

Original Article

Independent risk factors for thirst in hemodialysis patients: female sex, sodium profiling dialysis, and xerostomia

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Abstract: Objective: To investigate the risk factors for thirst in hemodialysis patients. Methods: A total of 198 hemodialysis patients were enrolled in this retrospective study. Participants were categorized into thirst (n = 157) and non-thirst (n = 41) groups based on Dialysis Thirst Inventory (DTI) scores. Comparative assessments included demographics (age, gender, dry weight, eating habits), vital signs (pre-dialysis systolic/diastolic blood pressure [SBP/DBP], heart rate), and clinical factors (dialysis vintage, diabetes, pre-dialysis serum sodium levels, use of sodium profiling, Xerostomia Inventory [XI] scores, and interdialytic weight gain [IDWG]). Binary logistic regression identified key factors associated with thirst. The groups were also evaluated for emotional distress, treatment adherence, satisfaction, sleep quality, and overall quality of life. Results: Thirsty patients were more likely to be female, undergo sodium profiling, and have high XI scores (≥ 23) compared to non-thirsty patients (all $P < 0.05$). Regression analysis confirmed that female sex, sodium profiling, and xerostomia were independent predictors of thirst (all $P < 0.05$). Thirsty patients also reported greater emotional distress, lower treatment adherence, reduced satisfaction with therapy, poorer sleep quality, and diminished quality of life (all $P < 0.05$). Conclusion: Thirst in hemodialysis patients is independently associated with being female, sodium profiling, and xerostomia. Increased thirst severity correlates with worsened emotional distress, lower therapy adherence, reduced treatment satisfaction, and impaired sleep and life quality.

Keywords: Hemodialysis, thirst risk factors, xerostomia, clinical management strategies

Introduction

Hemodialysis, the most commonly used renal replacement therapy for end-stage renal disease patients, is widely implemented in China [1]. While this life-sustaining technology significantly extends patient survival, it is accompanied by treatment-related complications, financial burdens, and inherent dialysis limitations, all contributing to various physiological challenges during therapy [2]. Among these challenges, thirst has emerged as a prevalent and distressing symptom, severely impairing the quality of life for hemodialysis patients [3]. Bossola et al. [4] report that 67%-97% of hemodialysis patients experience distress from thirst. Thirst, defined as an intense desire to consume fluids, is a complex sensory experience closely associated with xerostomia [5]. Its pathogenesis has been linked to factors such

as sodium intake, volume receptors, the renin-angiotensin system, blood urea nitrogen levels, and psychological factors [6]. If not addressed promptly, thirst often leads to compulsive fluid consumption, resulting in excessive interdialytic weight gain (IDWG) and fluid volume overload [7]. However, the significant ultrafiltration required during dialysis to remove excess fluids may sharply reduce effective circulating blood volume [8]. This reduction can cause patient intolerance, triggering hypovolemic shock and substantially increasing the risk of cardiovascular and cerebrovascular complications, potentially leading to death [9]. Given these challenges, strict control of daily fluid intake is necessary for patients. Failure to meet the demand for water promptly can contribute to psychological distress, including anxiety and depressive symptoms, further exacerbating oxidative stress and negatively affecting patient

well-being [6]. Previous studies have identified factors associated with thirst in hospitalized cardiac failure patients, such as omeprazole use, renal insufficiency, coronary heart disease, advanced New York Heart Association (NYHA) staging, and low indoor humidity [10].

Currently, research examining the risk factors for thirst in hemodialysis patients and developing evidence-based management strategies remains limited. To mitigate and prevent thirst, analyzing its associated factors is crucial for optimizing management strategies. This study enrolled 198 hemodialysis patients for a comprehensive analysis, with the goal of formulating effective clinical interventions. The study has several innovative aspects: (1) Dialysis Thirst Inventory (DTI)-based stratification revealed that 79.29% of hemodialysis patients experience thirst, a strikingly common symptom; (2) Univariate and multivariate analyses identified key predictors of thirst, enabling targeted interventions; (3) A comprehensive assessment demonstrated the negative effect of thirst on psychological status, treatment compliance, sleep, and quality of life, highlighting the need for prioritized clinical attention.

Materials and methods

Case selection

This retrospective study was approved by the Institutional Review Board of the Second Affiliated Hospital of Soochow University. We enrolled 198 patients undergoing hemodialysis at The Second Affiliated Hospital of Soochow University between July 2022 and November 2023. Participants were stratified into a non-thirst group (DTI score <10, n = 41) and a thirst group (DTI score ≥10, n = 157), based on their DTI scores.

Inclusion criteria: Eligible participants were adults aged 18-70 years, receiving maintenance hemodialysis for at least 3 months, undergoing 2-3 dialysis sessions per week (4 hours per session), clinically stable with intact oral mucosa (no congestion, erosion, edema, or ulcers), and cognitively intact with normal communication ability.

Exclusion criteria: Patients were excluded for: Sjögren's syndrome, active radiotherapy, mental disorders, severe gastrointestinal disorders affecting nutrient absorption, uncontrolled dia-

betes, rheumatic diseases, or sleep apnea; chronic or acute infections; acute left heart failure; oral pathologies such as mucosal redness, congestion, or ulcers; hemodynamic instability; pregnancy/lactation; recent (within 3 months) use of medications affecting salivary function; or incomplete medical records.

Data collection

DTI scores were collected for all participants to facilitate group stratification [11]. This scale utilizes a 5-point Likert scale (ranging from 1 = "never" to 5 = "always"), with the total score across all items constituting the DTI score (range: 5-25). Lower scores indicate infrequent thirst, while higher scores indicate more persistent thirst symptoms. A cutoff score of 10 was used to dichotomize patients into "thirst" (DTI ≥10) and "non-thirst" (DTI <10) groups.

Demographic characteristics (age, sex, dry weight, dietary habits, etc.) were recorded. Vital signs, including systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse rate, were measured before dialysis sessions.

Additional clinical data collected included dialysis vintage, diabetes history, pre-dialysis serum sodium concentrations, use of sodium profiling, Xerostomia Inventory (XI) scores, and mean interdialytic weight gain (IDWG). The XI uses a 5-point scale (1 = "never", 5 = "always"), with cumulative scores ranging from 11 to 55. Elevated scores on the XI reflect greater severity of xerostomia symptoms [12].

An inter-group comparison of negative emotional states was conducted using the Self-Rating Anxiety/Depression Scale (SAS/SDS). Both instruments use an 80-point scale, with higher scores indicating greater severity of anxiety and depression.

Quality of life was assessed using the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36), covering the domains of Physical Functioning (PF), Role-Emotional (RE), Mental Health (MH), and Social Functioning (SF). All subscales use a 0-100 scoring system, where higher scores indicate better quality of life.

Treatment adherence was evaluated using a hospital-designed form assessing compliance

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Table 1. Comparison of demographic characteristics

Indicator	n	Non-thirsty group (n = 41)	Thirsty group (n = 157)	χ^2	P
Age (years)				0.359	0.549
<60	100	19 (46.34)	81 (51.59)		
≥60	98	22 (53.66)	76 (48.41)		
Sex				4.453	0.035
Male	143	35 (85.37)	108 (68.79)		
Female	55	6 (14.63)	49 (31.21)		
Dry weight (kg)				1.430	0.232
<65	136	25 (60.98)	111 (70.70)		
≥65	62	16 (39.02)	46 (29.30)		
Dietary habits				2.469	0.291
Neutral	65	16 (39.02)	49 (31.21)		
Light	75	17 (41.46)	58 (36.94)		
Salty	58	8 (19.51)	50 (31.85)		

with diet, fluid intake, medication, dialysis regimen, and treatment adherence. Full adherence means all aspects of treatment were completed on time; partial adherence refers to incomplete or delayed adherence; non-adherence reflects random treatment or non-cooperation. The overall adherence rate was the percentage of patients with full or partial adherence.

Therapeutic satisfaction was assessed using a 100-point scale in a questionnaire survey: >85 = very satisfied, 65-85 = moderately satisfied, <65 = dissatisfied. The overall satisfaction rate was calculated as the percentage of cases reporting either “very satisfied” or “moderately satisfied”.

The Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep quality, with a score range of 0-21 points, where higher scores correlate with poorer sleep quality.

The primary endpoints included DTI, dialysis vintage, diabetes history, pre-dialysis serum sodium concentrations, sodium profiling use, XI, mean IDWG, treatment adherence, therapeutic satisfaction, and PSQI. Demographic characteristics, SAS/SDS, and SF-36 were secondary endpoints.

Statistical methods

Continuous variables were presented as mean $\pm$ standard error of the mean (SEM). Intergroup comparisons of continuous data were performed using independent t-tests,

while intragroup comparisons before and after treatment utilized paired t-tests. Categorical variables are presented as frequencies (percentages), with intergroup comparisons conducted using chi-square (χ^2) tests. Binary logistic regression analysis was used to identify independent risk factors for thirst in hemodialysis patients. All analyses were performed using SPSS 22.0, with significance set at $P < 0.05$ (two-tailed).

Results

Comparison of demographic characteristics

Demographic characteristics, including age, dry weight, and dietary habits, did not differ significantly between the thirsty and non-thirsty groups (all $P > 0.05$). However, a significant sex disparity was observed ($P < 0.05$), with a higher proportion of females in the thirsty group compared to the non-thirsty group. Detailed data are presented in **Table 1**.

Comparison of vital signs

No significant differences were observed in vital signs - including pre-dialysis SBP, DBP, and pulse rate - between the groups (all $P > 0.05$). For further details, refer to **Table 2**.

Comparison of other clinical data

Analysis of additional clinical parameters, such as dialysis vintage, diabetes history, pre-dialysis serum sodium concentration, DTI, and

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Table 2. Comparison of vital signs

Indicator	n	Non-thirsty group (n = 41)	Thirsty group (n = 157)	χ^2	P
Pre-dialysis SBP (mmHg)				0.291	0.590
<145	94	21 (51.22)	73 (46.50)		
≥145	104	20 (48.78)	84 (53.50)		
Pre-dialysis DBP (mmHg)				0.554	0.457
<80	96	22 (53.66)	74 (47.13)		
≥80	102	19 (46.34)	83 (52.87)		
Pulse rate (bpm)				0.166	0.684
<82	107	21 (51.22)	86 (54.78)		
≥82	91	20 (48.78)	71 (45.22)		

Note: SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 3. Comparison of Other clinical data

Indicator	n	Non-thirsty group (n = 41)	Thirsty group (n = 157)	χ^2	P
Dialysis vintage (months)				0.856	0.355
<82	138	31 (75.61)	107 (68.15)		
≥82	60	10 (24.39)	50 (31.85)		
Diabetes history				0.630	0.427
Yes	48	8 (19.51)	40 (25.48)		
No	150	33 (80.49)	117 (74.52)		
Pre-dialysis serum sodium concentration (mmol/L)				0.693	0.405
<140	90	21 (51.22)	69 (43.95)		
≥140	108	20 (48.78)	88 (56.05)		
Use of sodium profiling				4.445	0.035
Yes	66	8 (19.51)	58 (36.94)		
No	132	33 (80.49)	99 (63.06)		
XI (score)				16.789	<0.001
<23	103	33 (80.49)	70 (44.59)		
≥23	95	8 (19.51)	87 (55.41)		
IDWG (kg)				0.005	0.946
<3	86	18 (43.90)	68 (43.31)		
≥3	112	23 (56.10)	89 (56.69)		

Note: XI, Xerostomia Inventory; IDWG, interdialytic weight gain.

Table 4. Variable assignments

Indicator	Variable	Assignment
Sex	X1	Male = 0, female = 1
Use of sodium profiling	X2	No = 0, yes = 1
XI (score)	X3	<23 = 0, ≥23 = 1

Note: XI, Xerostomia Inventory.

results are summarized in **Table 3**.

Binary logistic multivariate analysis of thirst in hemodialysis patients

IDWG, revealed no significant differences between the groups (all $P>0.05$). However, the thirsty group showed significantly higher usage of sodium profiling and a greater proportion of cases with high XI scores (≥ 23) compared to the non-thirsty group (both $P<0.05$). Complete

Independent variables showing significant differences in the univariate analysis were incorporated into a binary logistic regression model, with the presence of thirst as the dependent variable. The analysis identified sex (Odds Ratio (OR): 2.733), use of sodium profiling (OR: 2.727), and XI scores (OR: 2.694) as independent predic-

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Table 5. Multivariate binary logistic regression analysis of thirst in hemodialysis patients

Indicator	β	SE	Wald	P	OR	95% CI
Sex	1.005	0.483	4.325	0.038	2.733	1.060-7.049
Use of sodium profiling	1.003	0.438	5.235	0.022	2.727	1.155-6.441
XI (score)	0.991	0.439	5.097	0.024	2.694	1.140-6.370

Note: XI, Xerostomia Inventory; SE, Standard Error; OR, Odds Ratio; CI, Confidence Interval.

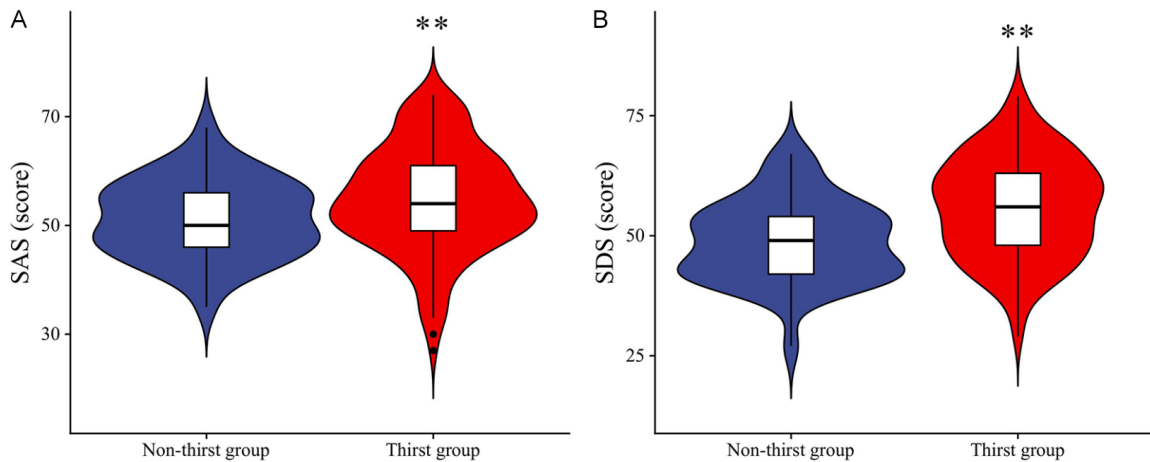


Figure 1. Comparison of negative emotions. A. SAS score comparisons between groups. B. SDS score comparisons between groups. Note: SAS, Self-Rating Anxiety Scale; SDS, Self-Rating Depression Scale. ** $P < 0.01$ vs. non-thirst group.

Table 6. Comparison of treatment adherence

Indicator	Non-thirsty group (n = 41)	Thirsty group (n = 157)	χ^2	P
Complete adherence	16 (39.02)	30 (19.11)		
Partial adherence	21 (51.22)	86 (54.78)		
Non-adherence	4 (9.76)	41 (26.11)		
Overall adherence	37 (90.24)	116 (73.89)	4.954	0.026

tors of thirst in hemodialysis patients (all $P < 0.05$). Based on these findings, adjustments to dialysis sodium concentration strategies and enhanced oral care may serve as critical interventions. Detailed results are presented in **Tables 4, 5**.

Comparative analysis of negative emotional states in thirsty versus non-thirsty hemodialysis patients

Psychological evaluation revealed significantly higher scores on both the SAS and SDS in the thirsty group compared to the non-thirsty group (both $P < 0.01$), as shown in **Figure 1**.

Comparison of treatment adherence

A comparative evaluation of treatment adherence revealed a substantially higher overall ad-

herence rate in the non-thirsty group (90.24%) compared to the thirsty group (73.89%) ($P < 0.05$). Further details are provided in **Table 6**.

Assessment of therapeutic satisfaction among thirsty and non-thirsty hemodialysis patients

The non-thirst group reported significantly higher therapeutic satisfaction rates (92.68%) than the thirsty group (75.80%) ($P < 0.05$). See **Table 7** for additional information.

Comparison of sleep quality

Sleep quality assessment using the PSQI revealed significantly poorer sleep quality in the thirsty group compared to the non-thirsty group ($P < 0.01$). Additional details are provided in **Figure 2**.

Table 7. Comparison of therapeutic satisfaction ratings

Indicator	Non-thirsty group (n = 41)	Thirsty group (n = 157)	χ^2	P
Very satisfied	15 (36.59)	41 (26.11)		
Moderately satisfied	23 (56.10)	78 (49.68)		
Dissatisfied	3 (7.32)	38 (24.20)		
Overall satisfaction	38 (92.68)	119 (75.80)	5.646	0.018

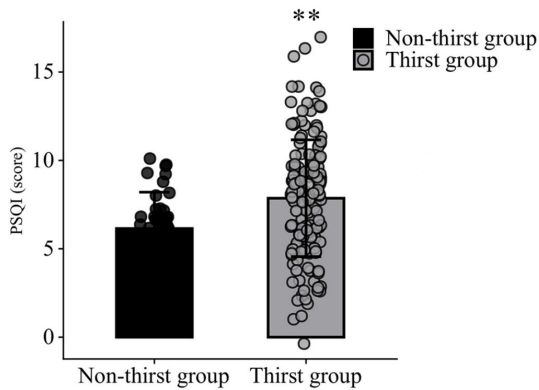


Figure 2. Comparison of Sleep quality. Note: PSQI, Pittsburgh Sleep Quality Index. **P<0.01 vs. non-thirst group.

Comparison of quality of life

Comprehensive quality of life evaluation, encompassing PF, RE, MH, and SF revealed consistently lower SF-36 scores across all measured domains in the thirsty group compared to the non-thirsty group (all P<0.01). Results are presented in **Figure 3**.

Discussion

With the continuous advancement of dialysis technology and improvements in national healthcare systems, hemodialysis has become the primary modality for renal replacement therapy in patients with end-stage renal disease [13]. However, it is important to recognize that hemodialysis serves as a therapeutic intervention rather than a cure. Post-treatment, patients often face various psychological and physiological challenges, among which thirst stands out as a particularly distressing symptom [14]. Thirst, a complex and multidimensional experience characterized by an intense urge to drink, often accompanied by oral dryness, can significantly impair patient well-being [15]. If unmet, the immediate fluid needs may lead to psychological stress, contributing to adverse emotions such as anxiety and depression,

which further diminish the quality of life [16]. Therefore, timely and accurate assessment of thirst, along with risk factor identification, is essential. Tailoring patient-specific clinical strategies to address these risks can help prevent excessive fluid intake driven by thirst while minimizing complications and psychological distress related to aggressive ultrafiltration during dialysis [17].

This study enrolled 198 hemodialysis patients, with thirst reported in 79.3% of cases, consistent with previously documented prevalence rates [4]. Comprehensive analysis of demographic characteristics, vital signs, and clinical parameters identified several distinguishing features in the thirst-affected cohort: a higher proportion of females, use of sodium profiling dialysis, and elevated XI scores (≥ 23). Multivariate modeling confirmed that being female, employing sodium profiling, and having XI scores of ≥ 23 were independently associated with increased thirst risk in these patients. These correlations can be explained through various pathophysiological mechanisms: In female patients, particularly postmenopausal women, estrogen deficiency may reduce salivary gland secretion, while fluctuations in progesterone levels can heighten thirst center sensitivity [18, 19]. Sodium profiling dialysis, which uses hypertonic dialysate, may cause rapid increases in plasma osmolality, stimulating hypothalamic osmoreceptors and inducing vasoconstriction, thereby reducing salivary gland perfusion [20, 21]. The association with high XI scores (≥ 23) likely reflects two interrelated phenomena: salivary gland dysfunction leading to epithelial cell damage, and oral dysbiosis exacerbating mucosal xerosis [22, 23]. Notably, our analysis revealed no significant correlation between pre-dialysis serum sodium concentrations and thirst perception. This null finding may be attributed to two factors: first, most participants maintained pre-dialysis sodium levels within normal physiological ranges [24], and second, static serum sodium measurements fail to capture individual variations in

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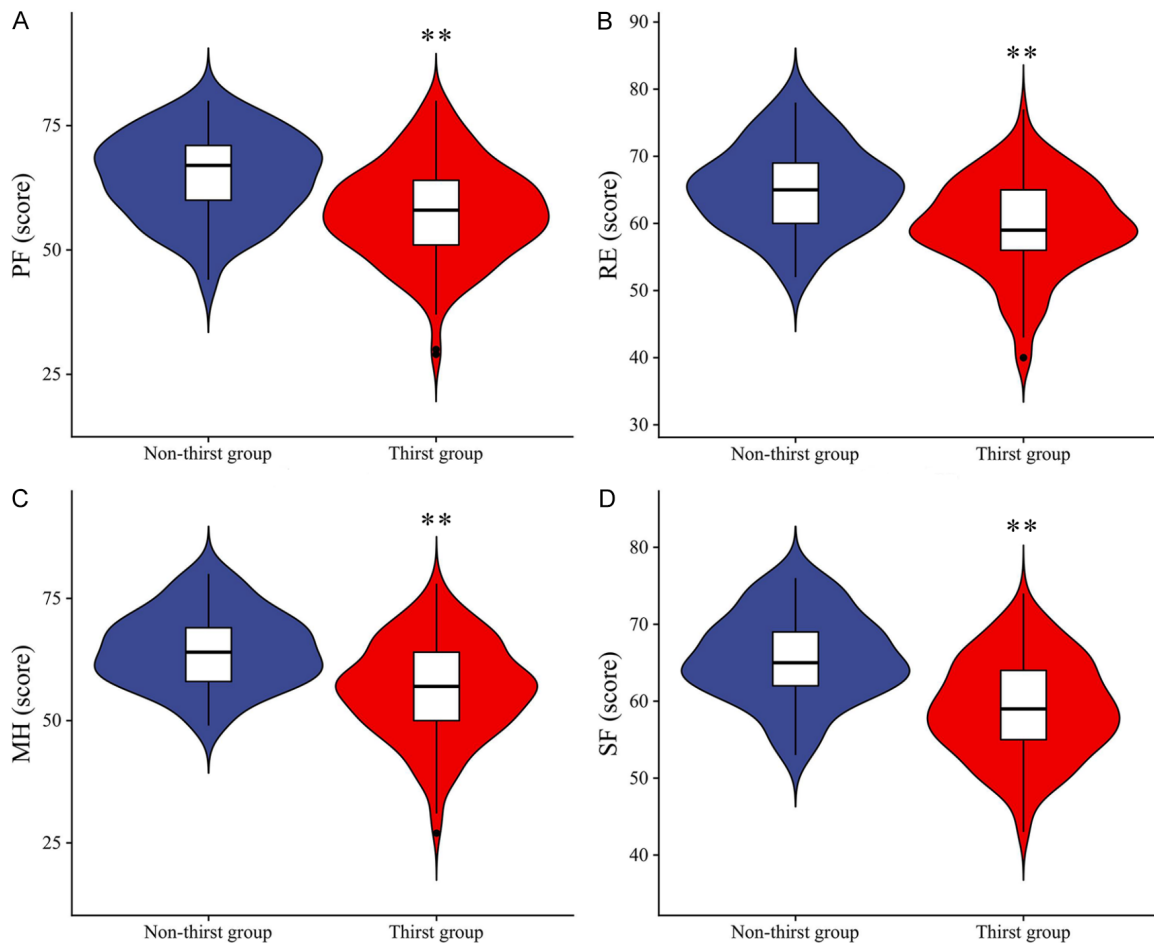


Figure 3. Comparison of quality of life. A. PF domain comparisons. B. RE domain comparisons. C. MH domain analysis. D. SF domain evaluation. Note: PF, Physical Functioning; RE, Role-Emotional; MH, Mental Health; SF, Social Functioning. **P<0.01 vs. non-thirst group.

sodium sensitivity, whereas sodium profiling represents a standardized therapeutic intervention more easily detected by statistical modeling.

Several studies have explored factors contributing to thirst in hemodialysis patients. López-Pintor et al. [25] identified multiple risk factors for thirst, including advanced age, systemic diseases, medication use, fluid intake restrictions, and salivary gland fibrosis/atrophy. Similarly, Lin et al. [26] observed that surgical procedures, hyperglycemia, and disease severity increased thirst risk in intensive care unit patients, which aligns with our findings. A cross-sectional study also demonstrated that age, gender, coronary heart disease history, fasting duration, and intraoperative fluid volume independently predicted postoperative thirst in patients under general anesthesia [27]. Moreover, our study indicates that hemodialysis patients

experiencing thirst tend to report more pronounced negative emotions, reduced treatment adherence, lower therapeutic satisfaction, and poorer sleep and quality of life. These findings highlight the importance of early identification and targeted interventions to alleviate psychological distress, improve treatment adherence, increase therapeutic satisfaction, enhance sleep quality, and improve overall well-being in these patients.

Based on the three independent predictors identified in this study, tailored clinical strategies can be developed. For female patients, particular attention should be given to the physiological effect on salivary secretion. Regular monitoring of salivary changes during dialysis is recommended, and artificial saliva replacement therapy should be implemented as needed. For patients undergoing sodium profiling dialysis, clinicians should reassess the

necessity of this technique. A stepwise reduction in sodium concentration (e.g., gradually decreasing from 150 mmol/L to 135 mmol/L) is advised to minimize fluctuations in blood sodium levels and the stimulation of thirst centers. For patients with severe xerostomia (XI score ≥ 23), a structured oral care plan should be established, incorporating xylitol-based mouthwash and scheduled oral hydration interventions.

A few limitations exist in this study. First, foundational studies are lacking, and expanding such analyses could provide deeper insights into the molecular mechanisms behind thirst. Second, future research should focus on developing a nomogram based on multivariate analysis findings to offer a more robust tool for predicting thirst in clinical settings. Lastly, clinical intervention studies are needed to validate the effectiveness of the proposed clinical strategies for managing thirst. Addressing these areas in future research will enhance the refinement of the project over time.

In conclusion, female sex, the use of sodium profiling dialysis, and severe xerostomia (XI score ≥ 23) emerged as three independent risk factors for thirst in hemodialysis patients. Furthermore, thirst in hemodialysis patients is associated with increased negative emotions, reduced treatment adherence and therapeutic satisfaction, as well as impaired sleep and quality of life, emphasizing the need for early screening and targeted interventions. These findings offer a clinically useful screening tool for early identification of hemodialysis patients at risk of thirst and may inform the development of tailored interventions based on individualized risk stratification.

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Disclosure of conflict of interest

None.

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