

Progress in diabetes care in the KwaZulu-Natal public health sector: a decade of analysis

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Aims: This study analysed diabetes-related information routinely collected by the KwaZulu-Natal (KZN) Department of Health (DOH).

Methods: Primary data were obtained for all public health facilities through the District Health Information System (DHIS) for the period 2006–2016 inclusive (11 years). Additional open source data on population estimates were obtained from Statistics South Africa. Quantitative analysis of DHIS data was performed using Microsoft Excel before graphical representations were generated using the ThinkCell software.

Results: The number of clinical visits by diabetic patients in KZN increased by 305% in the 10 years between 2006 and 2015. According to the data collected by the Department of Health, a large majority of patients diagnosed with diabetes are seeking medical care in the more populated district of eThekweni. The number of patients not returning for scheduled treatment (defaulters) has reduced since recording began in 2012. According to the data, the incidence of diabetes in KZN is oscillating; however, a strong correlation is found between incidence and patient screening.

Conclusion: The largest number of diabetic patients were seen in the highly urbanised district of eThekweni. The screening of high-risk patients has increased in frequency and exhibits strong correlations with incidence, further supporting the effectiveness of screening and its inclusion in a new primary healthcare protocol. There was a sharp reduction in number of defaulting patients in 2016, probably indicating improved compliance. The inconsistency of data input is a limitation of the study. However, this study within these constraints highlights the importance of 'big data' for healthcare policy and more effective health care in KZN.

Keywords: diabetes, district health information system, incidence, KwaZulu-Natal, non-communicable diseases, urbanisation

Introduction

Diabetes mellitus has become a common and costly disease, extending its reach worldwide.¹ In 2017, the global prevalence of the disease increased to 8.8%, translating to 424.9 million patients.² Despite the use of the most recent and high-quality data, most of the predictive estimations made by either authoritative bodies or independent researchers have been surpassed.³

The continent of Africa is expected to see the highest increase in the prevalence of diabetes, a projected 156% by the year 2045.² This surge in prevalence has been associated with urbanisation; however, many other predisposing factors exist within the unique African setting.³ These include the compounded effects of poverty, unplanned and unmanaged population growth and competing burdens of HIV and tuberculosis (TB), resulting in numerous interactions between infectious and non-communicable diseases.^{3–5}

An HIV-positive patient is twice as likely to develop diabetes, which in turn triples the risk of developing TB.⁶ In addition, Africa is home to the largest undiagnosed diabetic population. A recent study estimated the undiagnosed diabetic population in an African country to be as high as 62%.⁷ These patients are unknowingly at risk and often develop painful complications. These crippling factors, i.e. HIV/TB interaction with diabetes and the undiagnosed population, have manifested throughout the African continent, creating immense pressure for government welfare efforts and economic reforms.

A considerable amount of research has explored the burden of diabetes, unearthing quality evidence to guide policy and budget changes. A large majority of these studies utilise data from high-income countries and few can be adjusted to understand the unique settings of the developing world.^{2,3,7} A recent study revealed that the economic and human impact of diabetes is greater in developing countries.⁷

Within South Africa (SA), there has been a heightened awareness of the rising diabetes pandemic. The recently implemented sugar tax employed by the government is congruent with goals set by the World Health Organization to reduce obesity and its related consequences.⁸ According to the 2018 South African National budget report, revenue generated from the additional tax on sugary drinks has been landmarked for health promotion and media campaigns to more effectively manage the burden of non-communicable diseases including diabetes.⁹

The province of KwaZulu-Natal (KZN) has recently been highlighted for its high-risk population.^{10,11} This study analyses diabetes-related information routinely collected by the KZN Department of Health (DOH) over the last decade. Such an analysis would provide a richer understanding of diabetes from a South African perspective. In addition, the research could inform resource allocation, healthcare protocol, policy construction and reduce the disease burden of diabetes.

Table 1: Department of Health data fields used

Data collection field	Years of collection
Diabetes patient—new	2006–2016
Diabetes patients on register	2006–2016
Diabetes patients screened	2014–2016
Diabetes defaulters	2012–2016

Method

This quantitative study was designed as a descriptive approach to the DOH database, the District Health Information System (DHIS). The DHIS stores standardised clinical and healthcare data from each district in South Africa that are collected by allocated healthcare workers. No patient identifiers are collected, therefore anonymity in this primary data analysis is maintained. All diabetes-related data between January 1, 2006 and December 31, 2016 inclusive were requested and analysed under ethical approval from the University of KwaZulu-Natal (HSS/1835/017D) and the KwaZulu-Natal Department of Health (470/17). Data detailing population statistics were requested from Statistics South Africa.

Data were analysed using Microsoft Excel (2016; Microsoft Corp, Redmond, WA, USA). Pivot tables were used to redesign and structure the raw data after cleaning. Graphics were generated using ThinkCell, version 6 software (<https://www.think-cell.com/en/>).

Diabetes-related data requested from the KZN Department of Health involved specific data collection fields. Collection commencement dates vary as illustrated in Table 1.

A time series analysis was done to visualise the rates and trends in diabetes within the public sector.

The 2016 'Diabetes patient on register' (DPOR) records had missing information in 76 collection fields in the secondary data sheet. Hence 2016 was therefore excluded from the analysis so as not to skew the results. The analysis period for the collection field DPOR (number per district) is thus 2006–2015. In addition, the years 2010 and 2011 presented with 16 and 12 missing data entries respectively. Considering the scarcity of missing fields, as well as their central position within our study period, 2010 and 2011 data were statistically adjusted

by calculating the compound annual growth rate (CAGR) for a more accurate result. The graphical representation of the data in Figure 1 presents the results of the data analysis in raw form (i.e. it includes the missing data entries in years 2010 and 2011). A comparative (extrapolation) based on the actual numbers preceding and following the years with missing data points was used to present a comparison for what the intrinsic number of patient visits may have been during the period. The extrapolation is calculated by taking the CAGR between 2009 and 2012. Hence the extrapolation presents a postulation for what the actual number of patients could have been during 2009 and 2012 using the following formula:

$$\text{CAGR} = \left(\frac{\text{ENDING VALUE}}{\text{START VALUE}} \right)^{1/\text{number of intervals}} - 1$$

A three-year average of the field DPOR was used to determine the distribution of clinical visits by diabetic patients to limit the impact of extrinsic factors such as migration, urbanisation and intrinsic factors such as data capture errors.

Results

Data collection fields specific to diabetes have been modified since 2006. The collection field of DPOR has remained constant and refers to the number of patients seen at the respective healthcare facilities that have an existing diagnosis of diabetes. Due to the lack of patient identifiers, patients are counted at every visit. Therefore, this field can be most accurately described as a count of the number of clinical visits by diabetic patients, recorded for each year per district.

DPOR data for the year 2016 were excluded due to multiple missing data fields. Table 2 depicts the number of missing data entries for the DPOR collection field.

Figure 1 displays the provincial pattern of clinical visits by diabetic patients between the years 2006 and 2015.

As noted above, the number of visits to public healthcare facilities by diabetic patients is seen to rise with the exception of years 2010 and 2011. As these data points present with missing fields, the annual growth rate was used to extrapolate the results.

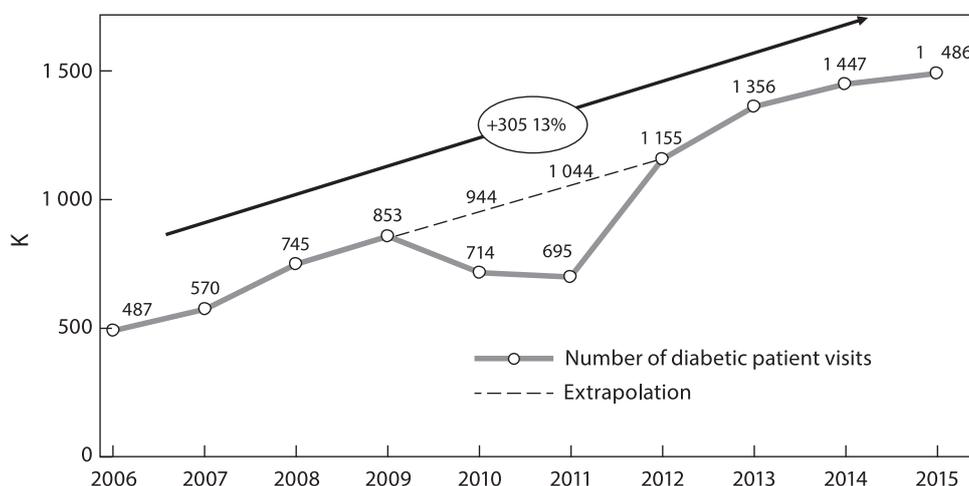
**Figure 1:** Number of clinical visits by diabetic patients in KZN (2006–2015).

Table 2: Number of missing data values (DPOR)

Year	Number of 'patients on register' entries with no value provided
2006	0
2007	0
2008	0
2009	0
2010	16
2011	12
2012	0
2013	0
2014	0
2015	0
2016	76

Figures 2 and 3 illustrate the number of DPOR by district, for the years 2006–2010 and 2011–2015 respectively. While Figure 1 demonstrated the overall pattern seen during the 10-year period, Figures 2 and 3 provide detailed insight into the distribution of clinical visits by diabetic patients within each district.

Figure 2 depicts a steady increase in the number of visits to public healthcare facilities by patients diagnosed with diabetes until 2009.

A proportional display of the true distribution of DPOR was determined from a three-year average (2014–2016), as seen in Figure 4. Data from the most recent three years were used to determine a more accurate illustration of the distribution of DPOR.

The results of the percentage calculation displayed in the above illustration are not based on the South African national or district population. These figures are intended to present a more

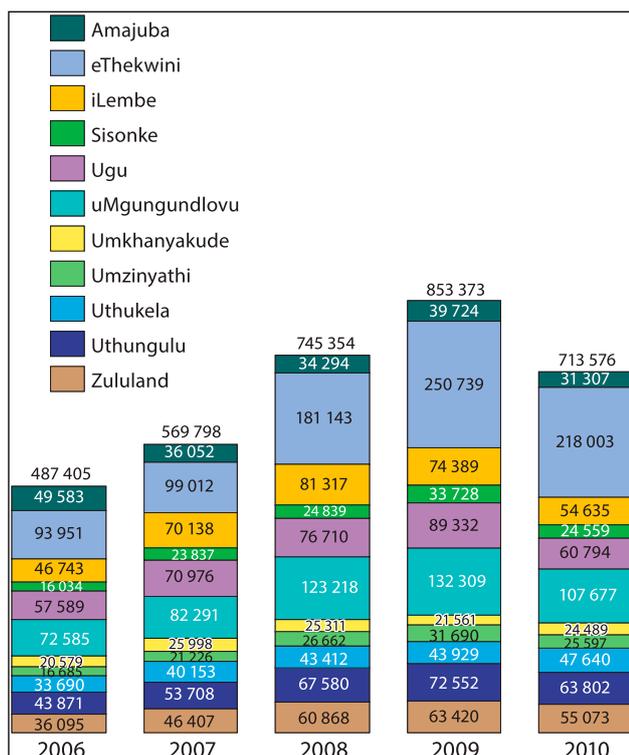


Figure 2: Distribution of diabetes-related consultations by district (2006–2010).

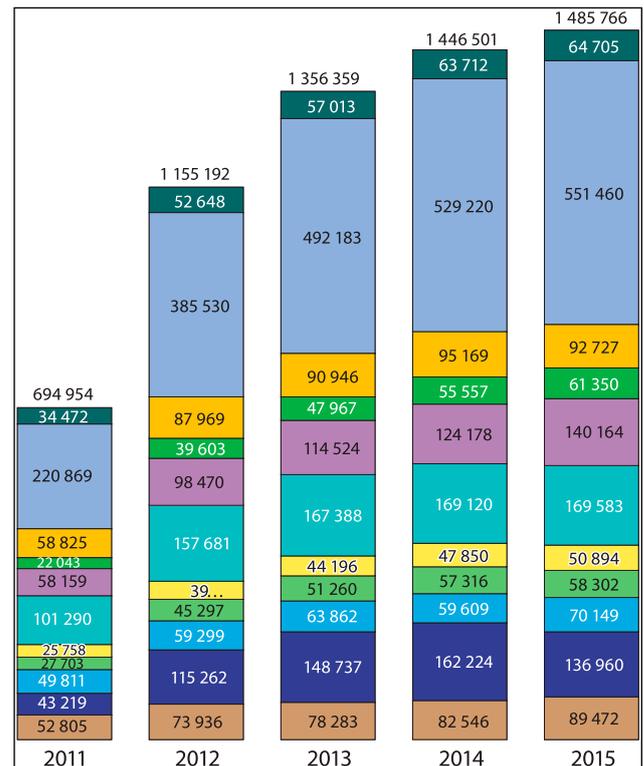


Figure 3: Distribution of diabetes-related consultations by district (2011–2015).

balanced view of the proportional distribution of the DPOR field or the number of diabetic patient visits among the districts of the KwaZulu-Natal province.

The normalised distribution, calculated by district, ranged from 3.37% (Umkhanyakude) to 36.68% (eThekweni).

To determine the change in distribution, data from 2006 and 2015 were isolated and are represented in Figure 5 below.

Figure 5 shows the 10-year change in the proportional distribution of DPOR. The district of eThekweni has seen the biggest change (51%).

The number of new diabetic patients recorded by the DHIS is informed by the data collection field 'Diabetes patient—New'. This field is a count of the number of patients newly diagnosed by a registered medical practitioner according to prescribed clinical criteria. As seen in Figure 6, the number of newly diagnosed diabetics in KZN reduced by 7% between 2006 and 2012 and then increased by 5% until 2016.

Considering that a newly diagnosed diabetic patient is only recorded once, the incidence of diabetes could be determined. The incidence rate is displayed per 10 000 people to enable the comparison of whole numbers in Figure 7.

The incidence of diabetes is seen to fluctuate between 2006 and 2016. The district of uMgungundlovu is seen to have the highest incidence of diabetes in the year 2008 (137 per 10 000 people).

Since 2015, the data collection field of 'Client screened for diabetes' has been collected. This field records those who are not on treatment for diabetes but have been screened in either a public health clinic or hospital outpatient department.

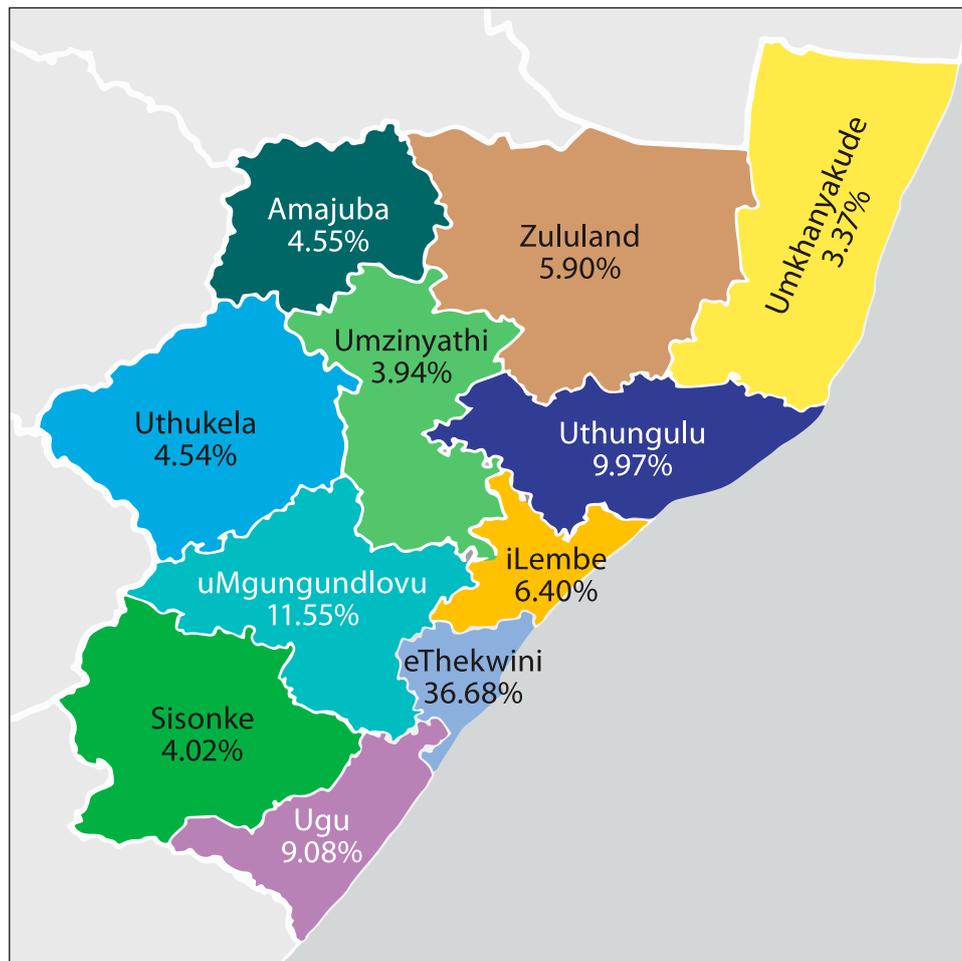


Figure 4: Map showing average distribution (2014–2016) of diabetic patient visits to public healthcare facilities in the public health sector of KZN.

As seen in [Figure 8](#), each district displayed an increase (84%–274%) in the number of patients screened for diabetes from 2015 to 2016. The district of eThekweni was seen to have the highest total count of more than 2 million patients screened for diabetes in the public sector for the year 2016 from the total district population of 3 665 197.

Correlation coefficients to determine whether screening had any effect on the number of new patients diagnosed were carried out and are displayed in [Table 3](#).

The correlation coefficient is statistically significant at a 90% confidence interval ($p = 0.08$).

Since 2012, the data collection field ‘Diabetes mellitus—defaulters’ has been collected by the DHIS. This field records the number of diabetic patients who have defaulted on subsequent scheduled appointments. A patient is recorded as a ‘Defaulter’ when he/she does not return for the next scheduled visit.

[Figure 9](#) shows a reduction in the number of defaulting diabetic patients in KZN. The lowest total of 11 898 was recorded for the year 2016.

The strength of the relationship between patients defaulting on treatment and mortality data from Statistics SA¹² was tested using a correlation coefficient. Although a strong positive relationship was found, it was not statistically significant using a 90% confidence interval. Further research may be beneficial

in understanding this relationship over a longer period and across a wider geographic cross-section. Defaulters’ data from the year 2015 and corresponding mortality data released by Statistics South Africa were used for the calculation, with the result is displayed in [Table 4](#).¹²

To determine whether the newly implemented screening procedure had affected patient compliance regarding follow-up appointments, the latest values (2016) of screening and defaulters (the measure of non-compliance) were correlated and are displayed in [Table 5](#). Although a strong negative relationship was found, it was not statistically significant ($p < 0.5$).

Discussion

Outcome 1: challenges with big data

According to the information as collected by the DHIS, the frequency of clinical visits by diabetic patients found by analysing the collection field ‘Diabetes patients on register’ (DPOR) was seen to fluctuate between the years 2006 and 2016. The original data revealed three low points in the years 2010, 2011 and 2016. Upon inspection of the raw data, present in the unit of whole numbers, these years are found to have the only missing data entries as seen in [Table 2](#).

Missing data entries are not uncommon and are likely to be attributable to human error during data collection, recording or translation.^{11,13} A study done to assess the District Health Information System in KZN found similar inconsistencies, with

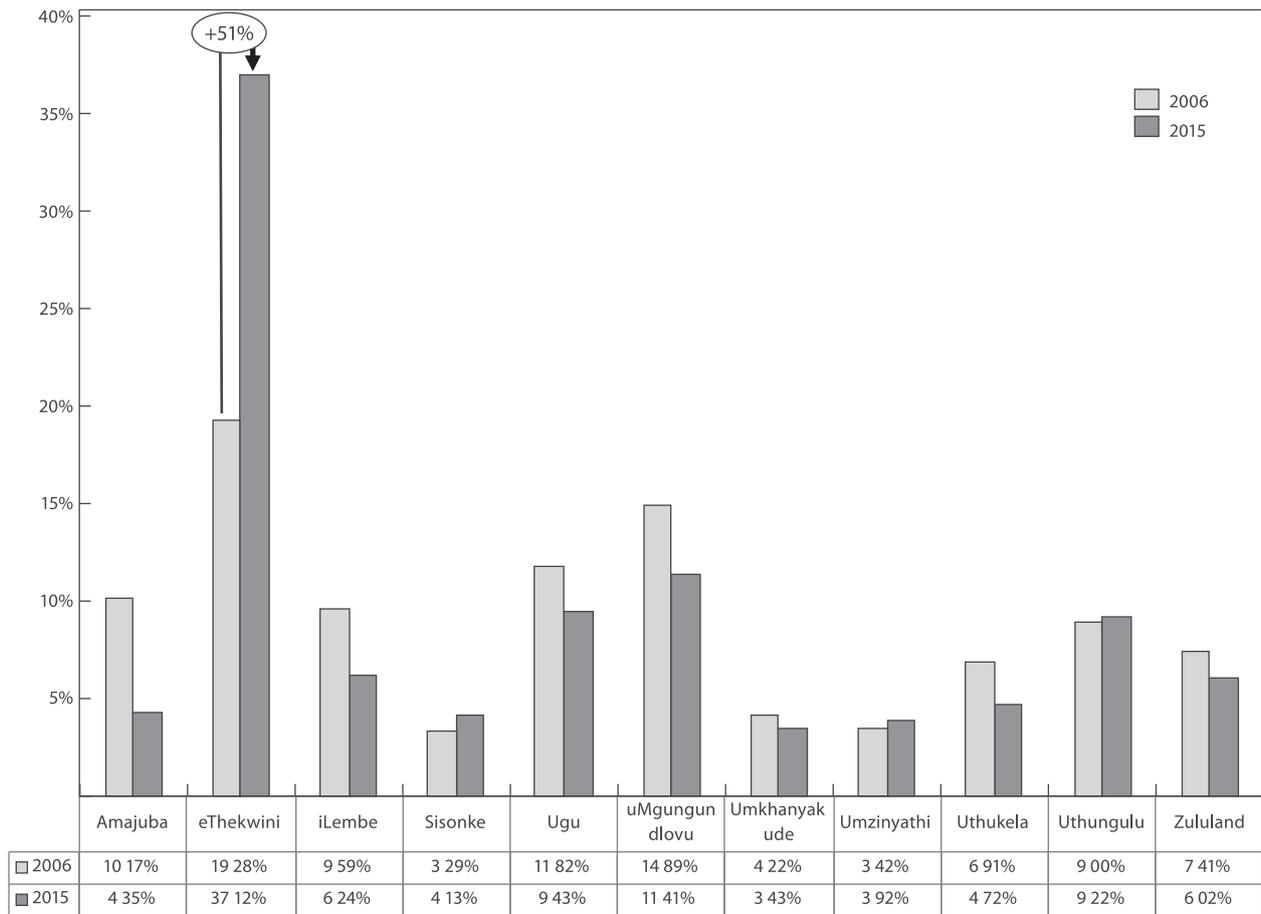


Figure 5: Change in distribution from 2006 to 2015.

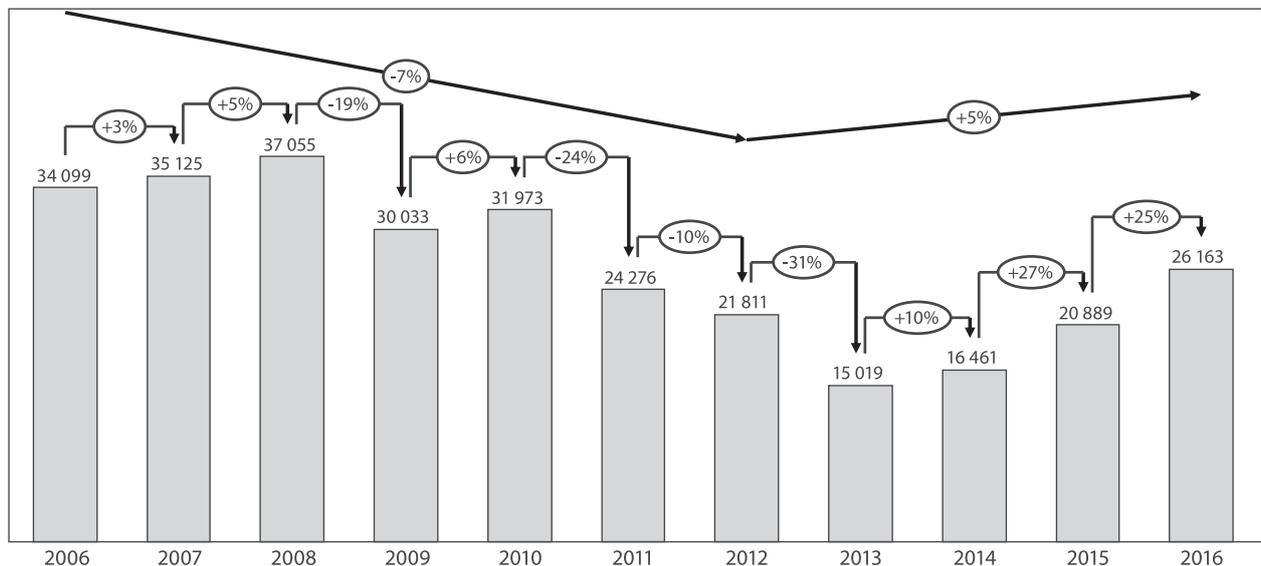


Figure 6: Number of newly diagnosed diabetics in the KZN public health sector (2006–2016).

special mention of missing data. It was found that due to a high perceived work burden, little analysis and poor feedback, 2.5% of data values of the sample data analysed by the study¹³ was missing and 25% fell outside the expected ranges with no explanation provided.¹³

previously too complex to manage. Administratively, this could be used by various stakeholders for the planning and management of health services. Clinically, big data can be used to support the practice of evidence-based medicine promoting more structured, outcome-based practice.^{14,15}

The digitalisation of data collection within the healthcare industry allows for more rigorous analysis of big data, which were

It can be assumed that the ‘low points’ identified in this study do not represent an accurate picture of the state of diabetes in

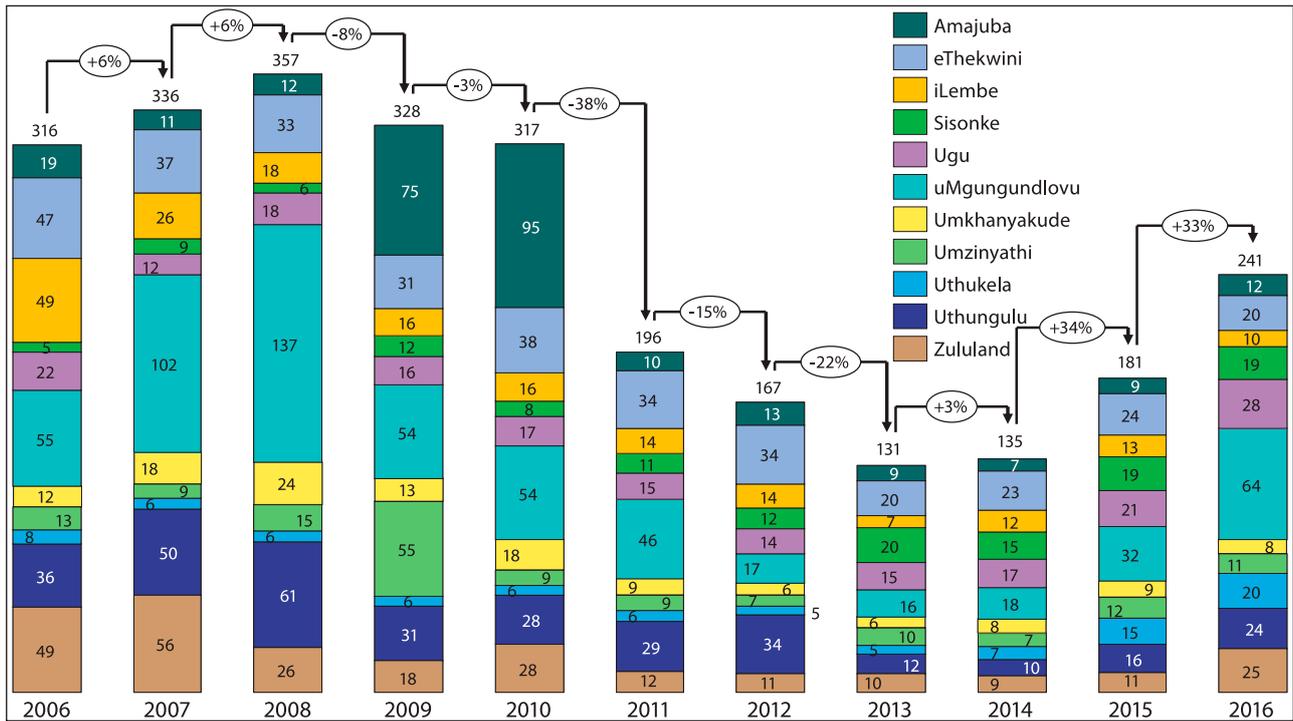


Figure 7: Diabetes incidence rate timeline by district (2006–2016).

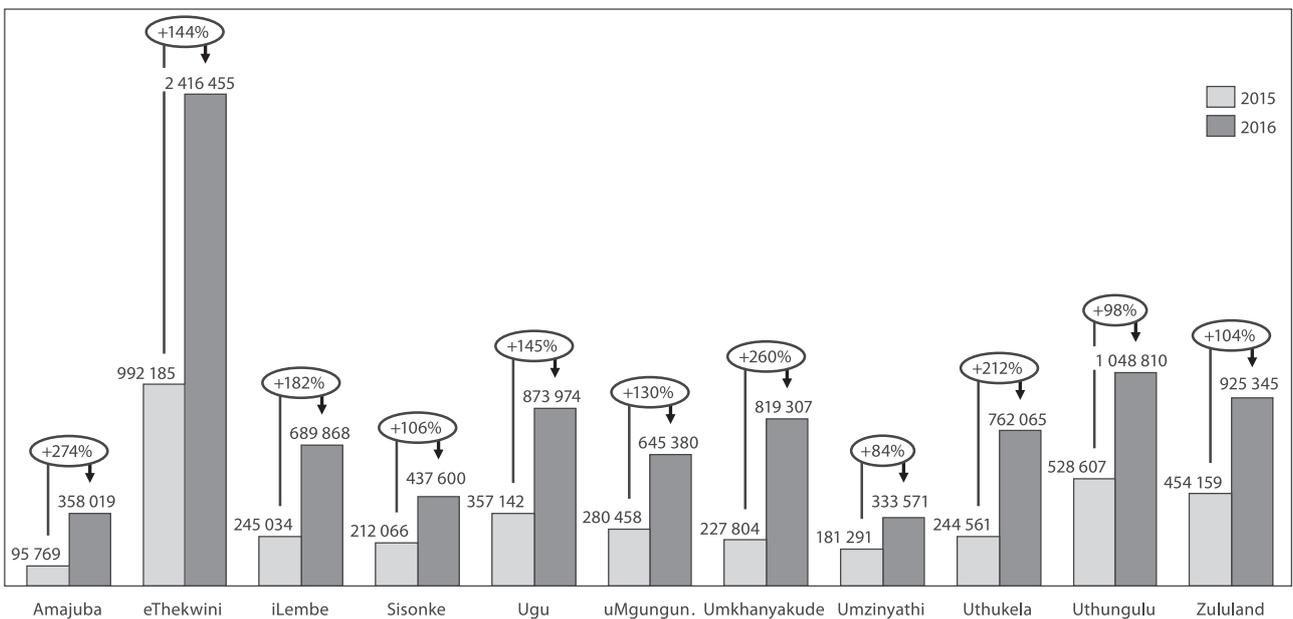


Figure 8: Number of patients screened for diabetes by district (2015–2016).

Table 3: Correlation between number of new patients and patients screened (2015–2016)

Correlation	Value	
	2015	2016
Number of new patients and number of patients screened	0.86	0.67
Result	A very strong positive relationship	A moderately strong positive relationship

KZN due to the missing data and a stark variation from multiple literature sources on the subject.^{2,14} It is for this reason that data from the year 2016 were excluded. Considering their centralised position in the study period, the annual growth rate was used to extrapolate the results and accommodate the missing data in the years 2010 and 2011. The data were extrapolated using the CAGR formula as explained in the Methodology section.

Results depicting this modification, together with those based on original data, can be seen in Figure 1.

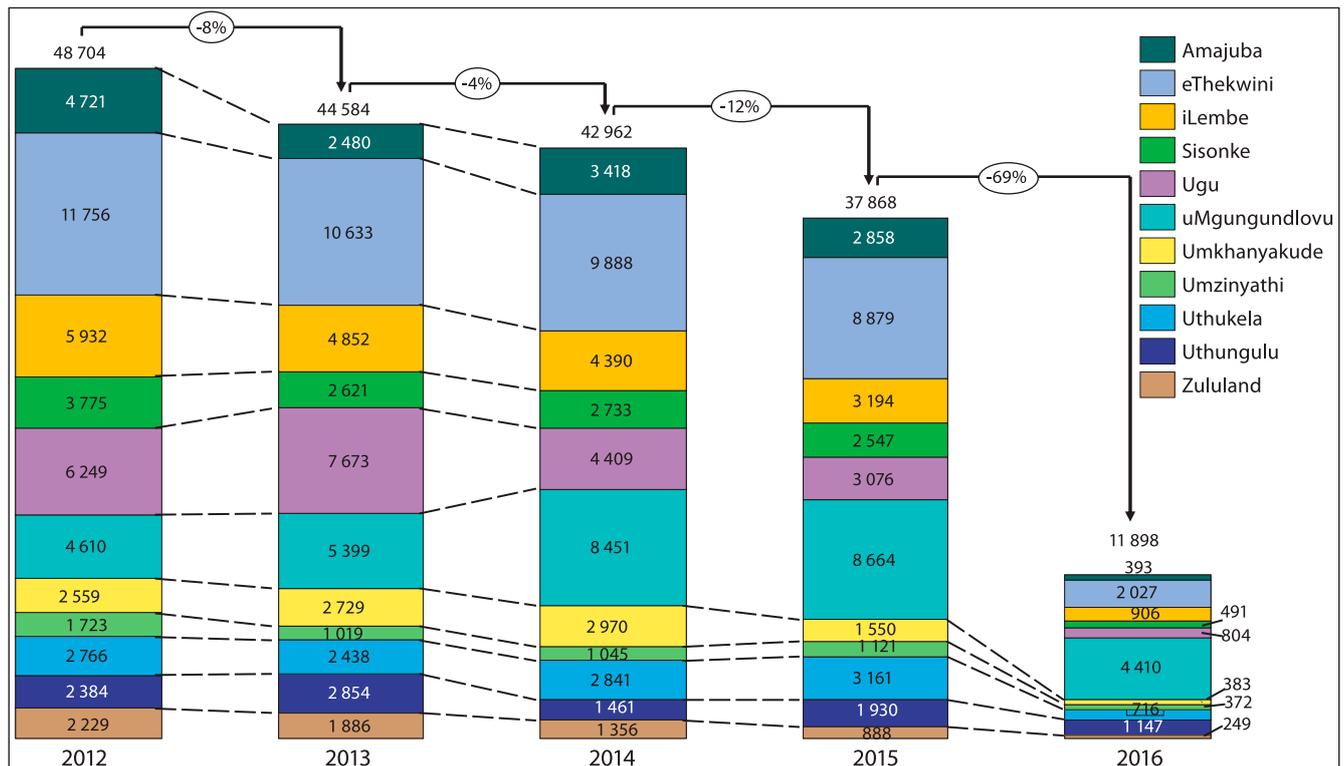


Figure 9: Five-year distribution of defaulting diabetic patients in the districts of KZN (2012–2016).

Table 4: Correlation coefficients of diabetes mortality and defaulters

Correlation	Value	Result
Diabetes mortality rate and Defaulters	0.73	A strong positive relationship

Table 5: Correlation coefficients of patients screened and defaulters

Correlation	Value	Result
Number of patients screened (2016) and defaulters (2016)	0.25	A strong negative relationship

Outcome 2: more diabetics seeking medical care

According to the adjusted data seen in Figure 1, there is a constant annual increase in the number of clinical visits by diabetic patients in KZN. An increase of 305% is seen in the 10-year period studied (2006–2015). This finding is congruent with reliable research reporting a steady increase in the number of diabetic patients and a corresponding increase in related medical visits.^{2,14}

Diabetic patients access healthcare services more often, resulting in more sick days, reduced productivity and increased healthcare expenditure.^{2,14} In one study done in the United States, patients with diabetes have been found to spend 2.5 times more on medical care than patients without the disease.¹ These compounding factors are exacerbated in developing countries because of the rapid transitions that accompany urbanisation.^{3,7} Many studies have reported a higher prevalence of diabetes within the more urbanised areas of South Africa.^{4,11}

Outcome 3: the strong link between urbanisation and diabetes

To better understand the geographical pattern of clinical visits by diabetic patients, the data as collected from the DOH and

without alteration were redesigned and are displayed in Figures 2 and 3. These figures highlight the highly urbanised districts of eThekweni and uMgungundlovu as high-risk. The well-established link between diabetes and urbanisation within an African setting is further evidenced by Figure 4, a display of the proportional distribution of DPOR. For this calculation, a three-year average was used to give a more balanced result and reduce the effect of extrinsic factors that could be attributed to data inconsistencies as seen with the DPOR field for the years 2010 and 2011.

The district of eThekweni is seen to have the highest proportion of DPOR (36.68%). This translates to more than one-third of all diabetes-related consultations in KZN occurring in eThekweni. Of the 11 districts in KZN, eThekweni is highly urbanised, the most densely populated, has the smallest geographical area and is the only district in KZN to fall within the fifth (highest) socioeconomic quintile.^{11,16} This measurement was explored in the 2007 South African Index of Multiple Deprivation (SAIMD) study released by the South African Department of Social Development, by Gemma Wright and Michael Noble.¹¹ According to this study, all KZN districts other than eThekweni have low (between 1 and 3) socioeconomic quintiles, with '1' being the least deprived and understood as the least urbanised.

The districts of uMgungundlovu and uThungulu present with the second and third highest proportions, between 10% and 12%. These areas have been highlighted as major districts as they contain major cities and large populations.¹⁷

To better understand the change in the geographical pattern of DPOR, the distributions of 2006 and 2015 were compared (Figure 5). The most significant observation shows a 51% cumulative increase in the number of DPOR in eThekweni over 10 years.

Cities within Africa have undergone dynamic development. eThekweni has both a fast-growing population and heavy immigration from rural areas.¹⁸ The overall population is expected to increase by 30% over the next 20 years, bringing with it a high burden of lifestyle diseases such as diabetes.¹⁸ This exponential growth pattern should be considered when allocating resources to manage the predicted surge in non-communicable diseases.

Outcome 4: inconsistent diabetes incidence rate

While incidence has been reported to have decreased in a few high-income countries, cities of low- and middle-income countries are predicted to have the most prominent increase in diabetes.² Data recording the number of new patients diagnosed in KZN have been consistently collected by the DHIS and are represented in Figure 6. As patients can only be diagnosed once and according to specific clinical criteria, this information was used to calculate the incidence of diabetes (see Figure 7). According to these data, the number of new patients and corresponding incidence is seen to fluctuate between 2006 and 2016.

This finding is inconsistent with literature that depicts a steady increase in the incidence of diabetes in Africa.^{2,11,19} The incidence of diabetes calculated in an earlier study examining data during a five-year period (2010–2014) depicted a similar irregular pattern.¹⁴ It is hypothesised that capture errors, misinterpretations and missing data during primary data collection may have resulted in an inaccurate representation of diabetes in KZN during the study period.¹¹

Outcome 5: an increase in diabetes screening and its positive effect on incidence rate

Diabetic screening and subsequent early diagnosis are recommended by the IDF as this has been shown to reduce the rate of harmful complications.² Since 2015, public health facilities in KZN have initiated the recording of patients screened for diabetes. According to the data as represented in Figure 8, the number of patients screened in 2016 increased by 80–260% in various districts. Table 2 shows the strong positive correlation coefficients found between the arrays of new patients and those who have been screened. These imply that more patients are identified in response to screening, reducing the large undiagnosed population.²

This result supports the well-documented importance of diabetic screening in improving diagnosis time and reducing the avoidable complications of uncontrolled glucose levels.² While a larger sample of data will be required to gain a more comprehensive analysis, the current trend could be associated with a greater understanding and compliance amongst healthcare workers and patients on the dangers of diabetes and the importance of preventative medicine.

Outcome 6: improved compliance was seen in the reduction of defaulting patients

Defaulting patients are identified as patients diagnosed with the disease but who do not return for their subsequent treatment/appointment, the duration of which could differ depending on the patient. The high-priority districts of eThekweni and uMgungundlovu are home to the largest proportions of defaulting patients. The pattern of urbanisation once again reflects the increased burden of non-communicable diseases in highly populated major cities. The risk factors for diabetes often occur due to urban lifestyle changes such as increased salt intake, obesity, high levels of stress and infrequent physical

activity.¹¹ There is a need for more high-quality data on the epidemiology and burden of diabetes in Africa as urban dwellers are expected to increase by 50% by the year 2035.⁴

According to the data, the rate of defaulters was seen to gradually reduce with a sharp drop in the year 2016. After closer inspection of the raw data (present as whole numbers) on defaulters, 2016 emerged as the year with the only record of null data entries ($n = 93$). This data inconsistency explains the drastic drop of 69% in 2016 and is likely to be due to common capture errors during primary data collection.¹³

The steady decline in the overall number of defaulters is reassuring considering the lack of funding in the South African national budget for NCDs in 2015/2016.²⁰ The 2018 national budget, however, has communicated an increase in funding as awareness of diabetes and its compounding effect on the pandemic of HIV and TB have increased.⁹ The increase in compliance seen with the reduction of defaulters is a testament to the success of new initiatives by the government to address NCDs and move towards the long-term goals as directed by the National Development Plan 2030.

Tables 3 and 4 provide greater insight into the effect of non-compliance through the analysis of data on defaulters. The correlation coefficient of 0.73 between Defaulters and Diabetes mortality depict a strong positive relationship. This implies that it is highly likely that an increase in noncompliance results in a higher mortality rate due to diabetes. Table 4 demonstrates a strong negative relationship between screening and defaulters with the correlation coefficient of 0.25. This result implies that frequent diabetic screening inversely affects the rate of non-compliance or improves treatment adhesion.

Conclusion

The rise in diabetes and its complications is seen most prominently in the highly urbanised areas of the developing world.^{2,11} The continent of Africa is expected to see the largest upsurge in patients, both diagnosed and undiagnosed. New research detailing the burden of disease in Africa is limited and the use of big data to more effectively predict disease patterns remains underutilised.^{15,21} Although the district of KZN has made huge strides regarding data collection, there is much room for improvement regarding the quality of data and a reduction in data inconsistencies. However, more data fields have been collected and adjusted throughout the years. Each data collection field can provide valuable insight into the population of public health users for the use of policy development, practitioner ratios and resource allocation. Further training for data collectors and managers would help refine the collection process and improve the quality of data.^{10,13,21} This training would ensure a collective understanding of the data collection fields among data collectors, which will improve data consistency. Additional training for managers would allow for quick identification and resolution of data inconsistencies at ground level. It is hypothesised that once data inconsistencies have been addressed, the calculated incidence rate would reflect current literature reporting annual increases.

An interesting finding in this study relates to the increased frequency of patients screened for diabetes and a reduction in the number of defaulting patients. This may be attributed to the increased initiative by the KZN DOH to collect diabetes screening data. Improved patient compliance and frequency of medical visits serves as a motivation for more extensive

research that could provide a blueprint to guide future diabetes care initiatives. Ultimately these findings could contribute to a major goal in the SA National Development Plan 2030, which is to 'reduce the disease burden to manageable levels'.²²

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