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# Major electrolyte disorder and associated factors among patients with chronic disease in Ethiopia: a systematic review and meta-analysis

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## Abstract

**Background** Alterations in electrolytes are associated with a number of clinical problems and prompt diagnosis of electrolyte disorder and treatment are crucial in the management of patients with chronic illness. Even though, major electrolyte disorders are common among patients with chronic diseases, the problem were not received enough attention. Thus, the aim of this review was to determine the pooled prevalence and associated factors of major electrolyte disorder among patients with chronic diseases.

**Methods** The PubMed, Cochrane Library, Science Direct, African Journals Online, and Google Scholar databases were searched by two authors (WCT and YAF) from January 15/2024 to January 22/2024 to identify articles reporting the prevalence of electrolyte disorders in patients with chronic disease in Ethiopia. A random-effects model was used to estimate the pooled prevalence of electrolyte disorder. Important data were extracted with Microsoft Excel and then exported to STATA software version 11 (STATA Corp LLC, TX, USA) for analysis. Cochran's Q test at a significance level of less than 0.05 and the $I^2$ index were used to examine the statistical heterogeneity among the included studies. A random-effects model was used to estimate the pooled prevalence of major electrolyte disorder due to the presence of heterogeneity.

**Results** The finding of this review showed that, the pooled estimate of electrolyte disorder among patients with chronic diseases in Ethiopia was found to be 56.66% (95% CI: 44.54, 68.79, $P < 0.001$). Having no formal education (POR = 7.06, 95% CI = 1.35, 36.98), taking diuretic (POR = 4.41, 95% CI = 1.78, 10.91), patients with anti-diabetic medication (POR = 10.11, 95% CI = 3.45, 29.66), having a body mass index ≥ 30 kg/m$^2$ (POR = 6.99, 95% CI = 2.01, 5.93) and having uncontrolled blood glucose [POR: 7.09, 95% CI = 5.10–9.80) were factors associated with electrolyte disorders among patients with chronic diseases.

**Conclusion** This systematic review and meta-analysis revealed that the pooled electrolyte disorders among patients with chronic disease was significant in Ethiopia. Patients who had no formal education, taking diuretic, taking anti-diabetic medication, body mass index ≥ 30 kg/m$^2$, alcohol consumption and having high uncontrolled blood glucose were significantly associated with electrolyte disorders. Special emphasis on the status of serum electrolytes should be given for patients with chronic disease in those taking diuretic and anti-diabetic treatments and who are overweight.

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**Keywords** Electrolyte disorder, Chronic disease, Systematic-review, Ethiopia

## Introduction

Electrolytes are substances with an electrical charge that are necessary for regular metabolic processes and maintaining homeostasis. Electrolytes regulate hormone activity, bone structure, neuron conductivity, muscle contraction, fluid and acid–base balance, and cell membrane functions [1, 2]. The body has a number of common electrolytes that are involved in preserving the proper fluid balance between the extracellular and intracellular compartments. Electrolyte balance is crucial for a variety of vital functions in the body, such as nerve impulses, muscle function, energy production, blood pressure control and digestion. Potassium, sodium, magnesium, calcium, and chloride are the major electrolytes responsible for the electrophysiological properties of the myocardial membrane and directly influence the electrical activity of heart cells, impacting the heart's rhythm and contractility [1, 3].

Since intracellular fluid (ICF) is the primary medium for most metabolic activities, significant changes in ionic strength may occur, potentially causing detrimental consequences on body functions [4]. Patients with chronic illnesses frequently experience electrolyte disorders, which can be caused by changes in the body's electrolyte distribution as a result of osmotic fluid shifts caused by metabolic abnormalities [5]. In clinical practice, electrolyte imbalances are frequently observed in patients with chronic disease, affecting a wide range of patients from asymptomatic to severely ill, and are associated with a greater risk of morbidity and mortality [3]. Numerous pathophysiological factors, including dietary conditions, gastrointestinal absorption capacity, coexisting acid–base imbalances, pharmaceutical drugs, and acute illness play the occurrence of electrolyte disorder [6].

Due to osmotic fluid changes, electrolyte disorder mostly affect those patients with chronic diseases. It has two significant effects on the body's electrolyte content. A dilutional effect could result from water movement carrying intracellular electrolytes into the extracellular space, either by increasing or decreasing extracellular electrolyte concentrations [7, 8]. Significant morbidity and mortality were reported from electrolyte disorders [9]. The most frequent causes of electrolyte disorder are chronic disease, primary sodium loss from perspiration, gastrointestinal loss from vomiting and diarrhea, renal loss from diuretic medication, salt-wasting nephropathy, and primary water retention from disorders such as hypothyroidism, hepatic cirrhosis, nephrotic syndrome, heart failure, and primary polydipsia [10].

One challenging condition influencing the outcome and duration of hospitalization for patients with chronic disease is the presence of electrolyte disorders at the time of admission or during the hospital stay. The prognosis and length of hospital stay were both improved by the efficient and prompt normalization of electrolyte levels [11]. Alterations in electrolytes are associated with a number of clinical problems and prompt diagnosis of electrolyte disorder and treatment are crucial in the management of patients with chronic illness [12]. The major electrolytes in the body are potassium, sodium, magnesium, calcium and chloride. Even though, knowing the status of electrolyte disorders and associated factors in patients with chronic disease is crucial, the problems were not well studied, especially in Ethiopia and scanty data with conflicting findings are available on the electrolyte profile of patients with chronic diseases. While it is a universal notion that diagnosis and treatment of comorbidities are necessary, due emphasis is not given to electrolyte disorders in such patients. In chronic diseases, electrolytes are being used for diagnosis and follow-up, while the electrolyte disorder itself is not given enough attention so far in Ethiopia.

Even though, major electrolytes disorders are common among patients with chronic diseases, the problem were not received enough attention. Thus, the aim of this review was to determine the prevalence and associated factors of major electrolyte disorders among patients with chronic disease.

## Materials and methods

### *Study design and protocol registration*

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P 2015) Guidelines [13] were used to report this study (Supplementary file 1). The protocol registration number is CRD42024579411.

### Article search strategy

The PubMed, Cochrane Library, Science Direct, African Journals Online, and Google Scholar databases were searched by two authors (WCT and YAF) from January 15/2024 to January 22/2024 to identify articles reporting the prevalence of electrolyte disorders in patients with chronic disease in Ethiopia. We used the search terms separately and in combination using Boolean operators

like "OR" or "AND". An example of the search strategy used was as follows: "prevalence" OR "serum electrolyte disorder" OR "electrolyte imbalance" OR "electrolyte disorder" OR "electrolyte disturbance" AND "Diabetes Mellitus*" OR "hypertension*" OR "cancer *" OR "HIV/AIDS*" OR "chronic pulmonary disease*" and "Ethiopia*". The reference lists of the retrieved articles were also reviewed to identify additional relevant articles (Supplementary file 2).

The qualifying standards for this review were established using the modified Population, Intervention, Comparison, Outcome, and Type of study/context (PICOT) framework Table 1.

#### *Outcome of interest*

In this study, electrolyte disorder defined as blood test results that indicate an altered potassium concentration less than 3.5 mEq/l or > 5.1MEq/L OR chloride level < 97 MEq/L or > 107 MEq/L OR sodium level < 135 MEq/L or > 145 MEq/L OR calcium level < 1.12 MEq/L or > 1.14 MEq/L [14]. The Centers for Disease Control (CDC) classify the following as chronic diseases: heart disease, stroke, cancer, type 2 diabetes, obesity, and arthritis [15].

### Eligibility criteria

#### *Inclusion criteria*

This review included cross-sectional and cohort studies that reported the prevalence of electrolyte disorder in patients with chronic problems, published in peer-reviewed journals, conducted in Ethiopia, and freely accessible articles.

#### *Exclusion criteria*

Studies that did not report the prevalence of electrolyte disorder, case reports, poster presentations, editorial letters, and that were conducted outside of Ethiopia were excluded from the review.

### Article selection and data extraction

Duplicate articles were eliminated after importing all of the search results into the EndNote version X7 software.

**Table 1** Framework for determining the eligibility of studies (PICOS)

| criteria | Description |
|---|---|
| Population | Patients with chronic disease/metabolic syndrome, cancer, CVD, diabetes mellitus |
| Intervention | Electrolyte disorder |
| Comparison | Not applicable for the review |
| Outcome | Major electrolyte disorder, associated factors |
| Study area/context | Ethiopia |

Next, two authors independently screened the articles to determine which studies meet the inclusion criteria. The first author's name, publication year, region, study population, sampling technique, sample size, study design, and prevalence of electrolyte disorder are all included in the data abstraction form created in a Microsoft Excel sheet. Data were independently extracted from full-text articles by two authors.

### Quality assessment

All potentially suitable articles were reviewed after duplicates or ineligible articles were removed. The full-text of retrieved articles were reviewed and pertinent data were extracted. At this stage, the two authors (AMZ, YAF) independently examined the methodological quality of the selected studies. To evaluate the quality of the included studies, the Joana Brigg's Institute (JBI) critical assessment checklist for simple prevalence studies was utilized [16]. The checklist contains 9 items. (1) Was the sample frame appropriate to addressing the target population? (2) Were the study participants sampled appropriately? (3) Was the sample size adequate? (4) Were the study subjects and the setting described in detail? (5) Was the data analysis conducted with sufficient coverage of the identified sample? (6) Were valid methods used for the identification of the condition? (7) Was the condition measured in a standard, reliable way for all participants? (8) Was there an appropriate statistical analysis? (9) Was the response rate adequate? For each question, a score of 0 was assigned for 'not reported or not appropriate' and a score of 1 was assigned for 'yes'. Then, the scores were summed to obtain a total score ranging from 0 to 9. Based on the assigned points, articles were categorized as having high (7-9), medium (5–6), or low (0–4) quality.

### Statistical analysis

Important data were extracted with Microsoft Excel and then exported to STATA software version 11 (STATA Corp LLC, TX, USA) for analysis. A forest plot was used to show the pooled prevalence of electrolyte disorder and 95% confidence intervals. Cochran's Q test at a significance level of less than 0.05 and the $I^2$ index were used to examine the statistical heterogeneity among the included studies. Values of 0–40%, 40–60%, 60–90%, and 90–100%, indicated low, medium, substantial, and high heterogeneity respectively [17]. A random-effects model was used to estimate the pooled prevalence of major electrolyte disorder due to the presence of heterogeneity. The DerSimonian and Laird method is the most widely utilized meta-analysis technique in this instance [18]. The potential sources of heterogeneity across the included articles were evaluated with sub-group, meta-regression, and sensitivity analysis. Publication bias was investigated

statistically using Egger's regression test. A $p$-value < 0.05 in Egger's regression test was considered to indicate evidence of statistically significant publication bias and asymmetric evidence in the funnel plot.

## Results

### Study selection

Our systematic search yielded a total of 8245 articles from four databases (Google Scholar (5115), PubMed (1245), Cochrane Library (1432), Science Direct (8), and African Journal Online (445)). From the total number of searched articles 1460 were removed due to duplication. The titles of the remaining 6785 articles were screened and 6210 of the studies were excluded because they did not pertain to the study population. The abstract of 575 articles were assessed for eligibility, and 8 ultimately met the inclusion criteria for the review. A summary of the steps involved in the screening process and the reasons for exclusion of articles after full text review are provided in (Fig. 1).

### Characteristics of included studies

The current review analyzed the findings of seven cross-sectional and one retrospective study published up to January 22/2024. The highest prevalence of electrolyte disorder was reported in the Amhara region (83.07%) [19] and the lowest was reported in the Oromia region (44.1%) [7]. The included studies were conducted in different regions of the country: one from the Amhara region [19], three from the Oromia region [7, 20, 21], one from Southern Ethiopia [22], and three are from Addis Ababa [23–25]. The detailed characteristics of the included studies are presented in Table 2.

### Quality of the included studies

Seven studies have medium quality and the remaining one study have medium quality. The quality of each of the included studies was evaluated using the nine-item risk of bias assessment tool. The detailed results of the quality assessment of the studies are presented in the supplementary file (Supplementary file 1).

### Publication bias

Begg's rank test and Egger's regression intercept tests were carried out to indicate the relationship between the effect sizes and sampling heterogeneity to determine publication bias. Based on the analysis, the funnel plot indicated uneven distribution of studies, indicating the presence of apparent publication bias. This observation was supported by Egger's test, which produced a statistically significant $p$-value of < 0.001 at a 5% significance level.

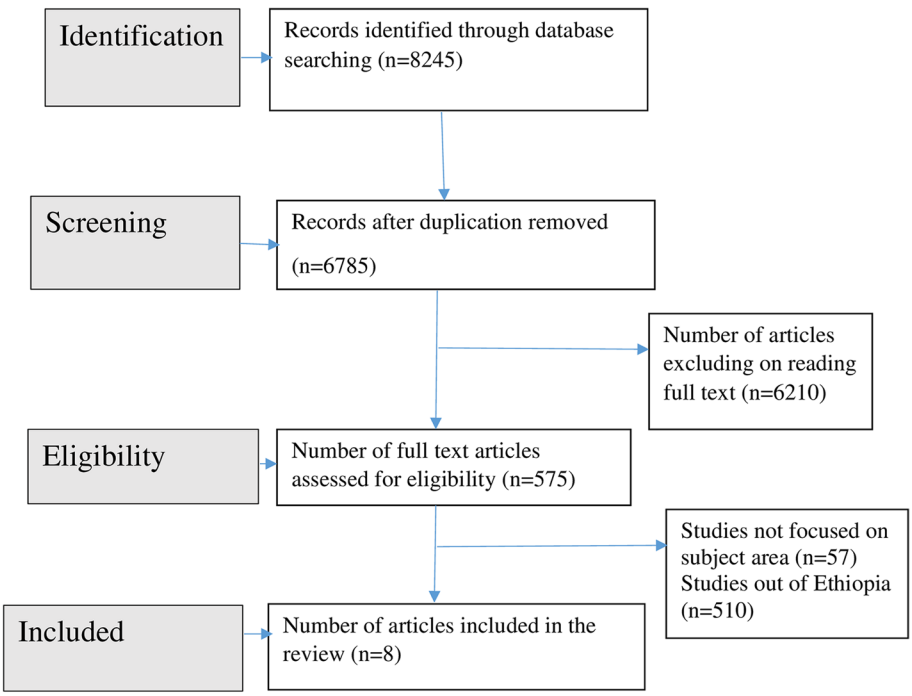


**Fig. 1** PRISMA flow diagram of article selection for a systematic review and meta-analysis of electrolyte disorder and associated factors among patients with chronic illness in Ethiopia

**Table 2** Characteristics of the included studies and prevalence of electrolyte disorder in Ethiopia

| Author | Pub Year | Region | Study Design | Study Population | Sample size | Prevalence (%) | Quality score |
|---|---|---|---|---|---|---|---|
| Timerga et al. [7] | 2020 | Oromia | IBCS | Metabolic disorder | 256 | 44.1 | High |
| Eshetu et al. [19] | 2023 | Amhara | IBCS | Patients with DM | 260 | 83.07 | High |
| Woyesa et al. [20] | 2019 | Oromia | IBCS | Patients with DM | 279 | 42 | High |
| Alem et al. [21] | 2019 | Oromia | IBCS | Patients with cancer | 84 | 60.7 | High |
| Timerga and Haile [22] | 2021 | South | IBCS | Patients with obesity | 250 | 47.6 | High |
| S. Gebregzabher et al. [23] | 2023 | Addis Ababa | Retrospective | Patients with CVD | 350 | 73.4 | |
| Diribsa G.C et al. [24] | 2019 | Addis Ababa | IBCS | Patients with CVD | 163 | 50.3 | Medium |
| MD molla et al. [25] | 2019 | Addis Ababa | IBCS | Patients with CKD | 366 | 46.8 | High |

### Meta-analysis

The finding of this review showed that, the pooled prevalence of electrolyte disorder among patients with chronic diseases in Ethiopia was found to be 56.66% (95% CI: 44.54, 68.79, $P<0.001$). The analysis showed that the presence of substantial heterogeneity among the included studies ($I^2=87.2\%$, $P<0.001$). As a result, the random effect model specifically the DerSimonian and Laird method was used to determine the pooled estimate of electrolyte disorder (Fig. 2).

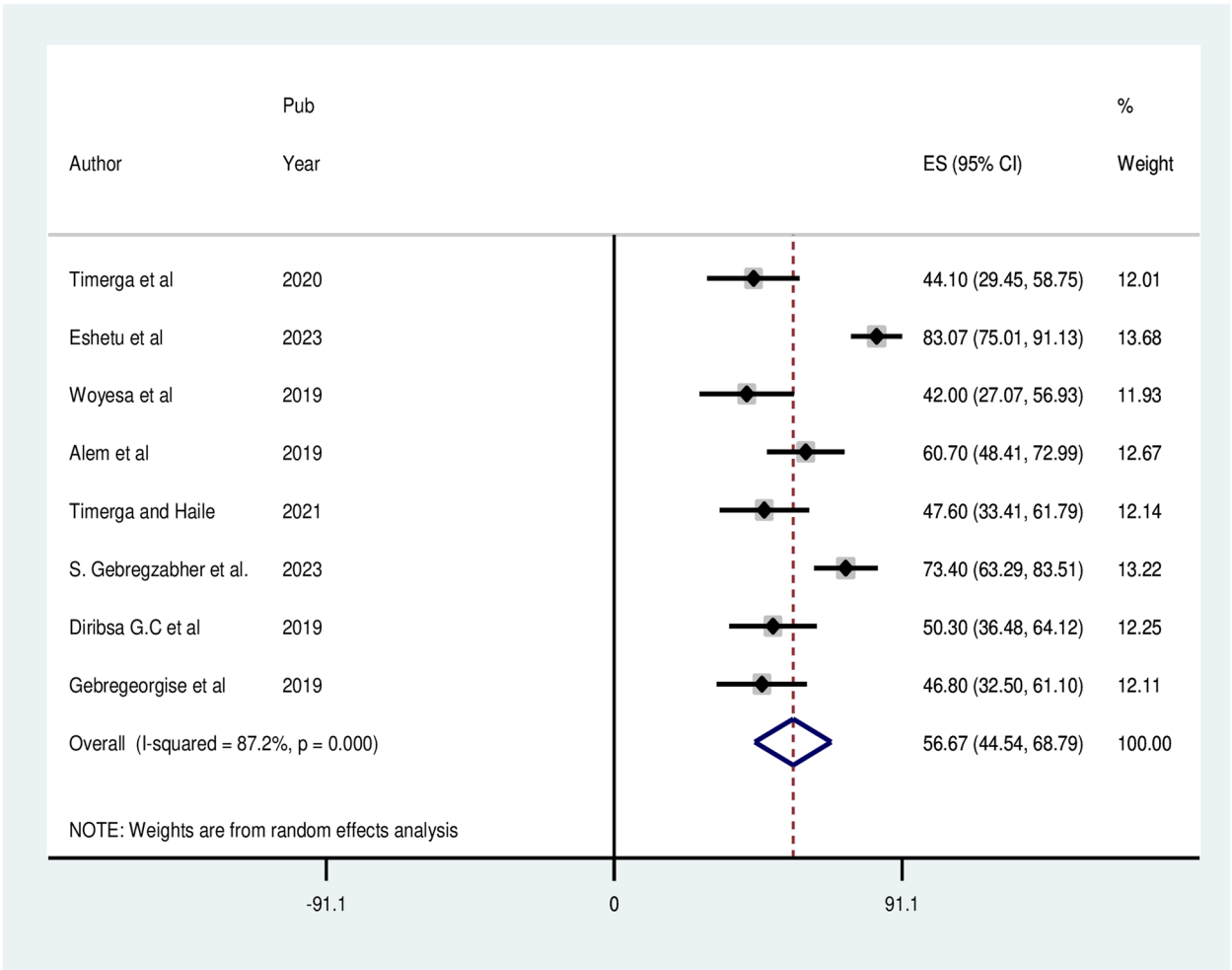


**Fig. 2** Funnel plot assessed for publication bias in 8 studies

### Subgroup analysis

Subgroup analysis was conducted based on the study population. The analysis showed that, the highest prevalence of electrolyte disorder was reported in patients with diabetes mellitus (63.03% (CI: 22.8, 103.27)) (Fig. 3).

### Sensitivity analysis

The sensitivity analysis also conducted using the random-effect model to evaluate the effect of individual study on the pooled estimate. The analysis revealed that, no single study influenced the overall pooled prevalence of electrolyte disorders (Fig. 4).

### Associated factors

A total of six common factors were identified to predict electrolyte disorders in patients with chronic diseases. These variables are patients who had no formal education, taking diuretic medication, taking anti-diabetic medication, obesity, uncontrolled blood glucose and alcohol consumption. The result of meta-analysis revealed that no formal education was associated with electrolyte disorder. According to the finding, the fixed pooled odds of electrolyte disorder in patients who had no formal education were 7.06 times [(POR = 7.06, 95% CI = 1.35, 36.98, $I^2 = 79.5\%$)] higher compared to patients with higher education.

The other factor that showed significant association was taking diuretics. According to the result, the random

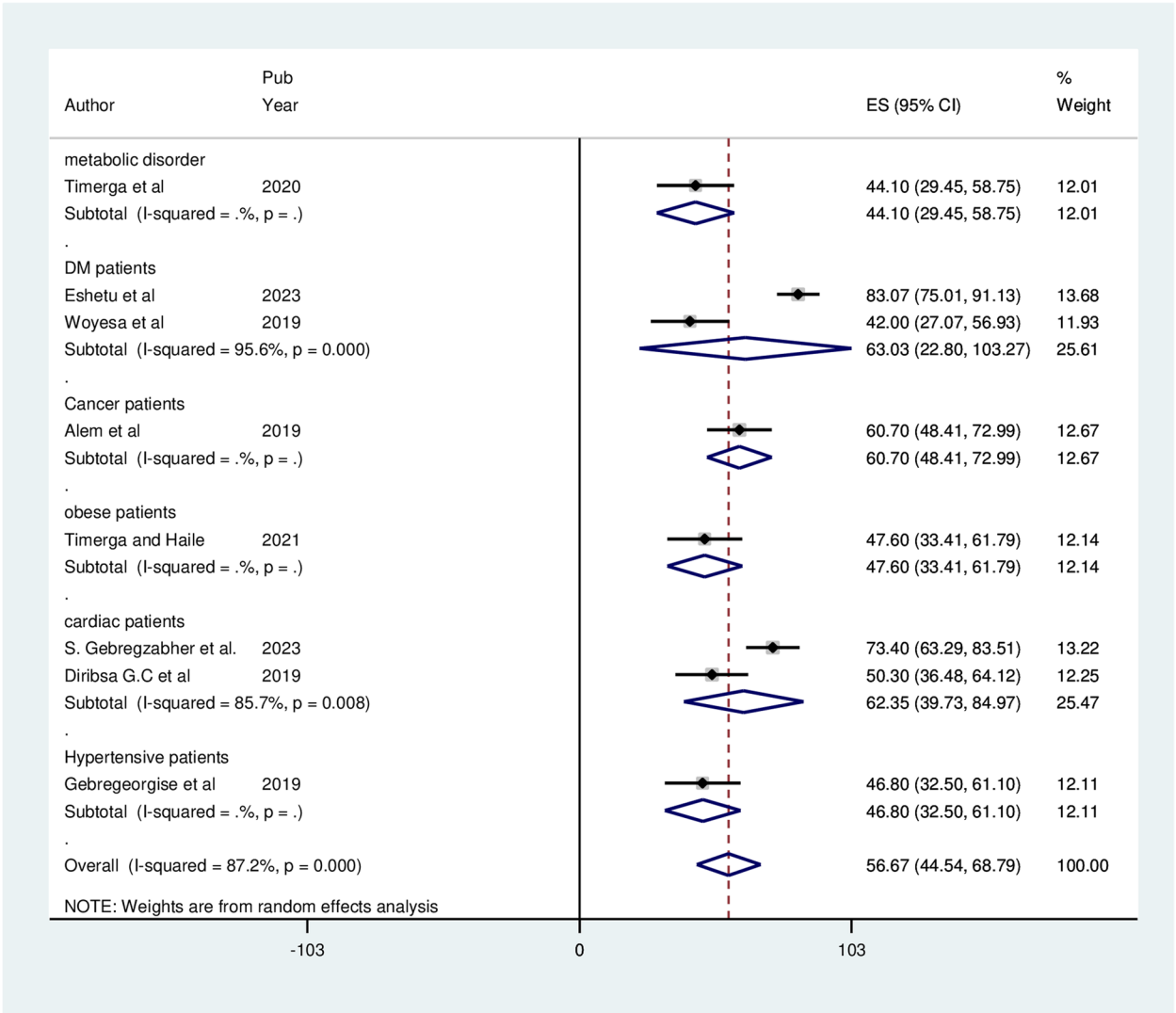


**Fig. 3** Forest plot indicating pooled prevalence of electrolyte disorder among patients with chronic disease in Ethiopia

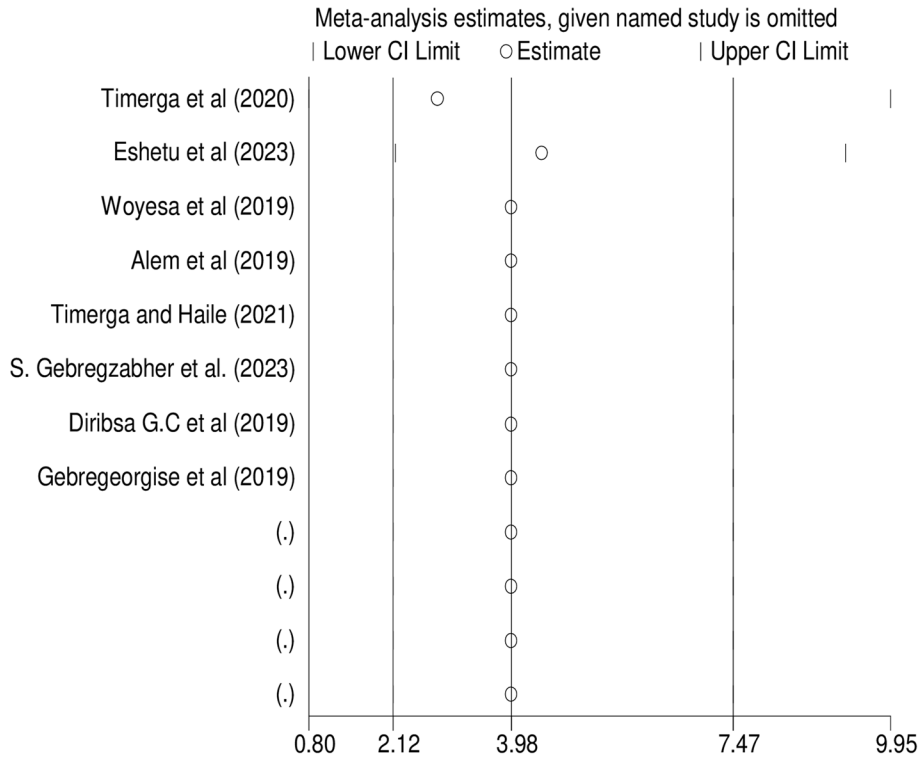


**Fig. 4** A forest plot showing subgroup analysis based on study population

pooled odds of developing electrolyte disorder were 4.41 times higher among patients with diuretics [(POR = 4.41, 95% CI = 1.78, 10.91, $I^2 = 82.4\%$)] compared to their counterparts. In addition, patients taking anti-diabetic medication were 10.11 times more likely to had electrolyte disorder than their counterparts [(POR = 10.11, 95% CI = 3.45, 29.66, $I^2 = 72.8\%$)]. The study also revealed that patients with BMI ≥ 30 kg/m$^2$ had 6.99 fold likelihood to develop electrolyte disorder [(POR = 6.99, 95% CI = 3.54, 13.8, $I^2 = 0.0\%$)] than having normal BMI. Furthermore, the review also revealed that patients who consumed alcohol were more than 3.45 times [POR: 3.45; 95%CI (2.01, 5.93, $I^2 = 0.0\%$)] more likely to have electrolyte disorder than did their counterparts. Lastly, patients with uncontrolled blood glucose were 7.07 [POR: 7.07, 95% CI = 5.10–9.8, $I^2 = 0.0\%$)] times more likely to develop an electrolyte disorder as compared to controlled blood glucose (Figs. 5).

## Discussion

The review revealed that the pooled prevalence of major electrolyte disorders among patients with chronic diseases was found to be 56.66% (95% CI: 44.54, 68.79, $P < 0.001$). The findings is in line with previous studies which reported that the prevalence of electrolyte disorder in Singapore (63%) [26] and Germany (65%) [27]. This finding is higher than that of previous studies conducted in different countries: America (21.4%) [28], Norway (24.6%) [27] and Italy (44%) [29]. One possible explanation is that the use of different methods and thresholds applied, and/or differences in the populations included in the study.

The current study revealed that no formal education was significantly associated with electrolyte disorders. According to our findings, the fixed pooled odds of electrolyte disorders in patients who had no formal education were 7.06 times greater than those in patients with higher education. This may be due to the fact that educated individuals are generally more aware of how to prevent electrolyte imbalances compared to those who are less educated. In addition, education is key to opening any locked secrets of life in the world that enable everyone to have a standardized and healthy lifestyle through behavioral change. Other studies in Iran [30] have shown that educated adults tend to share more knowledge about preventing electrolyte disorders, while those with no education are less informed about prevention methods compared to those with higher educational attainment. Ethiopia is a country with a large population with poor education status coverage, especially the aged population, which might lead to electrolyte disorders.

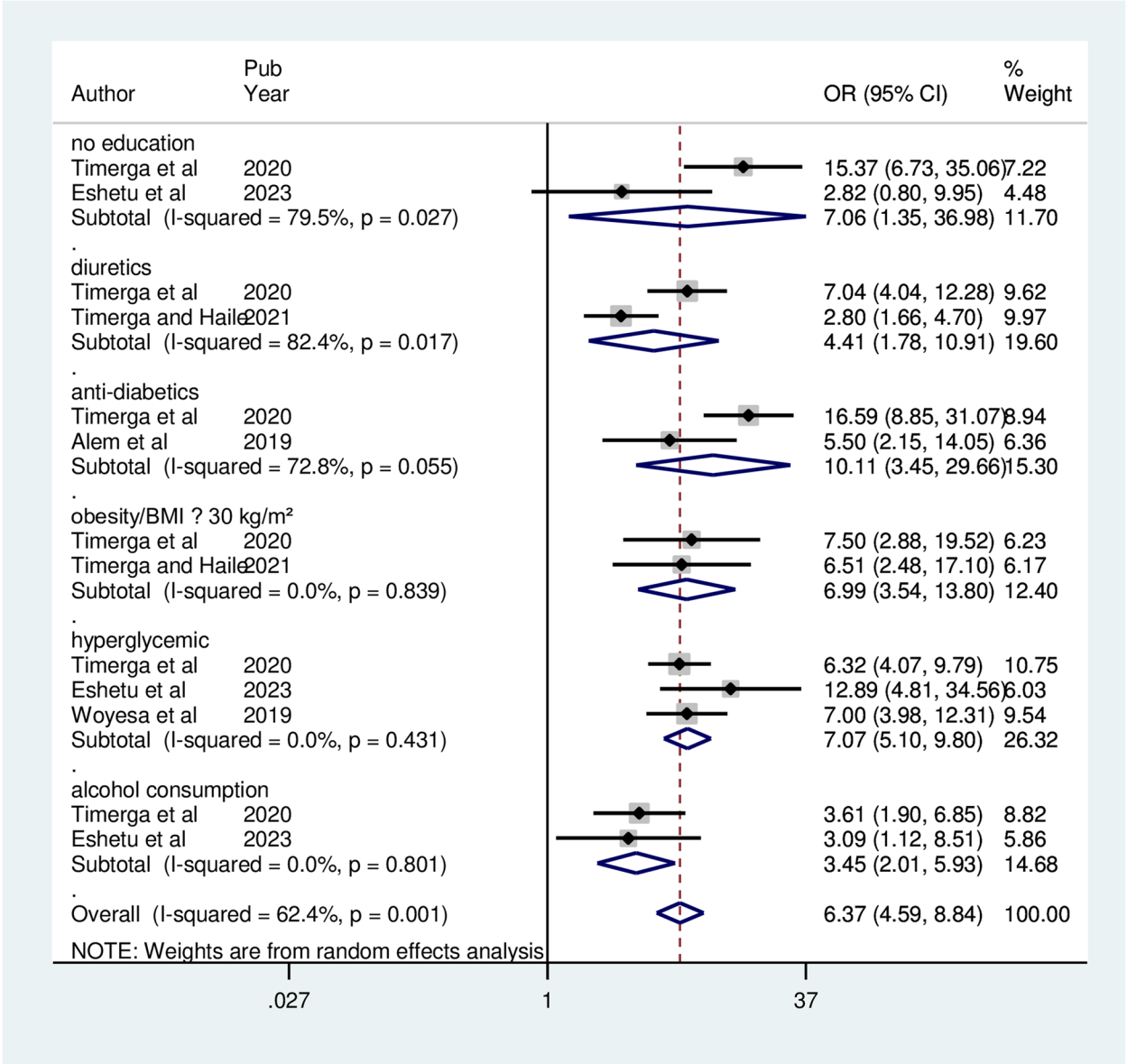


**Fig. 5** Result of sensitivity analysis of the 8 studies

The use of diuretics was significantly associated with the development of electrolyte disorders. According to the result, the random pooled odds of developing electrolyte disorder were 4.41 times higher among patients with diuretics compared to their counterparts. This was in line with studies conducted in the USA [31], Britain [32] and Germany [33]. This might be because drugs, especially diuretics, are a major cause of hypernatremia in patients with DM and hypertension. Moreover, a close orientation during the administration of diuretics should be designed to minimize electrolyte abnormalities. Given the regularity of electrolyte monitoring protocols, it would be wise to remain vigilant about the potential for electrolyte disorders beyond the diuretic treatment.

According to the findings of the current meta-analysis, patients on anti-diabetic medications were substantially more likely to have electrolyte disorder. In addition, patients taking anti-diabetic medication were 10.11 times more likely to had electrolyte disorder than patients who were not taking anti-diabetic medication. This finding is similar to those of studies conducted in Iran [34, 35], and Japan [34]. This may be because extreme hyperglycemia in patients with diabetes mellitus can result in osmotic diuresis, which can induce the loss of electrolyte,

especially sodium, chloride, and magnesium. Potassium loss is exacerbated by secondary hyperaldosteronism, which occurs as a result of dehydration. Consequently, hypokalemia may occur in patients with diabetes mellitus. Potassium facilitates the function of insulin in the delivery of glucose to cells; when insulin attaches to its receptors on the cell membrane, it opens channels for K + to enter the cells. Insulin should not be used excessively in patients with diabetes mellitus who have hypokalemia or low blood glucose since this can lead to hypokalemia.

The present review also showed that high body mass index was significantly associated with electrolyte disorder. The study also revealed that patients with BMI ≥ 30 kg/m$^2$ had 6.99 fold likelihood to develop electrolyte disorder [(POR = 6.99, 95% CI = 3.54, 13.8, $I^2$ = 0.0%)] than having normal BMI. A possible explanation could be that a high body mass index or obesity causes hemodilution from elevated blood volume, which increases cardiac output due to stroke volume. Excessive fat buildup also leads to increased circulating blood volume [36, 37]. Furthermore, the review also revealed that patients who consumed alcohol were more than 3.45 times [POR: 3.45; 95%CI (2.01, 5.93, $I^2$ = 0.0%)] more likely to have electrolyte disorder than did their counterparts. This finding was supported by similar studies [38]. The possible justifications could be, repeated exposure or prolonged consumption of alcohol results in increments of vasopressin levels, resulting in increased urine osmolality and decreased clearance of free water which might be resulted in hyponatremia by inducing water diuresis as short lived and followed by a period of fluid retention.

Finally, this meta-analysis showed that an electrolyte disorder was significantly more common in adults with uncontrolled blood glucose. Patients with uncontrolled blood glucose were 7.07 [POR: 7.07, 95% CI = 5.10–9.8, $I^2$ = 0.0%)] times more likely to develop an electrolyte disorder as compared to controlled blood glucose. Pathophysiologically, the chronic complication of diabetes mellitus and the side effects of drugs are well known to cause electrolyte disorder among patients with DM.

### Limitations

This systematic review explored the pooled prevalence of electrolyte disorder and factors influencing it at a national level, facilitating the pinpointing of specific interventions. Nonetheless, the study has certain limitations. Firstly, the total participants included were not a representative of the national figure which might be difficult to generalize. But, it can be used as a good finding than other primary studies since it was a pooled prevalence of others. In addition, it may lack national representativeness because no data were found from all regions of the country. Finally, the majority of the included studies were cross-sectional study designs and cause-effect relationships; therefore, they cannot be reflected in this review.

## Conclusion and recommendation

This systematic review and meta-analysis revealed that the pooled electrolyte disorders among patients with chronic disease was significant in Ethiopia. Patients who had no formal education, taking diuretic, taking anti-diabetic medication, body mass index ≥ 30 kg/m$^2$, alcohol consumption and having high uncontrolled blood glucose were significantly associated with electrolyte disorders. Special emphasis on the status of serum electrolytes should be given for patients with chronic disease in those taking diuretic and anti-diabetic treatments and who are overweight. Patients with diabetes mellitus should be assessed for their serum electrolyte level for strict good glycemic control.

#### Abbreviations

| | |
|---|---|
| DM | Diabetes mellitus |
| ECF | Extracellular fluid |
| ED | Electrolyte disorder |
| ICF | Intracellular fluid |
| CI | Confidence interval |
| POR | Pooled odds ratio |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12882-024-03873-8.

Supplementary Material 1. PRISMA checklist and quality assessment for meta-analysis of electrolyte disorder among chronic patients in Ethiopia.

Supplementary Material 2. Example of searches for the PubMed databases.

#### Acknowledgements

The authors would like to thank the authors of the included primary studies, which were used as sources of information to conduct this systematic review and meta-analysis.

#### Authors' contributions

WCT conceived the idea, participated in data extraction, analysis, and draft writing. AMZ and YAF participated in the analysis, manuscript preparation, quality assessment, and more revision. All the authors have read and approved the final version of the manuscript to be considered for publication.

#### Funding

Not applicable.

#### Data availability

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

## Declarations

#### Ethics approval and consent to participate

Ethical approval not applicable.

#### Consent to participate

Informed consent not applicable.

**Competing interests**
The authors declare no competing interests.

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