Determinants of Diabetes Ketoacidosis Among Diabetes Mellitus patients at North Wollo and Waghimra Zone Public Hospitals, Amhara Region, Northern Ethiopia

Addisu Getie (addisugetie@gmail.com)
Woldia University

Adam Wondmieneh
Woldia University

Melaku Bimerew
Woldia University

Getnet Gedefaw
Woldia University

Asmamaw Demis
Woldia University

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Abstract

Background: Diabetes Mellitus (DM) is a metabolic disorder associated with acute nonmetabolic and metabolic complications. Diabetic ketoacidosis is the most serious diabetic emergency in patients with diabetes mellitus. It is the leading cause of mortality in children and young adults. Even though the burden of diabetes ketoacidosis has increased over the past years in Sub-Saharan Africa, no research has been conducted on the determinants of Diabetes ketoacidosis in Ethiopia, particularly in the Amhara region. Thus, this study aimed to identify the determinants of diabetes Ketoacidosis among Diabetes Mellitus patients at North Wollo and Waghimra Zone public Hospitals.

Methods: An institution-based unmatched case-control study design was employed on 408 patients (102 cases and 306 controls) at North Wollo and Waghimra Zone Public Hospitals from March 1st to April 30th, 2020. A consecutive sampling method was used to select study participants. The data were collected using structured interviewer-administered questioners and reviewing of patient charts. The analysis was done using a binary logistic regression model. Then, P-value < 0.05 was considered statistically significant.

Result: The mean (±SD) age of the study participants was 46.96 (± 15.175 SD) years. Irregular follow-up in diabetes clinic (AOR: 4.19, 95% CI :2.28-7.71), not received diabetic education (AOR: 2.87, 95% CI:1.44-5.72), alcohol drinking (AOR: 2.99, 95% CI :1.46-6.12), discontinuation of medications (AOR: 4.31, 95% CI:1.92-9.68), presence of comorbidity (AOR: 2.57, 95% CI :1.37-4.84), and being type one of diabetes mellitus (AOR: 2.01, 95% CI:1.11-3.63) were determinant factors of diabetic ketoacidosis.

Conclusions: This study showed that the behavioral and clinical characteristics of diabetic patients were risk factors of diabetic ketoacidosis. Follow-up in the diabetic clinic, diabetic education, discontinuation of medications, alcohol drinking, presence of comorbidities, and type of diabetes mellitus were independent determinants of diabetic ketoacidosis.

Introduction

Diabetes Mellitus is a group of common metabolic disorders that share the phenotype of hyperglycemia characterized by the presence of chronic hyperglycemia accompanied by greater or lesser impairment in the metabolism of carbohydrates, lipids, and proteins (1). It is the leading cause of end-stage renal disease, traumatic lower extremity amputations, adult blindness, and predisposing to cardiovascular diseases (2). Diabetic ketoacidosis (hyperglycemic emergency) is one of the most common life-threatening acute metabolic complications of diabetes. It is usually associated with disability, reduced life expectancy, and causes enormous health costs for every society (3). A relative or absolute deficiency of insulin can cause increased counterregulatory hormones. This enhances glycogenolysis and gluconeogenesis that results in hyperglycemia. This results in the accumulation of large quantities of ketone bodies and subsequent metabolic acidosis causing diabetic ketoacidosis (4). Both decreased the concentration of insulin and increased concentration of counterregulatory hormones like cortisol,
glucagon, growth hormone, and catecholamines caused diabetic ketoacidosis by increasing the blood glucose level and ketone bodies (5). Diabetic ketoacidosis reoccurs frequently due to poor adherence to insulin therapy (6). Individuals who are hyperglycemic at the time of admission are at high risk of mortality, morbidity, and prolonged hospital stay (7). Diabetic ketoacidosis is the leading cause of mortality in children and young adults with type one diabetes, accounting for ~ 50% of deaths and half of all deaths are among patients younger than 24 years of age (5). Treatment of DKA uses a large number of resources, accounting for an estimated total cost of $2.4 billion annually (6).

In Africa, there is a dramatic increase in the prevalence of diabetic ketoacidosis in both rural and urban settings, and affecting both genders proportionally, which accounts for 3.2%. The mean age of onset of type two diabetes mellitus is 12–16 years; this period coincides with puberty when a physiologic state of insulin resistance develops (1). In Ethiopia, diabetes mellitus is increasing in the past thirty years, becoming a major social and economic burden regarding bed occupancy and drug. It is a cause of 71.1% of hospital admissions with a mortality of 5.8%. Among diabetic patients on follow up, only 18.1% were able to control their blood sugar level (3). The mortality rates of diabetic ketoacidosis increase substantially with aging and the presence of concomitant life-threatening illnesses (8). Hypertension and diabetic neuropathy co-exist with diabetic ketoacidosis, which accounts for 78.9% and 43.7%, respectively (9).

Diabetes mellitus is a known cause of mortality and morbidity in developing countries like Ethiopia. This is due to limited resources and scaries inpatient facilities. More than half of the diabetic patients in Ethiopia do not receive standard diabetes care, 95% don’t perform self-blood glucose monitoring at home, 33% don’t take their treatment regularly, and 75% require admission directly or indirectly due to uncontrolled diabetes (3).

Despite all challenges and costs incurred by diabetes and its complications, studies are limited to the overall determinants in Ethiopia. Therefore, identification of determinants of the disease and the possible preventive measures that could be instituted to arrest or delay the onset of diabetic ketoacidosis. Thus, this study was aimed to assess the possible determinants of diabetic ketoacidosis among diabetic patients in North Wollo and Waghimra Zone Public Hospitals.

**Methods**

**Study design and setting**

The unmatched case-control study design was conducted in North Wollo and Waghimra Zone Public Hospitals from March 1st to April 30, 2020. North Wollo zone founds in Amhara regional state with a capital city of Woldia that found 521 kilometers away from Addis Ababa. There are six hospitals found in North Wollo and Waghimra Zone which are Woldia comprehensive specialized hospital, Kobo primary hospital, Lalibela general hospital, Mekiet primary hospital, Wadila primary hospital, and Tefera Hailu
memorial hospital. The hospitals provide general and specialized treatment, known to be open 24 hours for emergency services and each of them is assumed to be more than five million peoples.

**Population**

All diabetes patients who were receiving treatment at public hospitals in North Wollo and Waghimra Zone were considered as a source population. Diabetic patients aged 18 and above who were diagnosed with diabetic ketoacidosis during the study period were included as a case and those adult diabetic patients without diabetic ketoacidosis were considered as a control group. However, newly diabetic ketoacidosis diagnosed patients, critically and mentally ill patients who cannot give a response were excluded from the study in both case and control groups.

**Sample size determination**

The sample size was determined using the double proportion formula with computer-based Epi info7 software Stat Cal by using the proportion difference approach. Among several exposure variables, selection of the appropriate exposure variables in controls was done based on the main interest variables of cases of the determinant for diabetic ketoacidosis using the assumptions; 95% confidence interval ($Z_{\alpha/2} = 1.96$), power of 80% ($Z_{\beta} = 0.84$), case to control ratio 1:3, the odds ratio to be detected $\geq 2$. Then the calculated sample size was 371 (10). Thus, adding 10% of the sample size to the larger sample size 371, the final required sample size was 408 (102 cases and 306 controls).

**Sampling Procedure and Sampling technique**

All hospitals found in the North Wollo and Waghimra zone were included in the study. The total sample size was proportionally allocated to the number of diabetic patients with diabetic ketoacidosis for cases and without diabetic ketoacidosis for controls in each hospital. Then, the study participants from each hospital were selected by a consecutive sampling technique.

**Data collection tools and procedures**

The data were collected by using structured interviewer-administered questionnaires and a review of case records of the hospital. The questionnaires were addressed the socio-demographic determinants, behavioral, and personal related determinants of diabetic ketoacidosis. A checklist consisting of clinical related determinants of diabetic ketoacidosis was also prepared to review the medical records of patients. The questioners were both open and close-ended and were prepared in English and translated to Amharic, which is a local language. Six BSc degree nurses were recruited as a data collector and three MSc nurses were supervisors who have experience in data collection.

**Data quality control**

The questionnaires were pretested on 10% of the sample size at Dessie Referral Hospital. The data collectors and supervisors were trained before actual data collection, and the principal investigator and supervisors were supervised the data collectors closely. During data collection, both supervisors and data
collectors checked the data for its completeness and missing information at each point. Furthermore, the data were also checked during and after entry into the computer before analysis.

**Data processing and analysis**

The data were coded, cleaned, edited, and entered into Epi data version 4.2.0.0 to minimize logical errors and design skipping patterns. Then, the data were exported to SPSS version 24 for analysis. Summary statistics (mean or median) for continuous variables and percentage and frequency for categorical variables were computed for case and control groups separately. Tables and figures were used to present the data. The bivariable analysis was used to see the association between each determinant and the outcome variable by using binary logistic regression. The goodness of fit was tested by Hosmer-Lemeshow statistic test. All variables with $P \leq 0.25$ in the bivariable analysis were included in the final model of multivariable analysis to control all possible confounders. A multi co-linearity test was carried out to see the correlation between independent variables by using standard error (standard error $> 2$ was considered as suggestive of the existence of multi co-linearity). The direction and strength of statistical associations were measured by the odds ratio with 95% CI. Adjusted odds ratios along with 95% CI were estimated and $P$-value $< 0.05$ was considered statistically significant.

**Ethical approval and consent form**

Ethical clearance was obtained from Woldia University, College of Health Sciences, Research and Community Service Review Committee (RCSRC). A formal letter of permission and support was written to RHB from Woldia University and finally to selected health facilities. The study participants were informed about the purpose of the study, their right to refuse. Written and signed voluntary consent were obtained from study subjects before distributing the questionnaire. The respondents were also told that the information obtained from them was treated with complete confidentiality and did not cause any harm to them. All methods were carried out in accordance with relevant guidelines and regulations.

**Results**

**Socio-demographic characteristics**

A total of 408 (102 cases and 306 controls) diabetic patients were included in the study, of which 241 (59.1%) were males and 167 (40.9%) were females. Their age was ranged from 18–80 years old with a mean and standard deviation of $46.96 \pm 15.175$ years, and the majority of respondents were found in the age range of 40–50 years (26.7%) (Table 1).
Table 1
Socio-demographic Characteristics of Diabetes mellitus patients admitted in North Wollo and Waghimra Zone public hospitals, 2020 (n = 408)

| Variable            | Frequency (N) | Percentage (%) |
|---------------------|---------------|----------------|
| **Age category**    |               |                |
| 18–30               | 46            | 11.3           |
| 31–40               | 95            | 23.3           |
| 41–50               | 109           | 26.7           |
| 51–60               | 82            | 20.1           |
| > 60                | 76            | 18.6           |
| **Marital status**  |               |                |
| Single              | 82            | 20.1           |
| Married             | 235           | 57.6           |
| Divorced            | 67            | 16.4           |
| Widowed             | 24            | 5.9            |
| **Religion**        |               |                |
| Orthodox            | 286           | 70.1           |
| Muslim              | 93            | 22.8           |
| Protestant          | 18            | 4.4            |
| Other               | 11            | 2.7            |
| **Residence**       |               |                |
| Urban               | 139           | 34.1           |
| Rural               | 269           | 65.9           |
| **Ethnicity**       |               |                |
| Amhara              | 274           | 67.2           |
| Tigray              | 78            | 19.1           |
| Oromo               | 44            | 10.8           |
| Other*              | 12            | 2.9            |
| **Level of education** |         |                |
| Can't read and write | 123         | 30.1           |
| Read and write      | 128           | 31.4           |
| Primary school      | 72            | 17.6           |
| Secondary school    | 53            | 13.0           |
| College and above   | 32            | 7.8            |
| **Occupation**      |               |                |
| Housewife           | 117           | 28.7           |

Other: Daily labor and drivers, other*: Gurage, Sidama, and Agew
Variable | Frequency (N) | Percentage (%)  
---|---|---
Government employee | 37 | 9.1 
Farmer | 124 | 30.4 
Student | 48 | 11.8 
Merchant | 42 | 10.3 
Privet workers | 35 | 8.6 
Other | 5 | 1.2 

Other: Daily labor and drivers, other*: Guragie, Sidama, and Agew

**Behavioral and clinical characteristics**

Of the 408 participants, 65.9% were living with diabetes mellitus longer than five years and 39% were overweight during diagnosis. Only 37.7% of the participants performed regular physical exercise and 51.2% had an infection. Regarding the type of diabetes mellitus (DM), 32.6% were type one (Table S1)

**The proportion of determinants of diabetic ketoacidosis among Cases and controls**

The onset of diabetes mellitus was highest among patients with the age range of 41–50 years old (31.4%). Of all cases, 82.4% had greater than five years of diabetic duration and more than 54% were overweight during diagnosis. Cases were more exposed almost for all determinant factors than controls. Behavioral determinant factors like alcohol drinking and cigarette smoking were higher among diabetic patients with diabetic ketoacidosis than those without diabetic ketoacidosis. More than 69% of cases did not perform regular physical exercise, 62.7% did not have regular follow-up in the diabetic clinic, and 90.2% discontinued their medication. Only 17.6% of cases were received diabetic education. Similarly, infections were more common among cases (72.5%) than controls (44.1%). The presence of comorbidity was also higher among diabetes mellitus patients with diabetic ketoacidosis (67.6%) than patients without diabetic ketoacidosis (48%). There was also a difference between the types of diabetes mellitus among cases and control groups. Regarding the type of diabetes mellitus, 43% of diabetic ketoacidosis were diagnosed with type one diabetes mellitus (Table 2).
Table 2
Proportion of determinant factors among cases and controls among Diabetes mellitus patients admitted in North Wollo and Waghimra Zone public hospitals, 2020.

| Variable                        | Case       |            | Control    |            |
|---------------------------------|------------|------------|------------|------------|
|                                 | N          | %          | N          | %          |
| Marital status                  |            |            |            |            |
| Single                          | 8          | 7.8        | 74         | 24.2       |
| Married                         | 69         | 67.6       | 166        | 54.2       |
| Divorced                        | 15         | 14.7       | 52         | 17.0       |
| Widowed                         | 10         | 9.8        | 14         | 4.6        |
| Age at onset of DM              |            |            |            |            |
| ≤ 30                            | 26         | 25.5       | 111        | 36.3       |
| 31–40                           | 26         | 25.5       | 74         | 24.2       |
| 41–50                           | 32         | 31.4       | 80         | 26.1       |
| 51–60                           | 8          | 7.8        | 23         | 7.5        |
| > 60                            | 10         | 9.8        | 18         | 5.9        |
| Duration of DM                  |            |            |            |            |
| 1–5 year                        | 18         | 17.6       | 121        | 39.5       |
| > 5 year                        | 84         | 82.4       | 185        | 60.5       |
| Body Mass Index                 |            |            |            |            |
| Underweight                     | 10         | 9.8        | 54         | 17.6       |
| Normal                          | 36         | 35.3       | 149        | 48.7       |
| Overweight                      | 56         | 54.9       | 103        | 33.7       |
| Regular follow up in DM clinic  |            |            |            |            |
| Yes                             | 38         | 37.3       | 225        | 73.5       |
| No                              | 64         | 62.7       | 81         | 26.5       |
| Received DM counseling’s        |            |            |            |            |
| Yes                             | 18         | 17.6       | 162        | 52.9       |
| No                              | 84         | 82.4       | 144        | 47.1       |
| Alcohol drinking                |            |            |            |            |
| Yes                             | 26         | 25.5       | 33         | 10.8       |
| No                              | 76         | 74.5       | 273        | 89.2       |
| Cigarette smoking               |            |            |            |            |
| Yes                             | 2          | 2.0        | 2          | 0.7        |
| No                              | 100        | 98.0       | 304        | 99.3       |
| Regular physical exercise       |            |            |            |            |
| Yes                             | 31         | 30.4       | 123        | 40.2       |
| No                              | 71         | 69.6       | 183        | 59.8       |

MD: Diabetes Mellitus, OHA: Oral Hypoglycemic Agents, Type I: Type one, Type II: Type two
**Discontinue medication**

|               | Yes   | 92    | 90.2  | 136   | 44.4 |
|---------------|-------|-------|-------|-------|------|
|               | No    | 10    | 9.8   | 170   | 55.6 |

**Emotional disturbance**

|               | Yes   | 76    | 74.5  | 179   | 58.5 |
|---------------|-------|-------|-------|-------|------|
|               | No    | 26    | 25.5  | 127   | 41.5 |

**Presence of infection**

|               | Yes   | 74    | 72.5  | 135   | 44.1 |
|---------------|-------|-------|-------|-------|------|
|               | No    | 28    | 27.5  | 171   | 55.9 |

**Type of treatment**

|               | OHA   | 18    | 17.6  | 59    | 19.3 |
|---------------|-------|-------|-------|-------|------|
|               | Insulin | 84    | 82.4  | 247   | 80.7 |

**Presence of comorbidity**

|               | Yes   | 69    | 67.6  | 147   | 48.0 |
|---------------|-------|-------|-------|-------|------|
|               | No    | 33    | 32.4  | 159   | 52.0 |

**Type of DM**

|               | Type I | 44    | 43.1  | 89    | 29.1 |
|---------------|--------|-------|-------|-------|------|
|               | Type II | 58    | 56.9  | 217   | 70.9 |

**MD**: Diabetes Mellitus, OHA: Oral Hypoglycemic Agents, Type I: Type one, Type II: Type two

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**Admission blood glucose level**

Of all diabetes mellitus patients, 34.3% were less than 250 mg/dl of admission blood glucose level, and nearly 15% of patients had an admission blood glucose levels greater than 400 mg/dl. Admission blood glucose levels less than 250 mg/dl were found among 14.7% of the cases, while 40.8% of controls had admission blood glucose levels less than 250 mg/dl. Conversely, 23.5% of cases had greater than 400 mg/dl admission blood glucose level, whereas only 12.1% of controls had a blood glucose level of greater than 400 mg/dl (Fig. 1).

**Baseline comorbidities**

Of all 408 diabetes mellitus patients, 52.9% had baseline comorbidities. Among those diabetes mellitus patients with baseline comorbidities, 67.6% were cases and 48% were controlled. Hypertension was found the highest comorbid, 28.2% of all diabetes mellitus patients with baseline comorbidities. Of these hypertensive patients, 27.5% were cases, whereas 28.6% were controls (Fig. 2).

**Determinant factors of diabetic ketoacidosis**

The results of this study showed that different behavioral and clinical factors were found as the determinants of diabetic ketoacidosis. These determinant factors were the presence of regular follow-up in the diabetic clinic, received diabetic education, alcohol drinking, discontinuation of medications (insulin and oral hypoglycemic agents), presence of comorbidities, and type of diabetes mellitus. Diabetes mellitus patients who did not have regular follow-up in the diabetic clinic were 4.19 times more likely to
develop diabetic ketoacidosis than those who had regular follow-up [AOR: 4.19; 95% CI (2.28–7.71)]. Similarly, diabetes mellitus patients who did not receive diabetic education were 2.87 times more likely to develop diabetic ketoacidosis than patients who received diabetic education [AOR: 2.87; 95% CI (1.44–5.72)]. The odds of diabetic ketoacidosis among diabetes mellitus patients who drank alcohol was 2.99 times higher than diabetes mellitus patients who did not drink alcohol [AOR: 2.99; 95% CI (1.46–6.12)]. Regarding medication, patients who discontinued their medication were 4.31 times more likely to develop diabetic ketoacidosis than those who did not discontinue their medication [AOR: 4.31; 95% CI (1.92–9.68)]. The odds of diabetic ketoacidosis among diabetes mellitus patients who had comorbidities were 2.57 times higher than their counterparts [AOR: 2.57; 95% CI (1.37–4.84)]. Concerning the type of diabetes mellitus, patients with type one diabetes mellitus were 2.01 times more likely to develop diabetic ketoacidosis than patients with type two diabetes mellitus [AOR: 2.01; 95% CI (1.11–3.63)] (Table 3).
Table 3
Binary and Multiple Logistic Regression Analysis for determinants of diabetic ketoacidosis among Diabetes mellitus patients admitted in North Wollo and Waghimra Zone public hospitals, 2020.

| Variable                              | Case | Control | COR(95% CI) | AOR(95% CI) |
|---------------------------------------|------|---------|-------------|-------------|
| Marital status                        |      |         |             |             |
| Single                                | 8    | 74      | 1           | 1           |
| Married                               | 69   | 166     | 3.85(1.76–8.40) | 1.89(0.66–3.23) |
| Divorced                              | 15   | 52      | 2.67(1.05–6.75) | 0.87(0.82–2.74) |
| Widowed                               | 10   | 14      | 2.88(1.09–7.63) | 1.87(0.34–5.65) |
| Duration of DM                        |      |         |             |             |
| 1–5 year                              | 18   | 121     | 1           | 1           |
| > 5 year                              | 84   | 185     | 3.05(1.75–5.33) | 2.42(0.72–4.78) |
| Body Mass Index                       |      |         |             |             |
| Normal                                | 36   | 149     | 1           | 1           |
| Underweight                           | 10   | 54      | 0.77(0.36–1.65) | 1.73(0.70–4.28) |
| Overweight                            | 56   | 103     | 2.25(1.38–3.67) | 1.89(0.02–3.50) |
| Regular follow up in the diabetic clinic |      |         |             |             |
| No                                    | 64   | 81      | 4.68(2.91–7.52) | **4.19(2.28–7.71)** |
| Yes                                   | 38   | 225     | 1           | 1           |
| Received DM education                 |      |         |             |             |
| No                                    | 84   | 144     | 5.25(3.01–9.16) | **2.87(1.44–5.72)** |
| Yes                                   | 18   | 162     | 1           | 1           |
| Alcohol drinking                      |      |         |             |             |
| Yes                                   | 26   | 33      | 2.83(1.56–5.02) | **2.99(1.46–6.12)** |
| No                                    | 76   | 273     | 1           | 1           |
| Regular physical exercise             |      |         |             |             |
| No                                    | 71   | 183     | 1.54(0.95–2.49) | 1.34(0.82–2.07) |
| Yes                                   | 31   | 123     | 1           | 1           |
| Discontinue medication                |      |         |             |             |
| Yes                                   | 92   | 170     | 7.36(3.69–14.68) | **4.31(1.92–9.68)** |
| No                                    | 10   | 136     | 1           | 1           |

AOR: Adjusted Odds Ratio, CI: Confidence Interval, COR: Crude Odds Ratio, DM: Diabetes Mellitus, Type I: Type one, Type II: Type two
This institutional-based unmatched case-control study was conducted in North Wollo and Waghimra Zone public hospitals with diabetes mellitus patients to investigate the determinant factors of diabetic ketoacidosis. The literature identified different determinant factors of diabetic ketoacidosis (2, 11–13). The results of this study identified determinants of diabetic ketoacidosis among diabetes mellitus patients. Follow-up in the diabetic clinic, receiving diabetic education, alcohol drinking, discontinuation of medication, presence of comorbidity, and type of diabetes mellitus were found determinant factors of diabetic ketoacidosis among diabetes mellitus patients. This study showed that the presence of follow-up in the diabetic clinic was found a determinant factor of diabetic ketoacidosis among diabetes patients. Diabetes mellitus patients who did not have regular follow-up in the diabetic clinic were nearly four times more likely to develop diabetic ketoacidosis than patients who had regular follow-up. This is in line with studies done in Southwest Ethiopia (14, 15). The reason might be due to diabetes mellitus patients who had regular follow-up in the diabetic clinic regularly knowing and monitors their blood glucose level which further prevents the development of diabetic ketoacidosis. Receiving diabetic education was also found a determinant factor of diabetic ketoacidosis. This findings was consistent with different studies done in selected hospitals of West Ethiopia (9, 16) and Northeast Ethiopia (17). The reason might be due to patients who received education about diabetes mellitus can aware of the different blood glucose controlling mechanisms as they can easily prevent the occurrence of diabetic ketoacidosis. The finding of this study also revealed that alcohol drinking was a determinant factor of diabetic ketoacidosis. Diabetic mellitus patients who drank alcohol were nearly three times more likely to develop diabetic ketoacidosis than those who did not drink alcohol. This is consistent with a study

| Variable                  | Case | Control | COR (95% CI)     | AOR (95% CI)  |
|---------------------------|------|---------|------------------|---------------|
| Emotional disturbance     | Yes  | 76      | 2.07 (1.26–3.42) | 1.36 (0.68–2.75) |
|                           | No   | 26      | 1                | 1             |
| Presence of infection     | Yes  | 74      | 3.35 (2.05–5.46) | 1.99 (0.61–2.07) |
|                           | No   | 28      | 1                | 1             |
| Presence of comorbidity   | Yes  | 69      | 2.26 (1.13–4.33) | 2.57 (1.37–4.84) |
|                           | No   | 33      | 1                | 1             |
| Type of DM                | Type I | 44    | 1.85 (1.16–2.94) | 2.01 (1.11–3.63) |
|                           | Type II | 58   | 1                | 1             |

AOR: Adjusted Odds Ratio, CI: Confidence Interval, COR: Crude Odds Ratio, DM: Diabetes Mellitus, Type I: Type one, Type II: Type two
conducted in Atlanta (6). Patients who discontinued their medication were 4.33 times more likely to develop diabetic ketoacidosis than patients who did not discontinue their medication. This finding agreed with studies conducted in Debre Markos referral hospital (13) and a tertiary health care centers in Ethiopia (11). This is because discontinuation of medications like oral hypoglycemic agents and insulin can increase the blood glucose level through decreasing tissue glucose uptake, increasing glucose absorption from the gastrointestinal tract, increasing gluconeogenesis and glycogenolysis, which results in lipolysis and cause diabetic ketoacidosis.

The presence of comorbidity was also a determinant factor of diabetic ketoacidosis which is supported by a study done in Hawassa comprehensive specialized hospital (10), Jima University Specialized Hospital (3), Shanan Gibe Hospital (9), and Jima Medical Center (12). This might be because diabetes mellitus patients who have comorbidities, such as hypertension, chronic heart failure, gastrointestinal disturbance, renal disease, and others can directly or indirectly disturb the normal functions of insulin and other hormones which might be cause for the occurrence of diabetic ketoacidosis. The findings of this study also revealed that type one diabetes mellitus patients were more likely to develop diabetic ketoacidosis than those patients with type two diabetes mellitus. This is supported by different studies conducted at Tertiary hospitals in North east Ethiopia (2), Debre Markos referral hospital (13), West Ethiopia (16), and Jima Medical Center (12). This is due to the fact that patients with type one diabetes mellitus had deficiency of insulin which causes breakdown of lipid resulting diabetic ketoacidosis, whereas type two diabetes mellitus patients had endogenous insulin which prevents lipolysis that can prevent the occurrence of diabetic ketoacidosis.

**Conclusion**

This study identified different behavioral and clinical determinants of diabetic ketoacidosis among diabetes mellitus patients. Absence of regular follow-up in the diabetic clinic, not receiving diabetic education, discontinuation of medications, alcohol drinking, presence of comorbidities, and being type one diabetes mellitus were independent determinants of diabetic ketoacidosis. Therefore, health professionals should intervene on the identified determinants of diabetic ketoacidosis to prevent the occurrence of diabetic ketoacidosis, know and manage the identified determinant factors of diabetic ketoacidosis, give health education regarding the determinant factors of diabetic ketoacidosis to all diabetic patients, and manage and prevent the possible baseline comorbidities. Furthermore, hospital administrators should emphasize and determine the determinant factors of diabetic ketoacidosis.

**List Of Abbreviations**

AOR
Adjusted Odds Ratio, BSc:Bachelor of Sciences, CI:Confidence Interval, COR:Crude Odds Ratio, DKA:Diabetic ketoacidosis, DM:Diabetes Mellitus, MSc:Master of Science, RCSRC:Research and Community Service Review Committee, SPSS:Statistical Package for Social Science, SD:Standard Deviation
Declarations

Ethical approval and consent form

Ethical clearance was obtained from Woldia University, College of Health Sciences, Research and Community Service Review Committee (RCSRC). A formal letter of permission and support was written to RHB from Woldia University and finally to selected health facilities. The study participants were informed about the purpose of the study, their right to refuse. Written and signed voluntary consent were obtained from the study subjects before distributing the questionnaire. The respondents were also told that the information obtained from them was treated with complete confidentiality and did not cause any harm to them. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable

Availability of dataset and materials

The datasets used for analysis are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

Funding

Woldia University: The funder has no role in the study design, data collection, analysis, and publication

Authors' contributions

AG. wrote the main manuscript text, AG. And AD. Worte the methodology and the discussion section. AG, MB, GG. And AW prepared figures and tables. All authors contributed to data analysis, drafting or revising the article, have agreed on the journal to which the article will be submitted, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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