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Diabetic ketoacidosis treatment outcomes and associated factors among adult diabetic patients in Ethiopia: A systematic review and meta-analysis

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ABSTRACT

Background: Diabetic ketoacidosis is a severe complication of diabetes that can threaten life and has a considerable effect on healthcare systems, especially in developing nations such as Ethiopia. Although it is clinically significant, comprehensive data on the factors that lead to unsatisfactory treatment outcomes in diabetic ketoacidosis patients in Ethiopia are lacking. This review aims to investigate and evaluate unsatisfactory treatment outcomes and multiple contributing factors related to diabetic ketoacidosis among patients with diabetes in Ethiopia. This review seeks to identify these factors to provide insights that can guide improvements in the management and treatment of diabetic patients.

Methods: Articles documenting unfavorable treatment outcomes and related aspects of diabetic ketoacidosis among Ethiopian diabetes patients were meticulously sought from various databases, including PubMed/MEDLINE, the Cochrane Library, Science Direct, HINARI, Google Scholar, and gray literature. After the data were extracted, they were imported into Stata software version 17 for analysis. The Cochrane Q test and I^2 statistic were used to evaluate heterogeneity.

Results: A total of 580 duplicates were eliminated from the initial set of 1578 papers obtained from PubMed (3), Google Scholar (1,550), HINARI (11), Science Direct (13), and the Cochrane Library (1). The pooled prevalence of poor treatment outcomes for diabetic ketoacidosis was 8 %. Key risk factors for poor treatment outcomes included a Glasgow Coma Scale (GCS) score of less than 15 (POR = 3.16; 95 % CI: 1.52–4.80), sepsis (POR = 2.92; 95 % CI: 1.12–4.72), and comorbidities (POR = 3.66; 95 % CI: 1.64–5.68).

Conclusion: The pooled prevalence of poor treatment outcomes of diabetic ketoacidosis in Ethiopia was high. A GCS score of less than 15, sepsis, and comorbidities were identified as significant risk factors for poor treatment outcomes in diabetic ketoacidosis patients. Addressing and minimizing these factors could help reduce the incidence of poor treatment outcomes in diabetic ketoacidosis patients in Ethiopia.

1. Introduction

Diabetes mellitus (DM) represents a group of metabolic disorders characterized by increased blood glucose concentrations [1]. The International Diabetes Federation estimated that 463 million adults were diagnosed with DM in 2019 and 571 million in 2021 [2]. By 2030, these figures are expected to increase to 643 million, and by 2045, they will reach 783 million [3]. One serious and potentially fatal side effect of diabetes mellitus is diabetic ketoacidosis (DKA) [4]. Multiple pathophysiologic factors have been postulated for the pathophysiology of DKA, including oxidative stress and pro inflammatory cytokines (i.e., tumor necrosis factor-alpha (TNF-α)) that might lead to inadequate insulin secretion or utilization in the body [5]. Polyuria, polydipsia, weight loss, vomiting, dehydration, exhaustion, altered mental status, Kussmaul respirations, tachycardia, and hypotension are among the clinical features of DKA [6]. When a patient has a blood pH of less than

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7.30 and a bicarbonate level below 18 meq/L, combined with some degree of mental status impairment, DKA is diagnosed [5,7].

Diabetic ketoacidosis is associated with high mortality rates in the developing world [8]. Sepsis is associated with a lower glass coma scale and comorbidities are potentially lethal consequences that can result from improper care of DKA [9]. Potassium use during admission and early treatment of comorbidities also increase the mortality of diabetes patients with diabetic Kato acidosis [10]. Fewer than 5 % of DKA deaths have been documented in treatment-experienced facilities in Asia, Europe, and the Americas [11]. DKA has an unacceptable death rate in Africa; studies from Kenya, Tanzania, and Ghana have shown death rates ranging from 26 to 29 % [12]. In Ethiopia, mortality from DKA is high [10]. A retrospective study conducted at Shashemene Referral Hospital reported that DKA contributed to 12 % of in-hospital mortality [13]. Another study conducted at Hiwot Fana Specialized University Hospital reported that approximately 11 % of patients with a diagnosis of DKA died in the hospital [9].

Different nations have implemented various prevention measures and tactics to lower mortality, including adopting DKA treatment standards, raising awareness of the pathophysiology of DKA, and educating people about diabetes self-management [14]. However, these strategies have not been appropriately implemented in developing countries such as Ethiopia [15,16]. The prevention and management of DKA are further complicated by the absence of drug supplies, their high cost, and the existence of comorbid illnesses, improper insulin storage, medication non adherence, electrolyte imbalance, and smoking [17,18].

Insulin therapy, fluid and electrolyte replacement, and addressing the underlying causes are necessary for the effective management of DKA [19]. However, a number of factors, such as the degree of acidosis, the patient's comorbidities, the promptness of medical response, and the healthcare infrastructure, can affect the effectiveness of treatment outcomes [19]. A comprehensive understanding of these factors is essential for optimizing treatment protocols and improving patient outcomes.

This systematic review and meta-analysis aimed to assess the treatment outcomes of DKA in adult patients and identify the key factors associated with improved or worsened prognosis. By synthesizing data from multiple studies in Ethiopia, we seek to provide clearer insights into the clinical management of DKA and the factors that influence recovery, complications, and mortality. The findings from this review are expected to contribute to evidence-based guidelines and inform clinical practices aimed at reducing the burden of DKA-related complications.

2. Methods

2.1. Search strategy and database

This systematic review and meta-analysis was reported in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines [20]. To avoid duplication, the presence of comparable published systematic reviews and meta-analyses on this subject was examined. The goal of the search approach was to find both published and unpublished research. Relevant publications were identified by searching international databases, PubMed/MEDLINE, the Cochrane Library, Science Direct, HINARI, Google Scholar, and gray literature. Using related keyword terms and phrases, the medical subject headings "Diabetic ketoacidosis," "Treatment outcome," "Associated factor," "Adults," and "Ethiopia" were employed. The Boolean operators "OR" and "AND" were used both singly and in combination to find relevant articles in a methodical manner. Every source of evidence that was included had its reference list checked for more research. Two authors (T.K. and D.M.) conducted the task of finding sources from all specified electronic databases between November 20, 2024, and January 16, 2025. Reference lists of qualifying research were also sought to incorporate as many relevant studies as possible. The aforementioned database was searched via the following Medical Science Heading (MeSH) terms: "Diabetic ketoacidosis" OR "DKA" AND "treatment outcome" OR " mortality" OR "poor treatment outcome" AND "determinants" OR "predictors" OR "associated factors" OR "risk factors" OR "contributing factors" AND "adults" OR "age greater than 18″ AND "Ethiopia." Article duplication was handled via EndNote *X*9.

2.2. Outcome of review

The poor treatment outcome of diabetic ketoacidosis and its associated variables among adult diabetes patients is the review's outcome variable. For the purposes of the current review, the operational definition that follows was taken into consideration. Patients who improved following treatment and were discharged were considered to have good treatment outcomes. Poor treatment outcome: Patients who refuse medical advice often experience treatment difficulties, lengthy hospital stays, or even pass away while in the hospital [10].

2.3. Inclusion and exclusion criteria

The primary focus of the inclusion criteria for this review was quantitative studies that documented the treatment outcome and related factors of diabetic ketoacidosis among adult diabetic patients in Ethiopia, as well as freely accessible and English-language publications. The exclusion criteria included case reports, abstracts, qualitative research, journals with restricted access, studies conducted outside of Ethiopia, and studies published in languages other than English.

2.4. Data extraction

On a Microsoft Excel spreadsheet, two writers (TAK and DM) separately extracted the data via a defined data extraction checklist. Disagreements between the two writers during the data extraction process were resolved through discussion. The corresponding authors' names year of publication, study design, study population, study area/region, sample size, sampling technique, participants, prevalence of poor treatment outcome, and factors associated with poor treatment outcome were extracted via a standardized Microsoft Excel sheet template. The following standards are used to choose the extracted associated factors: 1) comparable operational definitions are used in the original research. 2) Reportedly, comparable association metrics are related and documented in two or more studies in a comparable direction. 3) Are related and documented in two or more studies in a comparable direction. The extracted data were subjected to critical examination, and the findings were presented narratively.

2.5. Quality assessment

The Newcastle Ottawa scale, which provides an evaluation of each publication on the basis of methodological quality, caliber of comparability, and excellence of results separated into eight distinct categories, was used by three writers (TAK, AS, and DM) to assess the quality of the included studies. With the exception of comparability, which can be adjusted to the particular topic of interest to score up to two points, each item on the scale is scored from one point. As a result, each study can have a maximum score of 9, with overall values ranging from 0 to 3, 4–6, and 7–9, respectively, indicating low, moderate, and high risk of bias [21].

2.6. Statistical analysis

After extraction, the data were exported for analysis via Stata software version 11. A forest plot, which presents the prevalence of poor treatment outcomes at the 95 % CI for each study and the pooled prevalence of the combined studies, was used to illustrate the heterogeneity among the studies. The existence or lack of heterogeneity was statistically assessed via the Cochrane Q test and I2 statistic; values ranging from 0 to 40, 40–60, 60–90, and 90–100 %, respectively,

indicated low, medium, substantial, and high heterogeneity [22]. Publication bias (small study effect) was checked graphically via a funnel plot and statistically via Egger's regression test at the significance level of $P < 0.05$.

3. Results

3.1. Study selection and identification

From the original records of 1578 papers sourced from PubMed [3], Google Scholar (1550), HENARRY [11], Science Direct [13] and the Cochrane Library (1), a total of 580 duplicates were removed. After a review of their titles and abstracts, an extra 827 items were excluded. Finally, studies were excluded if they were carried out outside of Ethiopia, did not include diabetic patients, or did not provide data on the prevalence of diabetic ketoacidosis treatment outcomes. The meta-analysis ultimately included seven published articles Fig. 1.

3.2. Characteristics of the included studies

Five of the studies included were institution-based cross-sectional studies, whereas the others were retrospective studies. The Oromia region reported the highest prevalence of poor treatment outcomes (15.1 %) [23]. In contrast, Addis Ababa had the lowest value (1.5 %) [24]. The studies were carried out in different areas of the country: 2 from Addis Ababa [24,25], 3 from the Oromia region [10,23,26], 1 from Harrere [9], and 1 from the Amhara region [27]. The detailed characteristics of the included studies are presented in Table 1.

3.3. Quality of the included studies

Based on the quality assessment of the included studies, four studies (n = 57 %) were classified as high quality, whereas three studies (n = 43 %) were deemed medium quality.

3.4. Publication bias

To evaluate publication bias, Egger's regression intercept test was performed. Egger's test results objectively demonstrated that there was no significant publication bias, whereas a subjective analysis of the funnel plot indicated symmetry of publication bias. Fig. 2.

3.5. Meta-regression and sensitivity analysis

The studies analyzed exhibited significant heterogeneity. Meta-regression and sensitivity analyses were performed to investigate possible sources of this variability. Although the meta-regression evaluated aspects like sample size and year of publication, none of these factors were determined to significantly clarify the observed heterogeneity (Table 2). The sensitivity analysis also showed that the overall pooled prevalence of diabetic ketoacidosis treatment outcomes among adolescents in Ethiopia was not significantly influenced by any individual study. This suggests that the pooled estimates are stable and not significantly influenced by any single study Fig. 3.

3.6. Meta-analysis

Among diabetic patients in Ethiopia, the pooled estimate of treatment outcomes for diabetic ketoacidosis is 8 % (95 % CI: 0.05, 0.12). The meta-analysis revealed considerable heterogeneity among the studies,

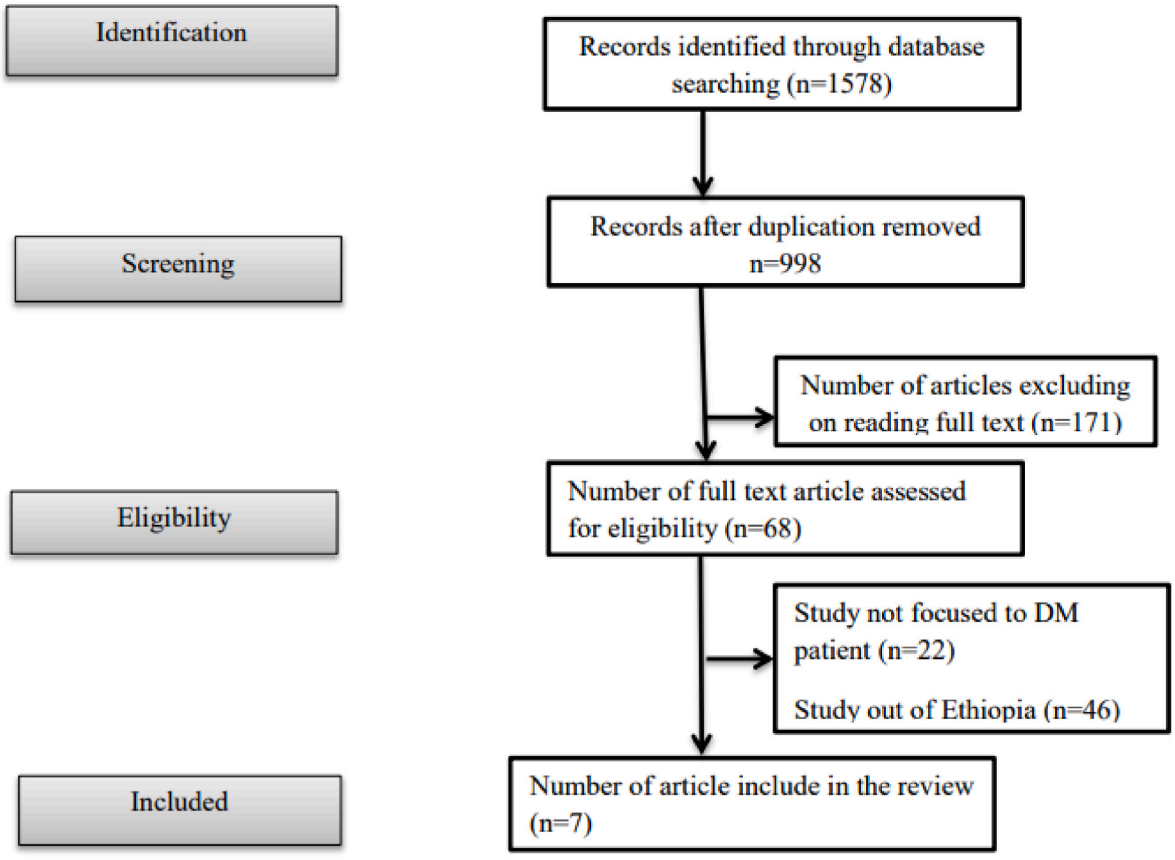

Fig. 1. PRISMA flow diagram of article selection for a systematic review and meta-analysis of diabetic ketoacidosis treatment outcomes and associated factors among diabetic patients in Ethiopia (N = 7).

Table 1
Baseline characteristics of the studies included in the review of diabetic ketoacidosis treatment outcomes and associated factors among diabetic patients in Ethiopia.

Auteur	publication year	Region	study design	study pop	Sample size	poor Rx outcome	Prevalence of poor Rx out come	Se of proportion	quality scores
Kassaye et al.	2018	Oromia	Cross sectional	DM Patient	357	54	15.1 %	0.004652661	8
Belachew et al.	2020	Addis Ababa	Cross sectional	DM Patient	261	4	1.5 %	0.000632184	7
Abegaz et al.	2018	Amhara	retrospective study	DM Patient	387	17	4.4 %	0.001250646	8
Derse et al.	2023	Addis Ababa	Cross sectional	DM Patient	357	14	3.9 %	0.001201681	8
Yigazu et al.	2023	Oromia	Cross sectional	DM Patient	201	23	11.4 %	0.006238806	7
Taye et al.	2021	Oromia	Cross sectional	DM Patient	225	28	12 %	0.005866667	8
Tekeste et al.	2020	Harrere	retrospective study	DM Patient	321	17	11.1 %	0.003803738	7

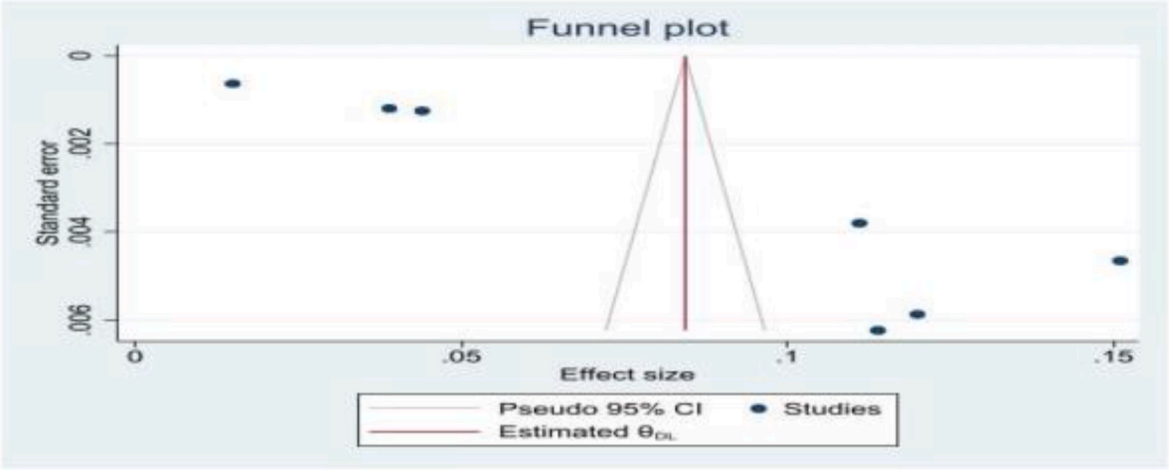

Fig. 2. Funnel plot assessed for publication bias in the review of diabetic ketoacidosis treatment outcomes and associated factors among diabetic patients in Ethiopia (N = 7).

Table 2
Meta-regression of diabetic ketoacidosis treatment outcomes and associated factors among diabetic patients in Ethiopia.

logprev |	Coefficient	Std. err.	t	P>|t|	[95 % conf. Interval]	
Pub year |	−0.0076,929	0.0167,924	−0.46	0.671	0.054,316	0.0389,301
Sample size |	−0.0002683	0.0004802	−0.56	0.606	0.0016,016	0.001065
_cons|	15.70871	34.00729	0.46	0.668	−78.71066	110.1281

with $I^2 = 99.9$ % and $P < 0.001$. A random effects model was therefore utilized to determine the pooled estimate of treatment outcomes for diabetic ketoacidosis in Ethiopia. (Fig. 4).

3.7. Subgroup analysis

We also performed a subgroup analysis based on study period (before 2020 and equal to vs. after 2020), sample size (less than 300 vs. 300 or more), and study region. The results indicated that the pooled prevalence of diabetic ketoacidosis treatment outcomes did not show significant differences based on the study period or sample size. However, when analyzed by region, the pooled prevalence was lower in Addis Ababa and Amhara regions compared to the overall pooled result, while it was higher in Oromia and Harrere regions (Table 3).

3.8. Associated factors of poor treatment outcome

Factors associated with poor treatment outcomes in patients with diabetic ketoacidosis. This encompasses a GCS of under 15, comorbidity, and sepsis. This meta-analysis revealed a correlation between a GCS score of less than 15 and poor treatment outcomes. Patients with a GCS score of less than 15 had odds of poor treatment outcomes from diabetic ketoacidosis that were 3.16 times greater than those with a GCS score of 15 (POR = 3.16; 95 % CI: 1.52–4.80). There was no heterogeneity among the studies. As a result, we employed the fixed effects model (I^2 = 0.00 %, Pvalue <0.001) (Fig. 4). This review revealed that patients with sepsis were 2.92 times more likely to experience poor treatment outcomes from diabetic ketoacidosis patients than were those without sepsis (POR = 2.92; 95 % CI: 1.12–4.72). The studies were homogeneous. Consequently, we applied a fixed effects model (I^2 = 0.00 %, P value < 0.001), as shown in Fig. 5. The risk of a poor treatment outcome from diabetic ketoacidosis was 3.66 times greater for patients with comorbidities than for those without comorbidities (POR = 3.66; 95 % CI: 1.64–5.68). The studies were homogeneous. Hence, we utilized a fixed effects model (I2 = 0.00 %, Pvalue <0.001) (Figs. 5–7).

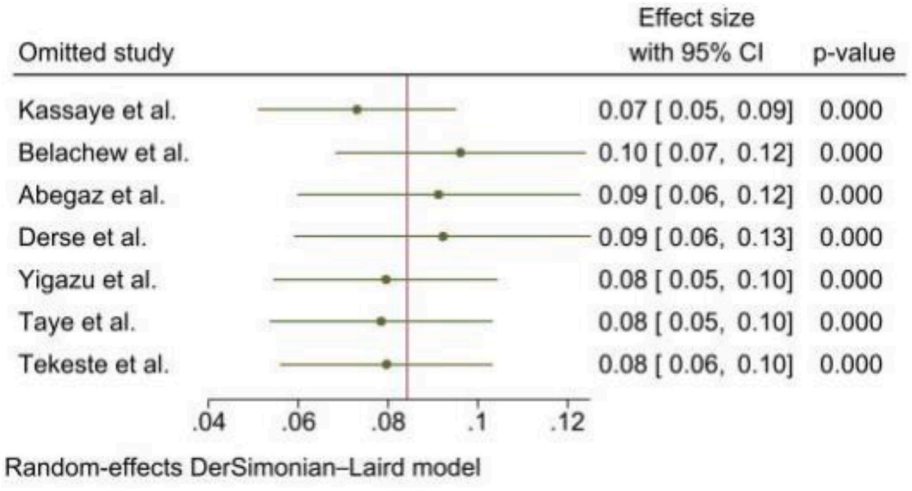

Fig. 3. Sensitivity analysis results of diabetic ketoacidosis treatment outcomes and associated factors among diabetic patients in Ethiopia (N = 7).

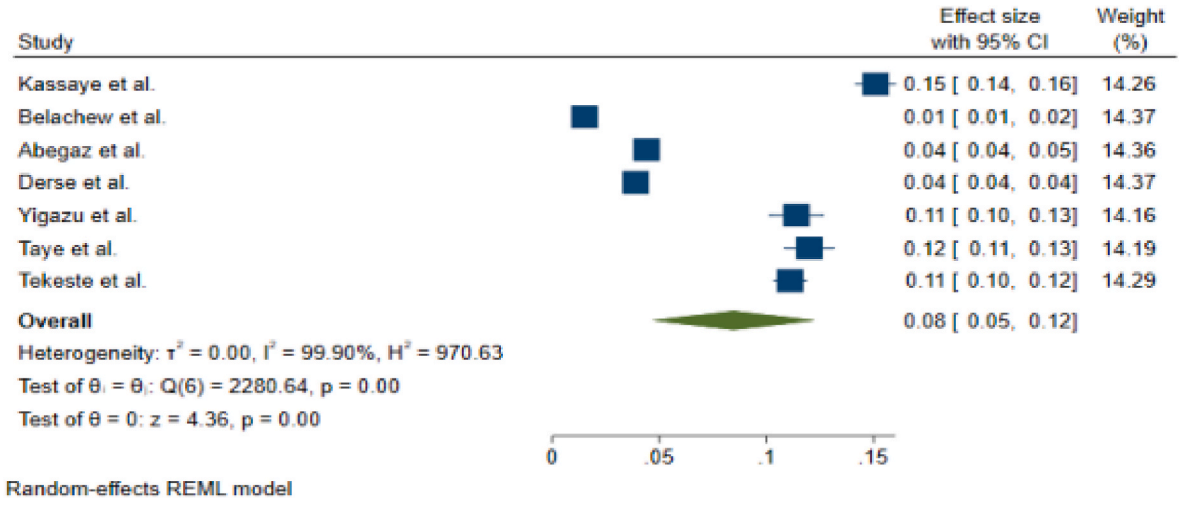

Fig. 4. Forest plot indicating the pooled prevalence of diabetic ketoacidosis treatment outcomes and associated factors among diabetic patients in Ethiopia (N = 7).

Table 3
Pooled subgroup analysis results by study period, sample size and region diabetic ketoacidosis treatment outcomes and associated factors among diabetic patients in Ethiopia.

Sub group	Categories	pooled results
By study period	Before or equal to 2020	0.091
	After 2020	0.080
By sample size	Less than 300	0.083
	Greater than or 300	0.085
By region	Addis Ababa	0.027
	Oromia	0.128
	Amhara	0.044
	Harrere	0.111

4. Discussion

This review offers an examination of how often inadequate treatment outcomes occur among diabetic patients facing hyperglycemic crises, with a particular emphasis on DKA in Ethiopia. The results of our study show that the pooled estimate for poor treatment outcomes in DKA among diabetic patients in Ethiopia is 8 % (95 % CI: 0.05, 0.12; P < 0.001).

This finding aligns with similar research carried out in South Africa (7.5 %) [28], Thailand (8.5 %) [29], China, and Taiwan, where poor treatment outcomes vary from 2.27 % to 10.6 % [30,31]. However, the observed prevalence in Ethiopia is notably lower than that reported in other countries, such as Nigeria (16 %) [32], Kenya (29.8 %) [33] Cameroon (21.7 %) [34], Zambia, and Malaysia, where DKA mortality rates are 16.66 % and 17.6 %, respectively [35–37]. These findings may differ due to several factors, such as variations in clinical presentation, the effectiveness of DKA detection and management, the prevalence of precipitating factors, and the capacity to address complications across various healthcare settings. While the Ethiopian findings suggest a relatively moderate mortality rate, it is important to note that the outcomes remain higher than those reported in some other regions with well-established medical infrastructure. For example, studies conducted in Colombia (2.3 %) [38], Thailand (4.3 %) [39], Israel (4.1 %) [40], Taiwan (0.67 %) [41], and Saudi Arabia (1.83 %) [42] reported significantly lower DKA-related mortality rates. Additionally, in treatment-experienced facilities across Asia, Europe, and the Americas, a 5 % mortality rate for DKA has been documented [11].

Although the pooled prevalence of diabetic ketoacidosis treatment outcome did not show significant differences based on the study period or sample size. However, when analyzed by region, the pooled prevalence was lower in Addis Ababa and Amhara regions compared to the overall pooled result, while it was higher in Oromia and Harrere regions.

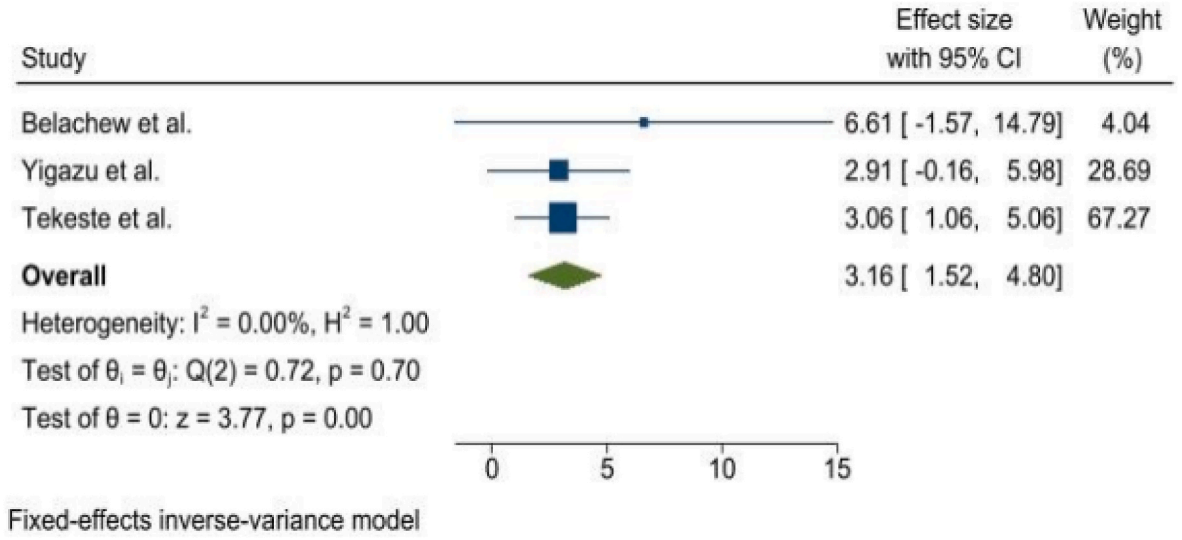

Fig. 5. Pooled association between a GCS score less than 15 and poor treatment outcome of diabetic ketoacidosis among diabetic patients in Ethiopia (N = 7).

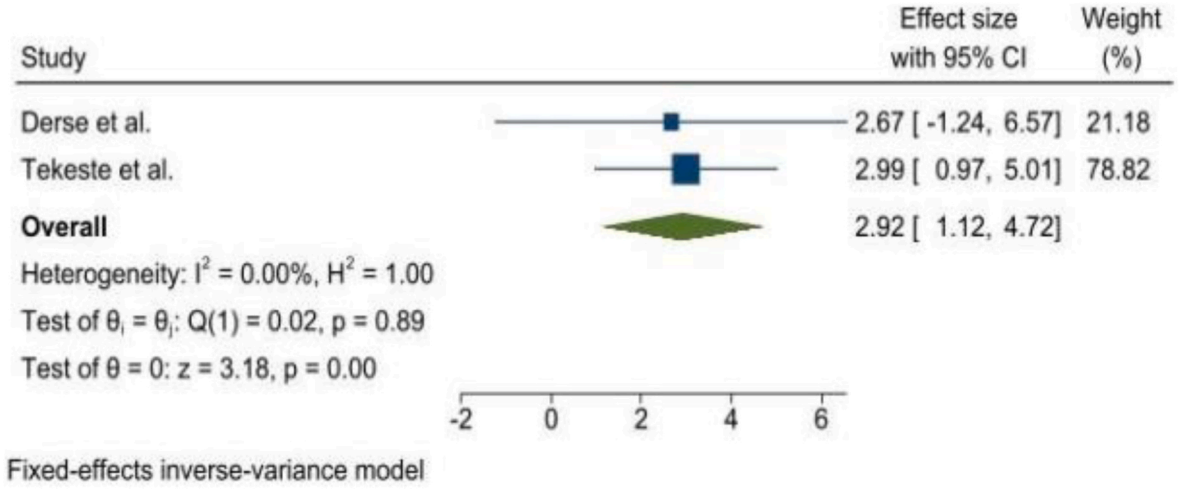

Fig. 6. Pooled association between sepsis and poor treatment outcome of diabetic ketoacidosis among diabetic patients in Ethiopia (N = 7).

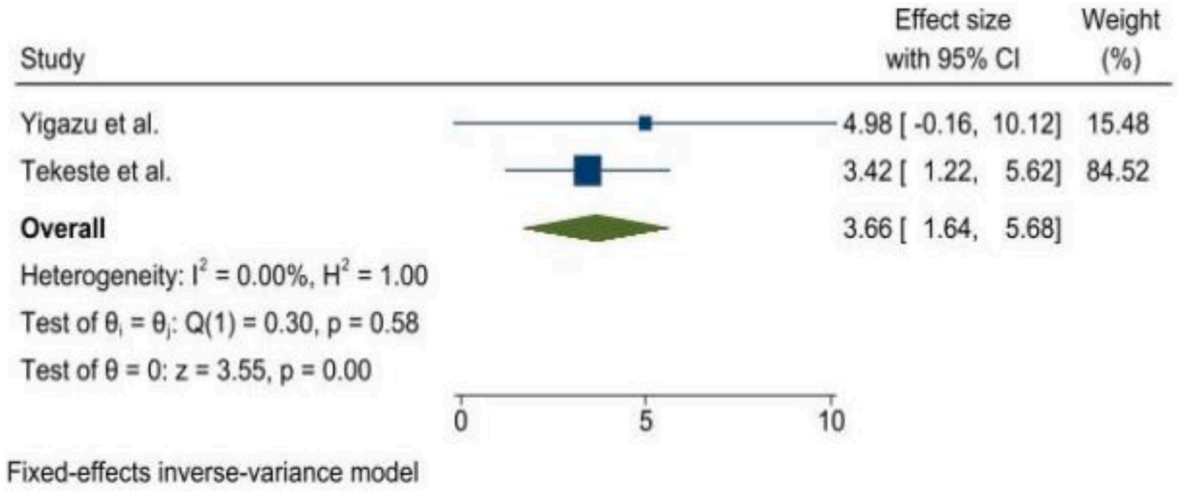

Fig. 7. Pooled association between comorbidities and poor treatment outcomes of diabetic ketoacidosis among diabetic patients in Ethiopia (N = 7).

Several factors may account for the regional variations observed in the pooled prevalence of diabetic ketoacidosis treatment outcomes. These discrepancies may arise from differences in healthcare infrastructure, access to medical facilities, and the availability of trained healthcare professionals across various regions. As an example, areas such as Addis Ababa and Amhara may experience varying degrees of healthcare access, potentially affecting the diagnosis and treatment results for diabetic ketoacidosis. Conversely, the Oromia and Harar regions may have superior or more extensive healthcare interventions that aid in enhancing treatment outcomes.

Furthermore, regional differences in socioeconomic factors like income levels, education, and public health initiatives could impact the prevalence and management of diabetic ketoacidosis. These discrepancies could also be elucidated by variations in regional health policies or public awareness initiatives. Additionally, differences in the lifestyle, dietary habits, and overall health of the local population may influence the results.

These discrepancies may indicate variations in the standards of healthcare facilities, encompassing technological advancements, laboratory capabilities, and the overall quality of clinical care provided in each environment. The differing outcomes of DKA treatment highlight the need to enhance healthcare infrastructure, training, and the management of diabetic emergencies in areas where mortality rates are elevated.

Patients with a GCS score of less than 15 had odds of poor treatment outcomes from diabetic ketoacidosis that were 3.16 times greater than those with a GCS score of 15 (POR = 3.16; 95 % CI: 1.52–4.80). Patients with a GCS score of less than 15 had significantly greater odds of poor treatment outcomes in diabetic ketoacidosis (DKA) than those with a GCS score of 15. This discovery aligns with studies carried out in Zambia [37], India [43], and Indonesia [44], which reported that lower GCS scores ($\leq$15) are independent predictors of mortality among hospitalized patients with DKA.

This association can be explained by the increased risk of complications, such as aspiration, faced by patients with altered mental states, especially those in a coma. This is particularly relevant in the context of DKA. A diminished level of consciousness often signals more serious underlying metabolic disturbances that may result in significant organ dysfunction. Consequently, these patients have an increased likelihood of organ failure, which further increases the risk of adverse treatment outcomes and death. The results underscore the necessity of vigilant monitoring and proactive management of DKA in patients with altered mental status to enhance clinical outcomes.

This review revealed that patients with sepsis are at greater risk of experiencing unfavorable treatment outcomes from DKA than are those without sepsis. This finding is consistent with the results of studies carried out in China [45], Saudi Arabia [42], and the United States [46]. These studies also revealed that sepsis is a major risk factor for negative outcomes among DKA patients. Several factors can explain the link between sepsis and unfavorable treatment outcomes in DKA patients. An uncontrolled immune response to infection can lead to sepsis, a condition that can potentially threaten life and cause organ failure. Studies conducted prior to clinical trials have shown that diabetes negatively affects the adaptive immune system and disturbs several aspects of the innate immune response. Both type 1 and type 2 diabetes are characterized by increased blood glucose levels and changes in the immune response that rely on glycaemia. These elements can worsen the pathophysiological processes of sepsis and lead to a more severe prognosis in individuals with diabetes [47,48]. Sepsis also initiates the secretion of counter regulatory hormones such as adrenaline and cortisol, which reduce the effectiveness of insulin in controlling blood glucose levels. This hormonal reaction can exacerbate hyperglycemia and complicate DKA management, increasing the risk of adverse outcomes. These mechanisms underscore the urgent necessity of early detection and intervention among diabetic patients with sepsis to improve their prognosis and diminish the likelihood of negative treatment results.

It was also discovered that having comorbidities raised the likelihood of unfavorable treatment results from DKA. This finding aligns with studies conducted in Jordan [49], Italy [50] and the United Kingdom [51], which showed that comorbidities like cardiovascular diseases (CVD) and chronic kidney disease (CKD) increase the risk of negative DKA outcomes. As an example, heart diseases, especially arrhythmias and acute cardiac events, can greatly complicate DKA and deteriorate the prognosis for those with diabetes. Likewise, chronic kidney disease (CKD) compromises the body's capacity to regulate fluid and electrolyte balance an essential aspect of DKA management [52]. CKD makes it more difficult to choose and dose medications for treating DKA, which further raises the risk of inadequate treatment results. Studies conducted in other areas, including in, corroborate these results [53–55]. They demonstrate that for diabetic patients, the coexistence of conditions such as CVD and CKD raises the risk of serious complications and unfavorable outcomes during DKA treatment [56,57]. The findings underscore the need for comprehensive management strategies that consider both diabetes and its comorbidities in order to enhance treatment outcomes for DKA patients.

This correlation can be attributed to the effect of comorbidities on various bodily systems. Comorbid conditions can worsen the severity of DKA, complicating its clinical progression and impairing the body's ability to mount an effective defense against the disease. These additional health problems could further impair organ function, complicating the effective management of DKA and adherence to the suggested treatment protocols. Consequently, comorbidities not only complicate the management of DKA but also result in slower or less thorough recoveries, culminating in adverse outcomes. This highlights the necessity for all-encompassing management strategies.

4.1. Limitations

Several factors may have introduced selection bias in the estimation of prevalence. First, a considerable number of the studies considered in this meta-analysis included participants solely from hospitals. This recruitment strategy might not provide a complete representation of the wider population of diabetic patients who are experiencing diabetic ketoacidosis. Furthermore, the studies examined in this meta-analysis were mainly from specific regions of Ethiopia, which could distort the estimated prevalence, as it may not represent the whole country. The majority of the studies chosen for the final analysis focused on only a few specific areas, which may have resulted in the neglect of significant regional variations and an inadequate representation of the entire population. Finally, the analysis focused only on studies published in English. This may have resulted in the omission of pertinent research available in other languages, thus further constraining the generalizability of the findings.

And we will suggest that future studies attempt to assess the individual contributions of these comorbidities to better understand their role in DKA outcomes and improve patient stratification for targeted treatment approaches.

5. Conclusion

Among diabetic patients, the rates of unfavorable treatment outcomes subsequent to DKA were found to be elevated. The key predictors of these outcomes included a Glasgow Coma Scale (GCS) score of less than 15, sepsis, and the presence of comorbidities. We advise healthcare staff to closely monitor and assess patients who have these risk factors to reduce the occurrence of negative outcomes. Furthermore, it would be advantageous to include diabetes screening in health extension programs and to offer diabetes care services at basic healthcare facilities. Physicians should also prioritize the early identification and management of DKA triggers and coexisting health issues at the time of initial patient presentation. In addition, bolstering inpatient management protocols for DKA and guaranteeing the availability of advanced

laboratory investigations are vital measures for improving patient outcomes and minimizing mortality.

Clinical trial number

Not applicable.

CRediT authorship contribution statement

Tsegaamlak Kumelachew Derse: Conceptualization. **Desalegn Metiku Kidie:** Writing – review & editing, Writing – original draft, Investigation. **Addisu Simachew Asgai:** Writing – review & editing, Writing – original draft. **Tadios lidetu:** Writing – review & editing, Writing – original draft. **Moges Tadesse Abebe:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Investigation, Data curation.

Consent to publish declaration

Not applicable.

Ethics approval and consent to participate

Ethical approval was not applicable for this systematic review and meta-analysis study.

Informed consent was not applicable.

Availability of data and materials

The original contributions presented in the study are included in the article/supplementary material, and further inquiries can be directed to the corresponding author.

Funding

This approach is not applicable since the study is a systematic review and meta-analysis.

Declaration of competing interest

The authors declare that we have no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.metop.2025.100360.

Abbreviations

CI	Confidence interval
DM	Diabetes mellitus
DKA	Diabetic ketoacidosis
POR	Pooled odds ratio

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