Trends in hospitalization of patients with diabetes mellitus in Ghana from 2012 to 2017 with predictions to 2032

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Background: This study explores sociodemographic and health factors associated with hospitalizing diabetes mellitus (DM) patients and estimates the number of future hospitalizations for DM in Ghana.

Methods: We conducted a secondary analysis using nationally representative patient hospitalization data provided by the Ghana Health Service and projected population counts from the Ghana Statistical Service. Data were stratified by year, age, sex and region. We employed Poisson regression to determine associations between sociodemographic and health factors and hospitalization rates of DM patients. Using projected population counts, the number of DM-related hospitalizations for 2018 through 2032 were predicted. We analysed 39 846 DM records from nearly three million hospitalizations over a 6-y period (2012–2017).

Results: Most hospitalized DM patients were elderly, female and from the Eastern Region. The hospitalization rate for DM was higher among patients ages 75–79 y (rate ratio [RR] 23.7 [95% confidence interval {CI} 18.6 to 30.3]) compared with those ages 25–29 y, females compared with males (RR 1.9 [95% CI 1.4 to 2.5]) and the Eastern Region compared with the Greater Accra Region (RR 1.9 [95% CI 1.7 to 2.2]). The predicted number of DM hospitalizations in 2022 was 11 202, in 2027 it was 12 414 and in 2032 it was 13 651.

Conclusions: Females and older patients are more at risk to be hospitalized, therefore these groups need special surveillance with targeted public health education aimed at behavioural changes.

Keywords: diabetes, Ghana, hospitalization, Poisson regression analysis, prediction, routine health data.

Introduction

Diabetes mellitus (DM) is a chronic metabolic disease associated with elevated levels of blood glucose or blood sugar that can lead to serious damage to the heart, blood vessels, eyes, kidneys and nerves over time.1 DM has been identified as the main driver of endocrine disorders in several studies, accounting for >8% of disease globally.2 DM is also considered a major comorbidity in other important non-communicable diseases (NCDs) such as cardiovascular diseases (CVDs), renal diseases and communicable diseases such as tuberculosis.3 Type 2 DM has been identified as the predominant form.4 Many studies have highlighted the increasing prevalence of NCDs, including endocrine, nutritional and metabolic diseases, globally and in Africa.2,4,5 These disorders have a occurrence among NCDs1 in low- and middle-income countries compared with high-income countries.5,6–7 There is a growing body of literature that recognizes the increasing prevalence of DM as a major challenge to the population and the health system specifically in Ghana. A retrospective review of medical records of patients in the two leading teaching hospitals in Ghana showed a significant increase in thyroid and other endocrine disorders presenting at these hospitals.8,9 Studies from Spain showed that the admission rates for DM patients were 2.6 times higher than for persons without DM.10,11 These studies further attributed the increase in hospitalization to DM complications in both type 1 and type 2 DM patients. DM-related hospitalization and its complications in high-income
countries account for 30–50% of the total direct medical expenditures in the USA, Italy and Spain.12–14 Chan et al.15,16 and the International Diabetes Foundation (IDF)17 recommend the use of routinely collected individual hospitalization and mortality data to study the relationships between risk factors, caring for patients and clinical outcomes.

Recent teaching hospital–based studies showed a steep increase in the admission of patients with endocrine disorders or DM of 633% over 31 y17 and 9.7% over 9 y in Ghana.18 Several non-representative studies about hospitalization rates for DM have been conducted in Ghana, however, it is not evident what factors may drive these rates at the national level. This uncertainty impedes patient care, hospital management and policy. Therefore the objective of the present study was to explore, at a national level, the sociodemographic and health factors associated with patients hospitalized for DM and to estimate the future (2018–2032) DM hospitalization rates in Ghana.

Methods

Study area

Ghana is a West African middle-income country bordered to the east by Togo, the west by Cote d’Ivoire, the north by Burkina Faso and the south by the Gulf of Guinea. The country currently has an estimated population of about 31 million (based on the 2010 census). At the time of this study, Ghana had 10 administrative regions and 216 districts.19 Each region has a hospital and almost every district has a hospital with subdistrict health facilities, which are the primary levels of care.20 In addition, there are five teaching hospitals. The provision of health services in Ghana ranges from tertiary hospitals (the highest) to community-based health planning and services (CHPS; the lowest).

Study design

Using the District Health Information Management System II (DHIMS-II) from the Ghana Health Service (GHS) and projected population counts from the Ghana Statistical Service (GSS), we performed a nationwide retrospective analysis of data from patients with DM who were hospitalized in Ghana between 2012 and 2017 and used these data to project future hospitalization numbers for 2018–2032. The DHIMS-II compiles administrative and patient data covering public and private hospitals in Ghana,20 while the GSS compiles national statistics including census and population projections. The DHIMS-II is coordinated by the GHS, which sets standards for record keeping and also performs routine audits of the data. The conduct of the study followed the REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement.21

Variables and data linkage

Data on individual admissions and discharges extracted from the DHIMS-II included the patient’s age, sex, education, occupation, health insurance status, date of admission and discharge, region, principal diagnoses, comorbidities, surgical procedures during admission and outcome of hospitalization. The principal diagnoses in the DHIMS-II database were classified according to the International Classification of Diseases, Tenth Revision (ICD-10).22 In the absence of predetermined ICD-10 codes in the database we used search terms and Stata version 14 (StataCorp, College Station, TX, USA) regular expression (gen diabetes = “diabetes” if regexm(p_dia, “[dD]iabetes|[dD]iabetic|(E0[8–9] [0–9])(E1[0–4])|N08.3)(g99.0)) to augment the search for patients diagnosed with DM for the reference period. We used only principal diagnoses of DM as the basis for hospitalization. The complete list of variables and responses are provided in Supplementary Table 1.

All patients admitted and discharged from 1 January 2012 to 31 December 2017 with diagnoses of DM (ICD-10 codes: E10–E14) were included in the analysis. We maintained data confidentiality and patient anonymity by excluding patient identifiers at data extraction. Hence it is not possible to identify patients at an individual level in our study. The population counts extracted from the GSS were stratified by year, age group, sex and region, allowing linkage with the hospitalization data.

Statistical analysis

Data management and analysis were performed using Stata version 14 (StataCorp). Both the DHIMS-II and GSS datasets were extracted as spreadsheets with the specified variables. Absolute and relative frequencies were calculated for all categorical variables. Age and length of hospital stay were summarized using the median and interquartile range (IQR).

Factors associated with hospitalization rates for DM and future predictions (2018–2032) were analysed using Poisson regression. The outcome variable in the model was the number of DM hospitalizations. The covariates were year, age group (using 5-y intervals, reference group: 25–29 y), sex (reference group: male), region (reference group: Greater Accra) and an interaction term for age group and sex. The log population count was used as the offset. Standard errors were based on a robust sandwich estimator. The calendar year for the predicted future hospitalization was set to 2016, thus eliminating a future effect of calendar year. This was based on the assumption that beyond 2016, secular trends associated with healthcare delivery would have levelled. Therefore only projected population counts per region, as well as age and sex distribution, were allowed to change for making predictions. The predictions assumed that the risk factors for DM incidence, improvements in diagnostics and treatments not included in the model remained constant for predicted years.

Patients with missing data in any of the variables used in the regression model (age, sex, date of admission) were excluded from the final analysis, representing 4% of all records. The exclusion of incomplete records was done after running plausibility checks that showed no discernible pattern in missingness.

Results

Nearly three million hospitalization records were analysed, 39 846 (1.4%) of which were associated with a DM diagnosis and had complete information on age, sex and date of admission (Figure 1).
Descriptive data

Overall, the median age of hospitalized patients with DM during the 6-y period was 55 y (IQR 43–65), without any sex difference. Two-thirds of patients with DM were female (24 864/39 864 [62.4%]). The median length of hospital stay was the same for female and male patients (median 4 d [IQR 2–7]). There was a steady increase in the annual number of DM hospitalizations from 2012 to 2016, with an increase from age groups 0–4 y to 50–54 y. The Eastern Region had the most hospitalizations (9729/39 864 [24.4%]) compared with the remaining nine regions in Ghana. More than half of the patients hospitalized had or were diagnosed with other comorbidities (Table 1).

Figure 2 shows that type 2 DM and unspecified DM with renal complications (ICD-10 codes: E11 and E14.2) were the main drivers for DM hospitalizations (Figure 2).

Factors associated with hospitalization for DM patients

The rate ratios (RRs) of hospitalization for DM and the associated factors from the Poisson regression are presented in Supplementary Table 2 and Figure 3. Calendar year was associated with a moderate increase in DM admission rates over the 6-y period (RR 1.16 per year [95% confidence interval (CI) 1.14 to 1.19], p<0.001). Although the RR of hospitalization for DM increased with age, the increase in patients <25 y of age was less pronounced (RR 0.74 [95% CI 0.55 to 1.00], p=0.050) and more pronounced in patients ≥30 y of age (RR 2.03 [95% CI 1.50 to 2.74], p<0.001) compared with patients 25–29 y of age. Patients with DM in the age group 75–79 y had the highest RRs (23.72 [95% CI 18.59 to 30.25], p<0.001) for hospitalization compared with the age group 25–29 y. Female patients had about twice the hospitalization rate compared with male patients (RR 1.91 [95% CI 1.44 to 2.53], p<0.001). Among the 10 regions of Ghana, the Brong Ahafo Region (RR 1.35 [95% CI 1.19 to 1.53], p<0.001) and Eastern Region (RR 1.94 [95% CI 1.70 to 2.21], p<0.001) admitted patients with DM at a higher rate compared with the Greater Accra Region (reference region) (Supplementary Table 2 and Figure 3).

Predicted number of hospitalizations of patients with DM from 2017 to 2032

We predicted the annual number of DM-associated hospitalizations from 2017 to 2032. In the reference year (2016), the empirical hospitalizations were 3257 for males vs 5540 for females. Our model predicted the number of male patients with DM hospitalized in 2022 to be 4301 (95% CI 4257 to 4346) and 6903 (95% CI 6860 to 6947) for female patients. In 2027, the predicted hospitalizations were 4782 (95% CI 4726 to 4839) for males vs 7632 (95% CI 7577 to 7688) for females. Male vs female patients with DM predicted to be hospitalized in 2032 also increased (5274 [95% CI 5245 to 5345] vs 8377 [95% CI 8307 to 8447], respectively) (Supplementary Table 3 and Figure 4). These increases translated into an overall percentage change of 9.7%, 18.5% and 25.9% for the years 2022, 2027 and 2032, respectively. Since we set our prediction base year to 2016 due to possible data incompleteness in 2017, the empirical and predicted number of hospitalizations in 2017 was assessed. The
Table 1. Sociodemographic and health characteristics of patients hospitalized for DM stratified by sex for total hospitalizations, 2012–2017, except for region and age, based on crude rates per 10 000 population

| Variables                        | Male, n (%) (N=14 982 [37.6%]) | Female, n (%) (N=24 864 [62.4%]) | Total (N=39 846) |
|----------------------------------|----------------------------------|-----------------------------------|------------------|
| Age (years), median (IQR)        | 55 (42–65)                       | 55 (42–66)                        | 55 (43–66)       |
| Hospitalization duration (days), median (IQR) | 4 (2–7)                         | 4 (2–6)                           | 4 (2–6)          |
| Estimated total (male+female) population/10 000 | n (crude rate)                 | n (crude rate)                    |                  |
| Region, n (crude rate/10 000 population) |                                  |                                   |                  |
| Ashanti                          | 1408 (0.12)                      | 2411 (0.21)                       | 11 470.73        |
| Brong Ahafo                       | 2515 (0.38)                      | 3790 (0.58)                       | 6570.19          |
| Central                          | 946 (0.16)                       | 1601 (0.26)                       | 6067.11          |
| Eastern                          | 3530 (0.49)                      | 6199 (0.87)                       | 7158.90          |
| Greater Accra                    | 1787 (0.18)                      | 2954 (0.29)                       | 10 075.24        |
| Northern                         | 426 (0.06)                       | 613 (0.09)                        | 6839.44          |
| Upper East                       | 113 (0.03)                       | 204 (0.05)                        | 3878.67          |
| Upper West                       | 157 (0.05)                       | 216 (0.07)                        | 3033.66          |
| Volta                            | 1890 (0.31)                      | 3137 (0.52)                       | 6065.23          |
| Western                          | 2215 (0.32)                      | 3739 (0.54)                       | 6874.27          |
| Age group (years)                |                                  |                                   |                  |
| 0–4                              | 40 (0.01)                        | 41 (0.01)                         | 9282.76          |
| 5–9                              | 38 (0.01)                        | 46 (0.01)                         | 8529.52          |
| 10–14                            | 86 (0.01)                        | 143 (0.02)                        | 7352.06          |
| 15–19                            | 298 (0.04)                       | 359 (0.05)                        | 6830.80          |
| 20–24                            | 365 (0.06)                       | 622 (0.10)                        | 6197.49          |
| 25–29                            | 399 (0.07)                       | 867 (0.16)                        | 5524.49          |
| 30–34                            | 705 (0.15)                       | 1214 (0.25)                       | 4872.36          |
| 35–39                            | 1015 (0.24)                      | 1437 (0.34)                       | 4213.26          |
| 40–44                            | 1302 (0.37)                      | 1741 (0.49)                       | 3553.06          |
| 45–49                            | 1398 (0.47)                      | 2528 (0.85)                       | 2961.43          |
| 50–54                            | 1690 (0.70)                      | 3255 (1.36)                       | 2399.80          |
| 55–59                            | 1779 (0.93)                      | 3037 (1.58)                       | 1916.86          |
| 60–64                            | 1812 (1.23)                      | 2635 (1.79)                       | 1473.67          |
| 65–69                            | 1287 (1.17)                      | 1920 (1.74)                       | 1104.31          |
| 70–74                            | 1135 (1.46)                      | 1827 (2.35)                       | 776.38           |
| 75–79                            | 917 (1.74)                       | 1751 (3.32)                       | 527.77           |
| 80–100                           | 721 (1.39)                       | 1441 (2.79)                       | 517.41           |
| Year, n (%)                      |                                  |                                   |                  |
| 2012                             | 1317 (8.8)                       | 1847 (7.4)                        | 3164 (7.9)       |
| 2013                             | 1982 (13.2)                      | 3251 (13.1)                       | 5233 (13.1)      |
| 2014                             | 2612 (17.4)                      | 4336 (17.4)                       | 6948 (17.4)      |
| 2015                             | 2769 (18.5)                      | 4338 (17.5)                       | 7107 (17.8)      |
| 2016                             | 3257 (21.7)                      | 5540 (22.3)                       | 8797 (22.2)      |
| 2017                             | 3045 (20.3)                      | 5552 (22.3)                       | 8597 (21.6)      |
| Education level, n (%)           |                                  |                                   |                  |
| None                             | 5927 (39.6)                      | 11 482 (46.2)                     | 17 409 (43.7)    |
| Primary                          | 1399 (9.3)                       | 2696 (10.8)                       | 4095 (10.3)      |
| Junior high/middle school        | 4253 (28.4)                      | 7448 (30.0)                       | 11 701 (29.4)    |
| Senior high, secondary/vocational| 1795 (12)                        | 2118 (8.5)                        | 3913 (9.8)       |
| Tertiary                         | 1608 (10.7)                      | 1119 (4.5)                        | 2727 (6.8)       |
| Occupation, n (%)                |                                  |                                   |                  |
| Unemployed                       | 3924 (26.2)                      | 6550 (26.3)                       | 10 474 (26.3)    |
### Table 1. Continued

| Variables                                      | Male, n (%) | Female, n (%) | Total (N=39 846) |
|-----------------------------------------------|-------------|---------------|-------------------|
|                                               | (N=14 982 [37.6%]) | (N=24 864 [62.4%]) |                   |
| Employeda                                     | 8099 (54.1) | 14 978 (60.3) | 23 077 (57.9)     |
| Unspecified                                   | 2959 (19.8) | 3331 (13.4)   | 6290 (15.8)       |
| Health insurance, n (%)                       |             |               |                   |
| No                                            | 2603 (17.4) | 3203 (12.9)   | 5806 (14.6)       |
| Yes                                           | 12 215 (81.5) | 21 392 (86.0) | 33 607 (84.3)     |
| Surgical procedure, n (%)                     |             |               |                   |
| No                                            | 13 958 (93.2) | 23 286 (93.7) | 37 244 (93.5)     |
| Yes                                           | 403 (2.7)   | 541 (2.2)     | 944 (2.4)         |
| Comorbidity, n (%)                            |             |               |                   |
| No                                            | 7156 (47.8) | 10 353 (41.6) | 17 509 (43.9)     |
| Yes                                           | 7826 (52.2) | 14 511 (58.4) | 22 337 (56.1)     |
| Outcome at discharge, n (%)                   |             |               |                   |
| Alive                                         | 14 223 (94.9) | 23 844 (95.9) | 38 067 (95.5)     |
| Died                                          | 735 (4.9)   | 975 (3.9)     | 1710 (4.3)        |
| Hospitalization duration, n (%)               |             |               |                   |
| 0–3 d                                         | 6767 (45.2) | 11 952 (48.1) | 18 719 (47.0)     |
| 4–7 d                                         | 4828 (32.2) | 8113 (32.6)   | 12 941 (32.4)     |
| >1 week                                       | 2831 (18.9) | 3855 (15.5)   | 6686 (16.8)       |

*aFarming/fishing and trading constituted nearly 50% (n=20 095) of the employed category. There were some missing observations (1 for education, 5 for occupation, 433 for health insurance, 1658 for surgical procedure, 69 for outcome at discharge and 1500 for hospitalization."

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**Discussion**

Although studies in Ghana estimated the prevalence of DM in the population to be between 3.3 and 6%, the IDF reported a 1.8% prevalence of adult DM with a global projection of 578.4 million and 700.2 million by 2030 and 2045, respectively. In Africa, the estimated prevalence of patients with DM was 19 million, 29 million and 47 million in 2019, 2032 and 2045, representing a 143% increase. These increases in prevalence are expected to result in corresponding increases in hospitalizations. Presently the most reliable nationally representative and useful source of data on patient hospitalizations in Ghana is from the GHS DHIMS-II.
Figure 3. RRs and 95% CIs from the Poisson regression model for hospitalized patients with diabetes, 2012–2017. Note: Triangles indicate reference categories.
present study showing a yearly increase in hospitalizations for patients with DM at a nationwide level is consistent with previous smaller studies that demonstrated similar increases over recent decades.\(^{17}\) However, Sarfo-Kantanka et al.\(^ {18}\) reported decreasing medical admissions for type 1 DM in the Komfo Anokye Teaching Hospital in their review of medical records for a 28-y period. They explained that the observed reduction in the number of admissions does not mean that the admissions for type 1 DM have decreased in the study area, but rather that the hospitalization of these patients is likely taking place in peripheral hospitals that have improved facilities and human resources.

We found that the hospitalization rate for DM in the Eastern Region was the highest, approximately double the rate in the largest regions. The Ashanti and Greater Accra Regions have the largest projected populations from 2012 to 2032, with the Upper West and Eastern Regions being the least populated regions. Our findings in Eastern Region could be because of the efforts of the specialized DM clinics run by the regional hospital and some district hospitals. However, further investigation is beyond the scope of the current study.

More than two-thirds of the patients were female, which is consistent with previous studies of DM in Ghana and sub-Saharan Africa.\(^ {24-26}\) However, other studies have reported more males than females.\(^ {27,28}\) It is worth mentioning that the high proportion of females being hospitalized for DM in Ghana is consistent with prevalence studies among outpatients.\(^ {25}\) Additionally, a probable reason could be due to the fact that women tend to seek healthcare more frequently than men.

The large size of the dataset and its national representativeness allowed for epidemiological exploration of a patient’s education level, which showed fewer hospitalizations for patients with a senior high school education or higher. The reported association of higher education with reduced hospitalization rates could mean that people with DM who have a higher education are able to adhere to prevention and treatment practices better than those who are less educated. The farmers/fishermen and trader categories of occupation contributed to nearly half of the admissions. These two variables were also found by Asamoah-Boaabeng et al.\(^ {29}\) In our study setting, most farmers and traders have lower education levels, possibly leading to poor adherence to treatment, which could have contributed to the higher hospitalization rate among these groups of patients.

Our analysis showed an annual increase in the hospitalization rate of patients with DM. While the Volta Region compared with the Greater Accra Region had no significantly different rate of hospitalization, the remaining regions did have significantly different rates. Higher hospitalization rates in the Eastern, Brong Ahafo and Western Regions of Ghana compared with the Greater Accra Region showed these regions may require additional health facility resources and intensified outpatient care in the future for patients with DM. Very few studies on DM hospitalization in Ghana were found in the literature that directly relate to these regions.\(^ {30-33}\)

Older age is associated with a higher prevalence and incidence of DM in Ghana.\(^ {26,34}\) Other studies in Ghana, Europe and the Americas\(^ {14-16}\) also found older patients with DM to be more at risk of hospitalization. Except for the age group 20–24 y, the remaining categories of age were associated with increased rates of hospitalization, with the highest in the age group 75–79 y. The 9-fold increase in the rate of admission for patients who should be actively working (age 30 y: RR 2.03) until they retire from active service (age 60 y: RR 17.30) is of particular concern. This means that most of these patients had late diagnoses of their DM either before or during hospitalization, hence active DM educational policies and management could help reduce these rates. In addition to educating patients with DM at the outpatient clinics, education of the general public on DM and its risk factors and the need for prevention and screening is vital.
We found that females had more than twice the hospitalization rate for DM compared with males. This significant association could be a result of the high burden of DM reported in both inpatients and outpatients by females. The implication of this nationwide finding is to have policies and strategies tailored towards women as a major contributor to DM hospitalization in Ghana. Our overall 4% of deaths from patients admitted for DM was one-fourth of the 16.7% crude mortality rate of endocrine admissions over a 9-y period in a tertiary hospital in Ghana. 

The predicted trends in hospitalized patients with DM followed the linear patterns of the projected population from 2012 to 2032. However, the increase in hospitalization rates in the 5-y empirical period and 15 y of prediction were estimated to be larger in women compared with men. The increasing rates over three time points are quite alarming, although they are similar to the IDF estimates for adult DM in Ghana. Hospitalization for DM in Ghana increased by 178% between 2012 and 2016. Our predictions based on the 8797 hospitalizations in 2016 revealed an overall increase of 13 651, representing 36%, by 2032. These increasing trends in admissions seem to follow the trends in overall DM prevalence. 

Conclusions
This study characterizes the nationwide hospitalization rates for patients with DM in Ghana, taking into account several risk factors. Our results showed an annual increase in hospitalizations due to DM that was dominated by females. Low levels of education, farming and trading were significant risk factors associated with higher hospitalization rates. Finally, this study provides a lower-bound estimate for hospital admissions due to DM from 2018 to 2032. These findings are essential for planning hospital staffing, equipment acquisition and treatment and for anticipating direct medical costs. In addition, our results provide policy indicators that can potentially help reduce the surge in DM (especially type 2 diabetes) hospitalizations across all ages across the 10 regions of Ghana.

Supplementary data
Supplementary data are available at International Health online (http://inthehealth.oxfordjournals.org).

Limitations
Notable among the limitations in this study is the fact that the two leading teaching hospitals in Ghana do not contribute data to the DHIMS-II database. Nevertheless, this impact is minimal with regards to type 1 DM, as a recent study by Sarfo-Kantanka et al. reported decreasing medical admissions for type 1 DM in the Komfo Anokye Teaching Hospital, which they ascribed to increasing human resources in peripheral healthcare facilities in the study area. The impact of the absence of data from teaching hospitals on the results presented is moderate with regards to type 2 DM. This is because district facilities in Ghana see a proportionately higher number of outpatients than the teaching hospitals, which see mainly referral cases. The district hospitals also have capacity to manage DM. Second, not all private hospitals are covered in the DHIMS-II. Our estimates for hospitalization rates should thus be taken as lower bounds. The unavailability of the information on patient health history, diagnostic tests and treatment leading to non-inclusion in the model and prediction could negatively impact our prediction if there is a drastic change in these variables in the future. We acknowledge that hospitalization depends on many factors, hence our estimates do not imply incidence or prevalence. Furthermore, most of the increase predicted is due to changes in the age distribution and the growing population. It could be envisaged that the situation may be even more serious if DM incidence in the population increases. We counted records of hospitalization without the possibility to identify individual patients. Hence multiple admissions of the same patient were indistinguishable from single admissions of multiple patients. In Poisson regression, this might introduce bias if readmission of the same patient was common. However, by choosing a sandwich estimator for the residual variance, the results should be robust to non-independence of a low proportion of observations. Despite its limitations, the study provides the most comprehensive nationwide estimate of hospitalization for patients with DM in Ghana.

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