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A Cross-Sectional Study on the Incidence and Severity of Hypoglycemia During Hemodialysis in ESRD: Diabetic and Non-Diabetic Cases

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Hypoglycemia is frequent in patients with ESRD with or without diabetes and those receiving hemodialysis. It is important to know the occurrence and prognosis of this condition to better manage patients with it.
Objective: The objective of this study is to measure the incidence and magnitude of hypoglycemia in ESRD patients during hemodialysis and to compare diabetic and non-diabetic cases.

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Methods: This cross-sectional observational survey was carried out from February2023 to July 2023 at Community Based Medical College in Bangladesh. In this cross-sectional study, 156 ESRD patients with regular hemodialysis were recruited. Self-measured capillary blood glucose levels were recorded during dialysis, and hypoglycemia episodes were graded. All data were analyzed using Statistical Package for Social Sciences (SPSS) software version 25.

Results: The study included 156 ESRD patients undergoing hemodialysis. Hypoglycemia occurred in 100% of diabetic patients and 38.71% of non-diabetic patients. Among diabetics, 46.88% experienced Level 2 and 43.75% Level 3 hypoglycemia. For non-diabetics, 24.19% had Level 2 and 6.45% Level 3 hypoglycemia. Overall, 51.28% of all patients experienced hypoglycemia, with diabetics at significantly higher risk for severe episodes.

Conclusion: Thus, the incidence of hypoglycemia during hemodialysis is extremely high with ESRD patients, and diabetics are more prone to severe episodes. They are also at great risk if they are non-diabetic patients. These findings underscore the importance of better surveillance and intervention efforts, especially for patients with diabetic end-stage renal disease receiving hemodialysis. The guidelines for the prevention and treatment of hypoglycemia deserve further research in order to create better prevention and intervention strategies for this population.

Keywords: Hypoglycemia; hemodialysis; ESRD; diabetes; normoglycemic patients.

1. INTRODUCTION

ESRD stands for end-stage renal disease, which is a stage in chronic kidney disease whereby the kidneys will not be able to effectively remove waste products from the bloodstream [1]. ESRD patients need renal replacement therapy to survive, which is often done through a process called hemodialysis. Although hemodialysis is one of the ways through which people with kidney diseases can be kept alive, it has some complications that come with it, and one of them is hypoglycemia [2]. Hypoglycemia, which means that the blood glucose levels are lower than normal, is an issue seen commonly in ESRD patients receiving hemodialysis. It can affect both diabetic and non-diabetic patients, but the pathology and risk factors might be dissimilar [3]. Therefore, knowledge of the rate, extent, and potential causes of hypoglycemia during hemolysis is really important for the proper management of the patients and the prevention of adverse outcomes [4]. Specifically, diabetic patients, who represent a sizable proportion of patients with ESRD, are predisposed to severe hypoglycemia. Patients on hemodialysis with diabetes have difficulty controlling their blood sugar due to factors such as altered insulin metabolism, impaired renal gluconeogenesis, and the effects of hemodialysis [5]. This area is particularly delicate because diabetes management and renal replacement therapy are inextricably linked; hypoglycemia is more likely to happen and may be more dangerous than in other patients. It is also important to note that non-diabetic ESRD patients may also experience hypoglycemia during hemodialysis, although the frequency and maybe the triggering factors are different than in diabetic patients [6]. Co-existing conditions like marasmus, liver disease, and the choice of glucose-free dialysate may predispose the affected population to hypoglycemic episodes. Hypoglycemia was noted to be present in non-diabetic patients with ESRD, emphasizing the importance of guarding and proper monitoring of such patients, irrespective of their diabetes status. Hypoglycemia during HD can range from mild, unrecognized, to symptomatic and severe episodes and is characterized by significant morbidity [4]. They include the following: Mild hypoglycemia is either asymptomatic or presents with minimal symptoms like hunger or minor confusion. But the more severe episodes may result in complications such as seizures, loss of consciousness, and cardiovascular manifestations [7]. When hypoglycemia is severe, patients with ESRD, who tend to have numerous comorbidities and decreased physical reserves, run the risk of a catastrophic event. There are several factors as to why hypoglycemia occurs in ESRD patients during the process of hemodialysis. The main factors include the action of exogenous insulin or oral hypoglycemic agents due to diminished renal elimination clearance, enhanced sensitivity of the insulin receptors, and the removal of glucose by dialysis [8]. Contributing factors may include the reduced ability of the liver to produce glucose in the non-diabetic patient, the diminished capacity of the kidney to perform gluconeogenesis, and the impact of uremic substances on glucose utilization [9]. One of the most common causes of IDH is using glucose-free dialysate, especially

for diabetic patients. Although the provision of glucose in the dialysate helps stabilize the blood glucose levels during the process, it may pose challenges for glycemic management among patients. The best usage of the dialysate concentration regarding glucose also continues to be explored until now. For one, preventing and managing hypoglycemia when a patient is undergoing hemodialysis is not one-dimensional [10]. This can involve fine-tuning of diabetes treatment, prescription of dialysis therapies, and management of blood glucose during therapy, as well as reviewing the symptoms of hypoglycemia with the patient. It is also important to have a close collaboration between nephrology and endocrinology services to determine the best approach for maintaining good glycemic control while at the same time not compromising on the occurrence of hypoglycemia [11]. This shows that the effects of hypoglycemia do not stop at the clinical level but rather affect patients on multiple fronts. When hypoglycemia occurs frequently and regularly, it often leads to hypoglycemia unawareness, a condition that makes patients unable to detect the early signs of low blood sugar. This can enhance the chances of having severe hypoglycemia and other complications that come with it. Additionally, insulin therapy is associated with a higher risk of developing hypoglycemic episodes that result in poor quality of life and non-compliance with regimes [12].

Therefore, further investigations on the frequency, depth, and factors associated with hypoglycemia during HD are essential and would contribute to the formulation of a framework for minimizing this adverse effect. Hypoglycemia is another well-studied concern of diabetic patients; however, there is a lack of data regarding the actual rates of hypoglycemia between diabetic and non-diabetic ESRD patients, as well as the variability of the severity levels of hypoglycemia in these groups [13]. The present study seeks to fill these gaps by implementing an observational study of hypoglycemic episodes during hemodialysis involving ESRD patients both with and without diabetes. It is therefore the aim of this research to contribute information that will help clinicians better understand how often hypoglycemia happens, how bad it is, and what other clinical features are associated with it. Knowledge of how hypoglycemia risk differs among patient subgroups is valuable for the formulation of potentially more effective prevention approaches. For diabetic ESRD patients, this may include fine-tuning insulin doses and adapting the timing of medications taken in relation to dialysis. Nutritional support may be the only area of prioritization for non-diabetic patients while identifying less apparent signs of hypoglycemia risk [14].

The purpose of this study is to compare the incidence and the degree of hypoglycemia in patients with ESRD with and without diabetes during the course of hemodialysis. The purpose is to move to a patient-centered model in which the quality of patient care is increased and outcomes elevated.

2. MATERIALS AND METHODS

This cross-sectional observational study was done from February 2023 to July 2023 in the dialysis ward of the Department of Nephrology, Community Based Medical College Hospital, Bangladesh. The aim of this research was to evaluate the frequency and seriousness of hypoglycemia in patients with ESRD on HD, both with and without a history of diabetes. The collected data were analyzed using the Statistical Package for Social Science (SPSS) version 25. The p value below the level of 0.05 was deemed statistically significant.

2.1 Study Population

The study included 156 ESRD patients undergoing regular hemodialysis. Participants were selected based on the following criteria:

2.2 Inclusion Criteria

- Patients diagnosed with ESRD of any etiology
- Age 15 years and above
- Undergoing regular hemodialysis for at least 3 months
- Both diabetic and non-diabetic patients
- Willing to participate and provide informed consent

2.3 Exclusion Criteria

- Patients with acute kidney injury requiring temporary dialysis
- Patients with severe comorbidities such as advanced liver disease, active malignancy, or severe cardiac dysfunction
- Patients unable to provide informed consent or reliably report symptoms
- Pregnant women
- Patients who had undergone renal transplantation

List 1. Classification of hypoglycemia

Level 1 hypoglycemia	Glucose level <3.9 mmol (70 mg/dl) and >/= 3 mmol/L (54 mg/dl)
Level 2 hypoglycemia	Glucose level <3 mmol (54 mg/dl)
Level 3 hypoglycemia	A severe event characterized by altered mental and/or physical status requiring assistance for treatment of hypoglycemia

2.4 Data Collection

The information included age, gender, diabetes status, duration of ESRD, dialysis duration, and medical history obtained by reviewing patient files and conducting interviews. Self-monitoring of blood glucose was performed at designated time points during HD, and the hypoglycemia definition was aligned with ADA 2022. Symptoms and interventions were noted while with the patients to ensure that no mishaps were encountered.

3. RESULTS

The study involved 156 participants who were ESRD and receiving routine hemodialysis, making the findings an invaluable resource in estimating the rates of hypoglycemia during dialysis sessions. The results are in the form of tables, each providing a unique vantage point for the gathered data.

The socio-demographic profile of the study participants is detailed in Table 1. Analyzing the age distribution, it can be identified that the majority of patients (41.67%) were in the 46–60year age range, with the second most frequent age range being 21–45 years. 31 percent in the 18–30year category and 31 percent in the 31–45 year category. The age of the participants was also average, and it was calculated to be 44 years. This group must be relatively middle-aged because the average age in the study was 82 years. In the same test, there was a great disparity in the number of male and female students, with 65 of them being male. 38% of the study population, compared to 34%. This supports the earlier studies that showed that males had higher chances of developing ESRD.

Table 2 shows how the diabetic and non-diabetic ESRD patients were distributed in the study group. Almost all the participants (79). This distribution is important to know the difference of the risk of hypoglycemia between those groups during hemodialysis.

A more detailed analysis regarding the incidence of hypoglycemic events in diabetic and non-diabetic patients in presented in Tables 3 and 4, respectively.

The prevalence of hypoglycemia amongst diabetic ESRD patients (Table 3) was 100% as all the 32 patients sampled had reported one or more hypoglycemic episodes during the study. The severity distribution was as follows: Moderate hypoglycemia (9. 38%), moderately severe hypoglycemia (46. 88%), and severe

Table 1. Socio-demographic characteristics of the participants (156)

Age Group (years)	Frequency (n)	Percentage (%)
15-30	25	16.03
31-45	40	25.64
46-60	65	41.67
≥61	26	16.67
Mean ± SD	44.63 ± 13.82	
Gender		
Male	103	65.38
Female	53	34.62

Table 2. Distribution of diabetes mellitus among patients (N=156)

Diabetes Mellitus	Frequency	Percentage
Absent	124	79.49%
Present	32	20.51%
Total	156	100%

hypoglycemia (43. 75%). These results suggest that diabetic ESRD patients receiving hemodialysis are at a heightened risk of moderate to severe hypoglycemia with more than 90% of all patients experiencing a Level 2 or Level 3 event.

Table 3. Distribution of Hypoglycemia Levels Among Diabetic ESRD Patients (N=32)

Level of Hypoglycemia	Frequency (n)	Percentage (%)
Level 1	3	9.38%
Level 2	15	46.88%
Level 3 (Severe)	14	43.75%
Total	32	100.00%

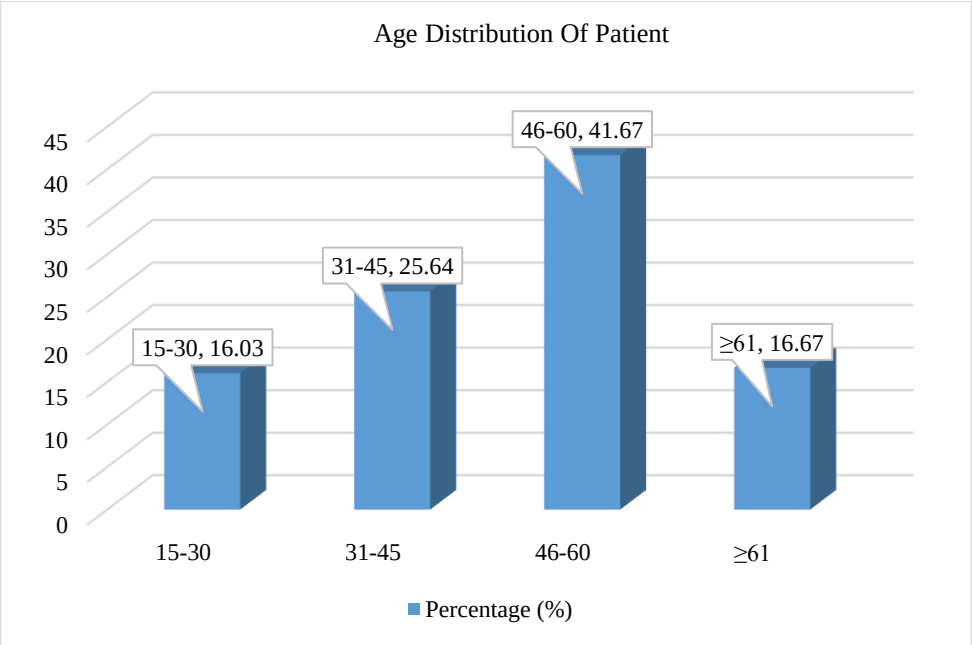

Fig. 1. Column chart showed showed Ager wise distribution (N=156)

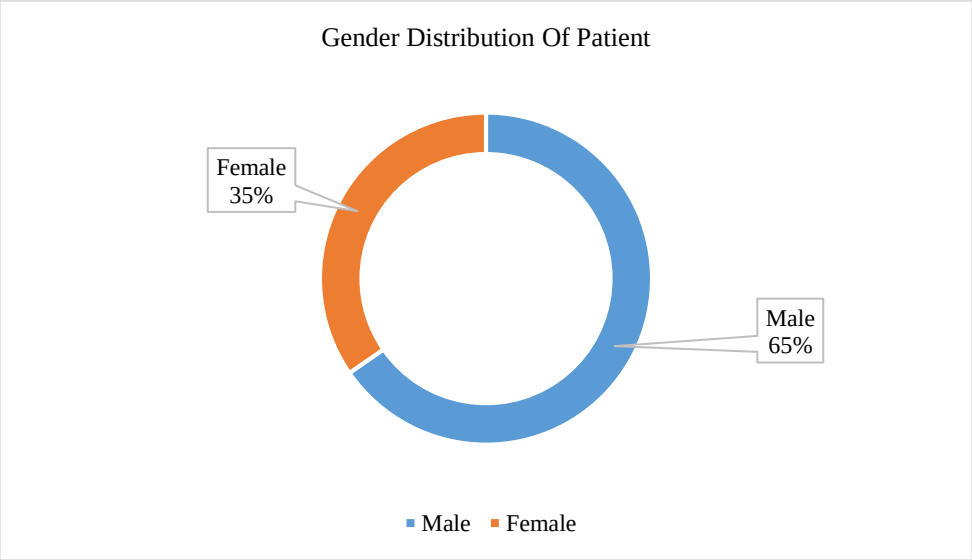

Fig. 2. Column chart showed gender wise distribution (N=156)

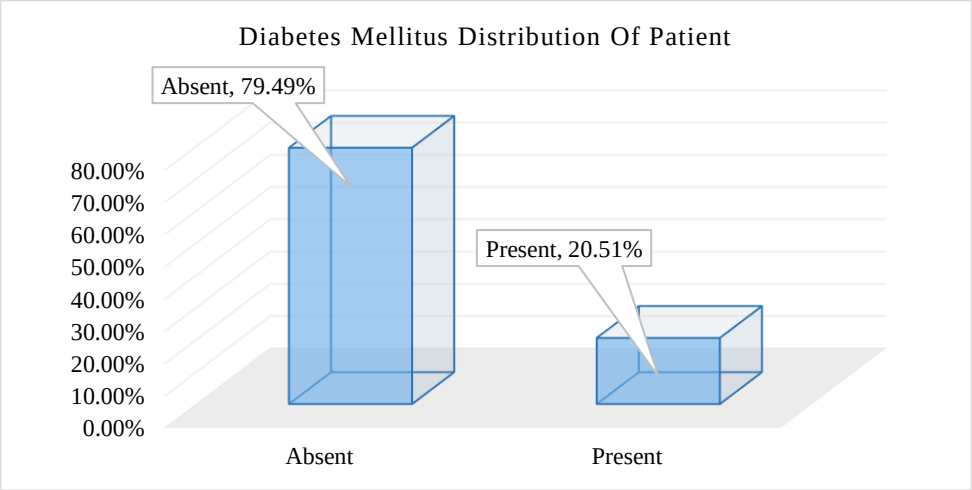

Fig. 3. Column chart showed diabetes mellitus r wise distribution (N=156)

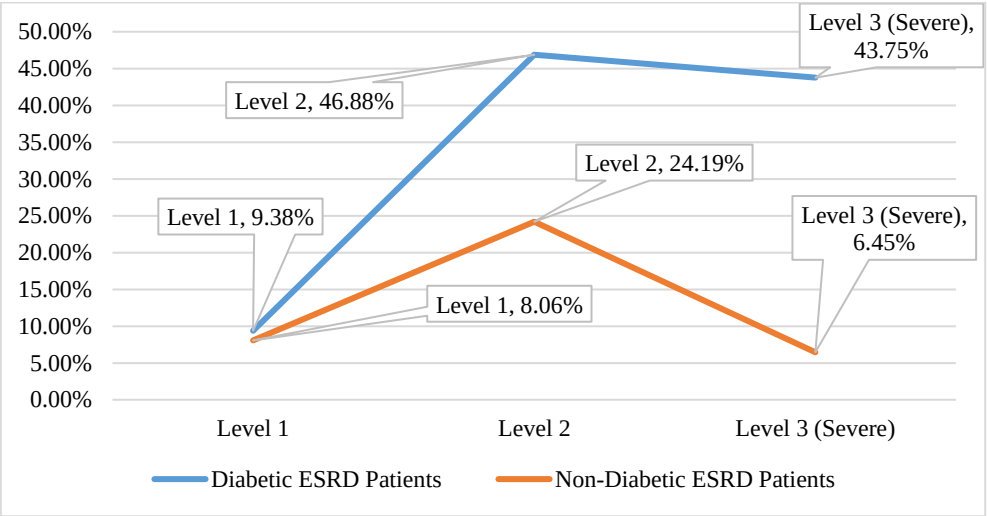

Fig. 4. Line chart showed diabetic ESRD Patients - non-diabetic ESRD patients wise distribution (n=156)

Table 4. Distribution of hypoglycemia levels among non-diabetic ESRD patients (N=48)

Level of Hypoglycemia	Frequency (n)	Percentage (%)
Level 1	10	8.06%
Level 2	30	24.19%
Level 3 (Severe)	8	6.45%
Total	48	38.71%

Hypoglycemia was observed in 48 out of 124 non-diabetic ESRD patients (38.71%) (Table 4). The severity distribution among those affected was as follows: Level 1 (moderate) hypoglycemia: 20.83% Level 2 hypoglycemia: 62.50% Level 3 (severe) hypoglycemia: 16.67%. Nevertheless, as mentioned above, it is also important to note that more than a third of non-diabetic patients suffered from hypoglycemia during dialysis, and approximately half of them faced Level 2 events.

4. DISCUSSION

The results of the present work are helpful in gaining a better understanding of the prevalence and degree of hypoglycemia among patients with ESRD undergoing HD, with or without diabetes.

This analysis demonstrates that there is a high prevalence of hypoglycemia in this population, in addition to important differences between diabetics and others. The demographic characteristics of our study sample dictate that the participants had a mean age of 44 years. Which is in line with the previous research about ESRD patients who were 82 years old and 65. 38% of them were male. For instance, Weigert et al. [13] revealed that the gender distribution of hemodialysis patients across Europe is almost similar to this study, where 60–65% were men. The age distribution in our study is also consistent with that of CKD patients reported in a previous study, where 41 [13]. The percentage of patients between 46 and 60 years old with ESRD is typical because chronic kidney disease and its associated risks are progressive. In our study, 20. diabetic patients constituted the majority of ESRD patients, or about 51% of the patients. This proportion is slightly lower than described in some other populations. For instance, according to the USRDS, the percentage of new cases of ESRD attributed to diabetes alone stands at about 40 percent [15]. Our lower percentage could be attributed to geographical variation in the causes of ESRD or could be due to the parameters used in our study, the type of population we included, and the center we are based in. The combined prevalence rate of hypoglycemia in the current study sample (51.28%) adds another layer of importance to this side effect in patients with ESRD receiving hemodialysis. This finding corroborates previous literature that shows this population is vulnerable to developing hypoglycemia. For example, Jackson et al. [7] noted that hypoglycemia resulting from the hemodialysis was widespread, especially where glucose-free dialysate solution was applied. What is even more striking is the fact that while all the diabetic patients in the study suffered hypoglycemia at least once, non-diabetic patients did so only in 38. This disproportion creates a high-risk during hemodialysis among diabetic ESRD patients. These results are higher than those noted by Gian Chandani et al. [16], alysis patients with diabetes were found to have a significant incidence of hypoglycemia, with 6% of hospitalized patients who were on hemodialysis having at least an episode of hypoglycemia. who revealed a 50% overall prevalence. Hemodialysis patients with diabetes were found to have a significant incidence of hypoglycemia, with 6% of hospitalized patients who were on hemodialysis having at least an episode of hypoglycemia. The higher incidence could be due to the study design, characteristics of patients, and dialysis regimens that are different in the present study. Analyzing the distribution of hypoglycemia severity in our study, presents valuable insights. Highly affected by hypoglycemia were diabetic patients with Level 2 (46. 88%) and Level 3 (43. 75%). This finding indicates that compared to CAD patients, diabetic ESRD patients are more prone to hypoglycemia episodes and may experience more serious events. Non-diabetic patients on the other hand have been seen to be at a lower risk of severe hypoglycemia with only 6. 45% of them experiencing Level 3 hypoglycemia though Level 2 is still prevalent among them with 24. 19% experiencing the same. These results are consistent with, but higher than, the studies by Gianchandani et al. [16] who mentioned that 10. Severe hypoglycemia was found to have occurred in 7% of diabetic hemodialysis patients. The higher rates demonstrated in our study can be attributed to the discordance in the definition criteria of severe hypoglycemia or there may be a higher risk patient population. For diabetic ESRD patients, the high prevalence of hypoglycemia implies that nurses must constantly monitor and promptly intervene when administering hemodialysis treatments. Such research results evidence the hypothesis of Burmeister et al. [17] that glucose-added dialysate can be an option for the treatment of hypoglycemia in dialysis patients, particularly those diagnosed with diabetes. In non-diabetic patients, though the risk was less, a significant number of patients (38.71%) experienced hypoglycemia, indicating that blood glucose levels should be checked in all ESRD patients on hemodialysis. Haviv et al. [14] came to similar conclusions and stated that hypoglycemia can manifest in patients with renal failure, even if they do not have diabetes. Shah et al. [18] ‘s report points to a significant clinical worsening of moderate to severe hypoglycemia among ESRD patients on hemodialysis. In chronic kidney disease, Yu et al. [9] also warn of the risks of chronic hypoglycemia, linked to an increased risk of stroke. Seeuqiust et al. also describe severe complications. Ricks et al.[11] report a need to develop individualized diabetes management for patients with ESRD. Hypoglycaemia was significant in the present sample, 38.71% non-diabetics, and the issues arising out of gender disparities and the need for gender-specific awareness and surveillance were also significant considerations.

The findings of the present study indicate that practice regarding self-monitoring and

management of blood glucose levels during HD may be suboptimal, especially in high-risk groups. They may require more frequent blood glucose testing, using CGMS, or altering the dialysate concentration to prevent the occurrence of hypoglycemia. This concurs with Burmeister et al. [17] call for the use of glucose-containing dialysate to avoid intradialytic hypoglycemia.

5. CONCLUSION

This type of cross-sectional study documents the frequency and potential severity of hypoglycemia during HD in ESRD patients, particularly diabetic patients. In terms of risk, it has been established that patients with diabetes are at a significantly higher risk of experiencing severe episodes as compared to non-diabetic patients. The results presented in this paper underscore the current limitations of monitoring and management practices, underscoring the need for more effective guidelines and interventions to minimize hypoglycemia in this population.

6. LIMITATION OF THE STUDY

Several limitations were present in this study, including involving a single center, a relatively small sample of 156 patients, and a short study period of six months. Probably, a number of hypoglycemic events were not captured due to the fact that the frequency of blood glucose measurement was limited and not continuous. Furthermore, markers of potential confounding variables were evaluated poorly, and the lack of a control group made it impossible to compare with patients without ESRD.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT AND ETHICAL APPROVAL

This research respected the ethical guidelines of the Declaration of Helsinki and local norms and regulations, with approval from Community Based Medical College Hospital, Bangladesh. The participants were informed of the research project, and all of them consented to participate. They say that data confidentiality was managed and upheld to the highest standards of professionalism. Hence, the present study shows that hypoglycemia poses a huge burden among ESRD patients on hemodialysis, especially those with diabetes, implying the need to establish better management modalities and new guidelines.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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