the 11 districts (45.45%) had an upward slope. The incidence of LLA was on an upward trend in urban compared with rural areas (slope 71.90 ± 26.75 vs 5.20 ± 10.04 , respectively). Positive slopes for LLA were noted in both regional and tertiary KwaZulu-Natal hospitals (48.00 ± 44.67 and 19.80 ± 36.38 respectively). The prevalence of diabetes-related LLA was associated with poor accessibility to adequate housing, piped water, electricity and sanitation. Each of these four variables independently had a significant effect on the prevalence of LLA within all districts in KwaZulu-Natal.

Conclusion: Diabetes-related LLA serves as a surrogate marker for overall diabetes control within a country. This study has shown that there was a strong positive correlation between amputation rates and time within KwaZulu-Natal. This finding serves as an indicator that only sub-optimal diabetes control is still being achieved.

Keywords: diabetes-related amputations, public healthcare sector, developing countries, sub-optimal diabetes control, KwaZulu-Natal, South Africa, urban versus rural

Introduction

Global studies have demonstrated that between 40% and 70% of all limb amputations are found in patients with diabetes mellitus (DM).¹ Studies conducted in South Africa also found that DM was a major determinant for non-traumatic amputations.^{2–4} One of the most devastating complications of diabetes is diabetic foot disease, which often leads to lower limb amputations (LLA) and is very common in developing countries.^{5–6} LLA in patients with DM often arise as a result of poor glycaemic control and/or peripheral neuropathy, infection and peripheral arterial disease.^{7–8} In Africa, foot complications in patients with diabetes often progress to infection or gangrene, which results in longer than expected hospitalisation and higher mortality rates.⁹ Peripheral neuropathy with associated infection and tissue destruction is a more common aetiology for amputations in Africa than peripheral vascular disease.¹⁰

Literature arising from some of the developed countries has shown that there is a decrease in DM-related LLA.^{11–14} This decrease was attributed to better foot management clinics and introduction of multidisciplinary diabetes clinics with improved patient education. Dunbar *et al.* stated that there is a paucity of data from South Africa regarding the prevalence

of DM-related amputations.⁴ Pillay *et al.* showed in their study conducted over a two-year period in KwaZulu-Natal, South Africa that there was a decline in amputation rates within the public healthcare sector (0.09% vs 0.05% in 2013 and 2014 respectively).¹⁵ This study now takes an in-depth look as to whether this decreasing trend is maintained within this public sector in KwaZulu-Natal over a five-year period. No study thus far conducted in South Africa has assessed the trends noted between the various districts of a province nor are there studies stratifying and assessing trends in amputation rates between district, regional and tertiary/quaternary institutions within a province of South Africa.

Methods

The province of KwaZulu-Natal is the second most populated province in South Africa and comprises 10 district municipalities and 1 metropolitan municipality. This descriptive study was a quantitative database review.¹⁶ Only one source of data was used, that is the District Health Information System (DHIS) data, which is the primary data collection system of the Department of Health in KwaZulu-Natal. The data are routinely collected at all public healthcare facilities in the province and are managed by the data management unit at the Department of

Health provincial head office. The data are aggregated per facility and no individual patient identifiers are used.

The following data elements are collected for diabetes at each healthcare facility:

- Number of new patients initiated on treatment;
- Number and age of new patients initiated on treatment at clinics versus hospitals;
- Number of laser surgeries performed at hospitals;
- Number and percentage of diabetes-related amputations;
- Number and percentage of defaulters.

The data collected by DHIS for all patients with diabetes seen at public healthcare facilities within the province of KwaZulu-Natal from 2013 to 2017 inclusive was requested from the Department of Health and interrogated to assess the above aims. The data element collected from the DHIS for this study was 'diabetes-related amputations'. The location of the hospital was classified as urban or rural. Urban areas encompassed urban and semi-urban settings while the term rural used in our study encompassed rural and semi-rural settings. Data relating to type of housing, access to piped water, electricity and sanitation was obtained from the South African mid-year population estimates from 2016.¹⁶ Amputation rates were calculated as the total number of amputations in a district divided by 100 000 population size.

Approval to utilise the data collected was obtained from both the Department of Health and the University of KwaZulu-Natal (UKZN) Biomedical Research and Ethics Committee (BREC 460/18).

Data collection and statistical analysis

Descriptive statistics (mean and standard deviation or median and interquartile range as appropriate) was used to describe the sample groups. Continuous variable group means were compared using unpaired t-tests for normally distributed data, otherwise non-parametric (Mann–Whitney U) methods will be used. A p-value of < 0.05 was regarded as statistically significant. A comparison in terms of the rates per 100 000 population size was done using the slopes test.

Results

Table 1 provides us with an overall description of the total number of amputations performed per year in KwaZulu-Natal over the five-year period.

Our study demonstrated that a strong positive correlation existed between amputation rate and increasing years of the study ($r = 0.70$) (Figure 1).

Table 2 and Figure 2 provide a description of the trends noted within each district within the province of KwaZulu-Natal. The trend of diabetes-related amputations within the Ugu district

Table 1: Total number of amputations, per 100 000 population, performed annually in KwaZulu-Natal (2013–2017)

Year				
2013 (Year 1)	2014 (Year 2)	2015 (Year 3)	2016 (Year 4)	2017 (Year 5)
90.69	106.74	125.01	131.33	113.83

has increased significantly over the five-year period. Although not statistically significant, the slopes of Amajuba, eThekweni, Utungulu and uMgungundlovu are positive, indicating that the trend is on the rise within these districts.

When the hospitals within each district are stratified into district versus regional versus tertiary/quaternary we notice that the slopes are positive in the regional and tertiary hospitals, indicating that there is an increase in the rates of diabetes-related amputations in these hospitals (see Table 3 and Figure 3).

Further sub-division of the hospitals into urban versus rural revealed that the slope was positive for both urban and rural settings (Table 4). The regression equation for urban amputations was $y = 71.9x + 1000.5$. This indicates that there was an upward trend for this group. The trend was not that significant for rural amputations (Figure 4).

Regression analysis was used to compare regions that had increases with those that had decreases in the amputation rates, with reference to the type of dwelling, accessibility to toilets, accessibility to piped water and accessibility to electricity.

Table 5 summarises the independent variable (regions that had an increase or decrease) (nominal variable) and the effect on dependent variables. All the partial eta square values exceed the minimum upper limit (of 0.120) for indicating a large effect. It therefore demonstrates that all four variables independently (type of housing, poor accessibility to piped water, electricity and sanitation) had a significant effect on the prevalence of amputation within all districts within KwaZulu-Natal.

Discussion

Diabetes-related complications in the form of lower limb amputations (LLA) remain a major concern globally in the form of both human suffering and increased financial burden on the fiscus. Studies conducted in developed countries have demonstrated that the burden of diabetes-related amputations is on the decrease.^{11–14} These decreasing trends in developed countries provide us with an insight (or act as a surrogate marker) into overall diabetes control achieved in these countries. Similar data from studies conducted in South Africa and Africa itself are scarce. This study aimed to demonstrate the trends in diabetes-related amputations within the province of KwaZulu-Natal—the second most populous province in South Africa.¹⁶

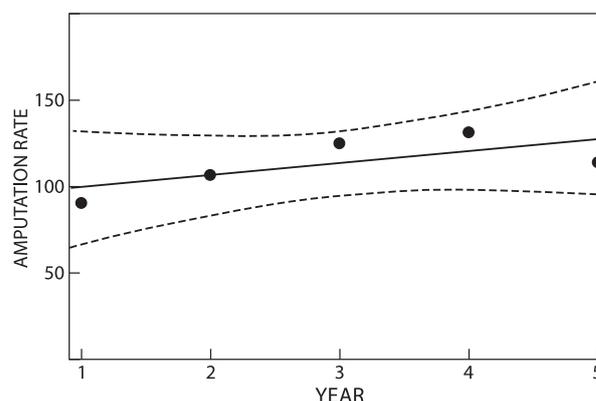
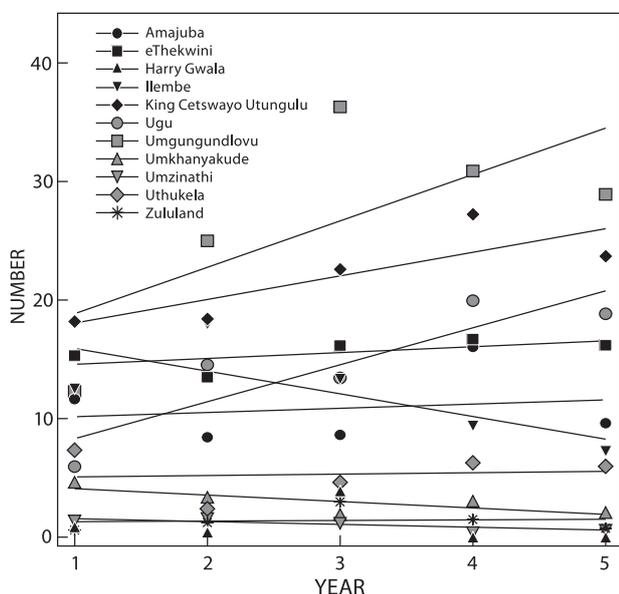


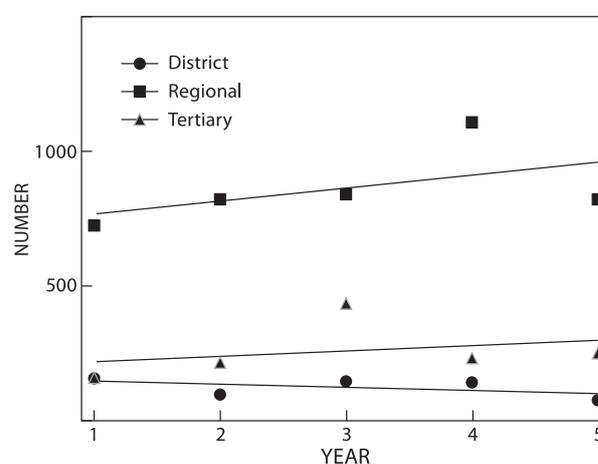
Figure 1: Correlation between amputation rate per 100 000 population and time period.

Table 2: Diabetes-related amputations per district of KwaZulu-Natal per 100 000 population

District	Year					Slope	p-value
	2013	2014	2015	2016	2017		
Amajuba	11.63	8.42	8.62	16.04	9.60	0.36 ± 1.14	0.77
eThekweni	15.31	13.48	16.15	16.70	16.18	0.50 ± 0.36	0.27
Harry Gwala	0.87	0.43	3.90	0	0	-0.22 ± 0.59	0.74
iLembe	12.52	17.96	13.35	9.39	7.25	-1.99 ± 1.00	0.15
Utungulu	18.18	18.40	22.59	27.22	23.69	1.98 ± 0.79	0.09
Ugu	5.95	14.53	13.43	19.93	18.82	3.11 ± 0.92	0.04
uMgungundlovu	12.28	24.96	36.26	30.85	28.89	3.91 ± 2.39	0.20
uMkhanyakude	4.63	3.36	1.92	3.04	2.08	-0.54 ± 0.25	0.12
uMzinyathi	1.37	1.57	1.17	0.39	0.59	-0.27 ± 0.1	0.07
uThukela	7.33	2.39	4.63	6.28	5.98	0.12 ± 0.69	0.87
Zululand	0.62	1.24	2.99	1.49	0.75	0.05 ± 0.34	0.89

**Figure 2:** Graphical depiction of trends in diabetes-related amputations over a five-year period.

Overall, we have shown that the total amputation rates increased over the five-year period within the province of KwaZulu-Natal. In addition, we found that the trend in diabetes-related LLA in 5 of the 11 districts (45.45%) had an upward slope. This was an expected finding in a country like South Africa as studies conducted in both South Africa and other developing countries have demonstrated sub-optimal diabetes control.^{8-9,17} Poor glycaemic control increases the risk of developing diabetes-related complications including LLA. South Africa is grappling with the effects of both communicable diseases like HIV, TB and non-communicable diseases like DM. Importantly in South Africa, it must also be noted that there is a general lack of access by patients to a multidisciplinary foot-care team with limited access to screening for problems in feet. Integral to this is a scarcity of podiatrists within the public healthcare sector. Much effort in terms of health policy, infrastructure and research has been implemented by government to help curb the effects of HIV and TB. Studies like ours now provide evidence of the increased burden of diabetes coupled with LLA and serve to reinforce that diabetes and its

**Figure 3:** Graphical depiction of trends of diabetes-related amputations within district versus regional versus tertiary hospitals in KwaZulu-Natal over a five-year period.

complications pose an ever-present danger to both our patient population and the economy of the country as a whole.

Interestingly, we noted that there was a decrease and/or no statistical increase in diabetes-related amputation rate in the other six districts of KwaZulu-Natal (55.55%). In a resource-limited developing country like South Africa where optimal control of diabetes is not readily achievable this finding might probably be multifactorial in aetiology. Literature from various studies conducted in Africa indicate that African patients often present to hospital only after the onset of gangrene or late sepsis that might be resistant to antibiotics, fluids and insulin, culminating in systemic infection which increases risk of mortality prior to amputation.^{8-9,18-19} The long distances that patients in Africa must travel to access adequate healthcare is another hindrance to patients presenting early enough for amputation.

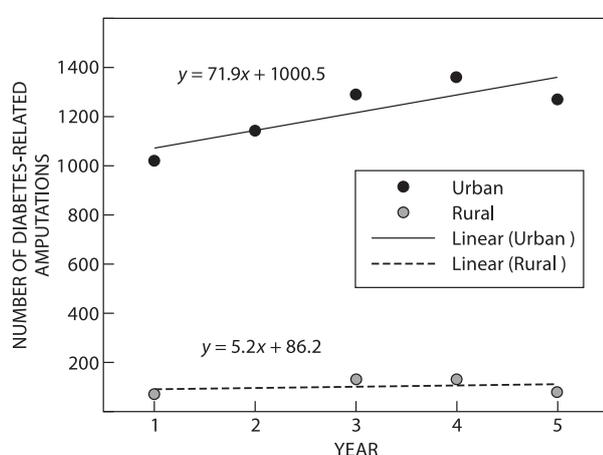
The incidence of LLA is on an upward trend in urban when compared with rural areas. Here again, this trend could be present as many patients in rural areas who must travel long distances to seek healthcare do not seek appropriate health care or present too late for the limb to be salvaged. Another plausible reason for this noted trend is that the medical condition of

Table 3: Diabetes-related amputations per 100 000 population stratified according to district versus regional versus tertiary hospitals

Classification of hospital	Year					Slope	p-value
	2013	2014	2015	2016	2017		
District	157	97	146	142	76	-11.70 ± 10.89	0.36
Regional	725	822	841	1108	822	48.00 ± 44.67	0.36
Tertiary/quaternary	159	216	435	232	250	19.80 ± 36.38	0.62

Table 4: Urban versus rural diabetes-related amputations within KwaZulu-Natal over a five-year period

Location of hospital	Year					Slope	p-value
	2013	2014	2015	2016	2017		
Urban	1020	1141	1290	1360	1270	71.90 ± 26.75	0.07
Rural	72	94	132	132	79	5.20 ± 10.04	0.64

**Figure 4:** Graphic depiction of trends noted between urban versus rural.**Table 5:** Effect of housing, accessibility to toilets, piped water and electricity on amputation rates

Dependent variable (scale variable)	Partial eta square
Type of housing (formal vs informal)	0.301
Poor accessibility to toilets	0.259
Poor accessibility to piped water	0.678
Poor accessibility to electricity	0.490

patients who present with uncontrolled diabetes and requiring LLA are classified as critically ill and need to be transferred to institutions situated in urban areas for more specialised care.

Also demonstrated in our study is that the bulk of the burden of diabetes-related LLA seems to be situated in regional and tertiary hospitals within KwaZulu-Natal. This reiterates the previous statement that the possibility exists that patients requiring LLA are transferred to regional and tertiary healthcare institutions due to severity of their condition. The trend of LLA at both regional and tertiary healthcare level is on an upward trajectory. Government needs to heed the results of such studies in terms of maintaining adequate infrastructure in the form of both staffing and equipment at this level of health care.

Boulton *et al.*²⁰ had previously described that the prevalence of diabetes-related amputations in developing countries is

associated with poor access to basic amenities. Our study demonstrated similar findings in that the prevalence of diabetes-related amputations was associated with poor accessibility to adequate housing, piped water, electricity and sanitation. KwaZulu-Natal is the second most populated province in South Africa with an unemployment rate higher than the overall rate in the country (33% vs 29.80%).¹⁶ This fact coupled with the poor access to basic amenities and the high prevalence of infectious diseases in the form of HIV and TB in the province is placing a huge burden on the prevalence of optimal control of diabetes and negative outcomes like LLA.

LLA place an enormous burden on the patient in terms of both overall health and economic productivity. Much emphasis must be placed on preventing and delaying LLA. Within the context of diabetes mellitus this requires improved control. This improved control requires input from both the individual patient and the government of the country. Patients need to assume ownership of their medical condition while government needs to improve service delivery in all aspects of diabetes care, most notably in this circumstance to increase patient foot education and the presence of more podiatrists within the province and the country. Global studies have demonstrated that the introduction of specialised foot clinics and ongoing patient foot education have contributed to the decrease in the overall amputation rates.¹¹⁻¹⁴ In order for us to follow these examples of decreased LLA rates, government needs to invest in increased patient foot education and training and deployment of podiatrists to areas of need.

Conclusion

As mentioned earlier, diabetes-related LLA serve as a surrogate marker for overall diabetes control within a country. We have shown that there was a strong positive correlation between amputation rates and time within KwaZulu-Natal. This finding serves as an indicator that we are still achieving sub-optimal diabetes control. Within KwaZulu-Natal we found some districts that showed an increased trend whilst others demonstrated a downward slope in LLA rates. We have therefore provided possible aetiologies for both trends.

The general trend of diabetes-related LLA within KwaZulu-Natal has shown us that we are still a long way from winning this battle—a battle that requires urgent intervention both at patient and government levels if we are ever to reach trends noted in developed countries.

Limitations of study

The DHIS data element made no differentiation between major and minor diabetes-related LLA.

Potential lack of accuracy of data collected by each healthcare facility remains a limitation of a study of this nature.

Disclosure statement – No potential conflict of interest was reported by the authors.

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