# Trajectory of thirst level in critically ill oncology patients: A group-based trajectory model

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**Research Article**

**Keywords:** Critical illness, Thirst, Group-based trajectory model, Longitudinal study

**Posted Date:** June 5th, 2025

**DOI:** https://doi.org/10.21203/rs.3.rs-6488220/v1



**Additional Declarations:** No competing interests reported.

# Trajectory of thirst level in critically ill oncology patients: A group-based trajectory model

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## ABSTRACT

**Purpose:** To investigate the trajectories and determinants of thirst level in critically ill oncology patients.

**Method:** A prospective, longitudinal, and observational study was conducted from November 2024 to February 2025 in a tertiary cancer hospital in Sichuan province, China. Thirst level were assessed by Critically Ill Patients' Thirst Assessment Scale at five time points: upon admission to the intensive care unit (ICU), and at 6, 12, 18, and 24 hours post-admission. Group-based trajectory modeling and unordered multivariate logistic regression were applied to identify distinct trajectory among ICU patients and the determinants of trajectory group.

**Results:** Of the 209 patients included in the study, the majority (56.9%) were aged between 51 and 70 years, and 68.4% were male. Four group trajectories of thirst level were identified: persistent low-level group(15.36%), persistent middle-level group(42.91%), high-level rising group(20.29%), and high-level descending group(21.43%). With persistent low-level group as the reference category, patients with diagnosis of sepsis had lower likelihood to be classified in either persistent middle-level group(*OR*=0.068, 95%*CI*: 0.006-0.829) or high-level descending group(*OR*=0.032, 95%*CI*: 0.001-0.749). Elevated temperature increased the likelihood to be high-level rising group(*OR*=4.172, 95%*CI*: 1.350-12.897). With persistent middle-level group as the reference

category, patients with diagnosis of major surgery had a higher likelihood to high-level rising group(*OR*=8.642, 95 % *CI*: 1.025-72.858).

**Conclusions:** This study identified four distinct thirst level trajectory groups, emphasizing the importance of early risk stratification upon ICU admission. Utilizing indicators such as admission diagnosis and body temperature can enable more precise and timely thirst management strategies.

**Keywords:** Critical illness, Thirst, Group-based trajectory model, Longitudinal study

## 1. Introduction

Critical ill oncology patients are those who have organ dysfunction and need to be admitted to the Intensive Care Unit (ICU) to prolong the survival time and improve the quality of life with tumors[1]. In recent decades, advances in early detection and management have led to a significant increase in both the number of critically ill oncology patients and their survival rates[2]. According to the latest report, the most frequent reasons leading oncology patients to ICU are postoperative, respiratory failure, infection, and sepsis[3].

Thirst is frequently identified as one of the most prevalent, serious and under-managed symptoms in ICU[4]. An observational study[5] of 353 ICU patients assessing the prevalence and intensity of five common symptoms (thirst, pain, anxiety, fatigue, and dyspnea) over a seven-day period, found that thirst was the most prevalent symptom on the first day of ICU admission (66%), and remained the most prevalent and intense symptom throughout the seven-day observation period (64%). Indeed, up to 71% of ICU oncology patients experienced moderate to severe unmet thirst needs[6]. Moreover, ICU oncology patients undergoing anti-tumor therapy frequently experience oral complications such as mucositis and ulceration, which exacerbate thirst[7–9]. Persistent thirst has been associated with an increased risk of delirium[10]. Additionally, oral dryness may impair taste, chewing, and swallowing, potentially increasing the risk of aspiration and negatively impacting post-discharge nutritional status[11].

Unrelieved thirst is a form of distress that nurses can and should alleviate as much as possible, and identifying the factors associated with thirst in ICU patients can help nurses early to prevent and alleviate patients' distress[12]. Non-pharmacological interventions present a comparatively safer and more broadly applicable alternative in clinical practice, which include saliva stimulants[13, 14] and saliva substitutes[11, 15]. Although thirst management in ICU patients has gradually been emphasized by clinical caregivers in recent years, recent studies[7, 16] have shown that the current status of thirst has not been well improved. Therefore, personalised and evidence-based management of thirst is essential in critically ill oncology patients, acknowledging their unique characteristics.

While thirst has subjective properties, traditionally assessed in awake patients[5, 12, 17], its presence in critically ill patients who lacking the self-report ability should not be overlooked. Within the ICU setting, thirst symptoms may be present even before patients regain consciousness. Guided by the Symptom Management Dynamic Model[18], our focus extends beyond simply identifying the presence of thirst, to understanding its dynamic nature and the complexities of symptom management.

Longitudinal studies on thirst level in ICU patients over time are limited. Previous surveys[19–21] were mainly cross-sectional, evaluating the association between the thirst levels of awake patients and clinical outcomes. A recent observational study[22] explored temporal trends in thirst among ICU patients, but it did not adequately account for the inherent heterogeneity within this population, leading to the conclusion that thirst exhibits consistent dynamic trends across all ICU patients. This warrants further reflections. GBTM is a statistical method designed to identify a finite number of distinct groups of individuals exhibiting similar trajectories time, based on a single outcome or behaviour[23]. Therefore, this study aimed to utilize GBTM to identify distinct groups of critically ill oncology patients following similar trajectories of their thirst level within the first 24 hours after ICU admission, and further assessed the association between these trajectories and relevant clinical outcomes, providing evidence to inform scientific and personalized thirst management in

critically ill oncology patients.

## 2. Methods and Analysis

### *2.1 Design and setting*

This prospective, longitudinal and observational study investigated thirst severity in critical ill oncology patients at Sichuan Cancer Hospital from November 2024 to February 2025. This study was performed in line with the principles of the Declaration of Helsinki. Ethical approval was received from the Medical Ethics Committee and Clinical Trail Review Committee of the Sichuan Cancer Hospital(SCCSMC-01-2024-241). Informed and written consent was obtained from all participants. This study was registered on the Chinese Clinical Trial Registry(ChiCTR.org.cn, registration number ChiCTR2500097798, registration date: February 25, 2025), and adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

### *2.2 Participants*

**Inclusion criteria were**: (1) age ≥18 years; (2) admission to the ICU for ≥ 24 hours; (4) provision of informed consent and voluntary participation in the study.

**Exclusion criteria were:** (1) patients that diagnosed with Sjögren's syndrome or uremia; (2) history of psychological disorders (e.g., schizophrenia, bipolar disorder) or cognitive impairment (e.g., dementia); (3) presence of conditions known to cause cognitive impairment and impair the ability to understand the questionnaire, such as craniocerebral injury or toxic encephalopathy; (4) ICU readmission within 72 hours; (5) death during ICU hospitalization.

### *2.3 Data measurement*

Given that some patients were either non-conscious upon ICU admission or required ongoing sedation during their ICU stay, Visual Analogue Scale (VAS)[24], a commonly used tool for evaluating subjective symptoms such as pain and thirst, was not feasible. To mitigate this limitation, the Critically Ill Patient's Thirst

Assessment Scale (CIP-TAS) was employed(Supplementary Appendix 1). The CIP-TAS[25] developed by Chunli Liao of the Department of Critical Care Medicine, Yunnan Cancer Hospital in 2024, assesses thirst from objective perspectives. This scale evaluates indicators such as lip moisture/dryness, oral mucosal condition, tongue texture and coating, sputum viscosity, saliva volume and viscosity, accompanying symptoms of dry mouth, patient behavioral signs. The overall Cronbach's α coefficient of the CIP-TAS was 0.827. The Item-Content Validity Index (I-CVI) ranged from 0.800 to 1.000.

### *2.4 Other covariates*

A custom-designed general information questionnaire was used to collect comprehensive data on ICU patients, including the following: (1) demographics included gender, age, diagnosis of ICU admission, marital status, type of medical insurance, smoking(yes/no), alcohol taking(yes/no), full denture status(yes/no), (2) clinical characteristics included invasive mechanical ventilation(IMV)(yes/no), nil per os (NPO)(yes/no), input and output balance, comorbidities, medications, total ICU length of stay, 24-hours fluid input and output volume, body temperature, blood pressure, Body Mass Index(BMI), Acute Physiology and Chronic Health Evaluation II(APACHE II), venous thromboembolism(VTE) risk assessment, blood glucose, sodium, potassium, ionized calcium, osmolality, C-reactive protein(CRP), creatinine clearance(Ccr), the duration of mechanical ventilation, the duration of NPO status.

### *2.5 Process of data collection*

A unified electronic case report form (eCRF) was designed for centralized data management, enabling efficient data entry, retrieval, and analysis. All research staff and nurses received comprehensive training on study procedures. Strict adherence to standardized protocols for patient screening, data collection, and evaluation, along with uniform inclusion and exclusion criteria, was maintained to minimize variability. Throughout the data collection period, patients received routine ICU care. The temperature (18-22°C) and humidity (50-60%) of the

ICU environment were monitored daily. All collected data underwent a thorough double-checking process to ensure accuracy.

### *2.6 Data analysis*

#### *2.6.1 Sample size*

The sample size was calculated with the convenience sampling formula[12]: $N = \frac{Z_\alpha^2 P(1-P)}{d^2}$, where $N$ is the number of samples; $d$ is the admissible error; $Z_\alpha$ is the statistic representing a certain confidence level ($\alpha$ =0.05, $Z_\alpha$ = 1.96); and $P$ is the estimated overall rate ($d$ = 0.1$P$). Based on previous studies indicating a thirst incidence of approximately 70% in critically ill patients, and anticipating a 10-20% rate of invalid samples, the minimum required sample size for this study was calculated to be 180. Ultimately, 209 critically ill oncology patients were included.

#### *2.6.2 Statistical analysis*

GBTM, as described by Nagin, has been widely used in development trajectory[26]. Two key outputs of the GBTM are the shape of each trajectory, typically defined by a polynomial function of time, and the probability of trajectory group membership[23, 27]. The selection of a GBTM typically involves two steps[28]. First, the optimal number of trajectory groups is determined. This process begins by fitting models with one group, incrementally increasing the number of groups. To ensure parsimony and avoid overfitting, the maximum polynomial order for the trajectories was fixed at three (cubic term). The optimal number of groups was selected based on the following criteria: (1) a Bayesian Information Criterion (BIC) value as close to 0 as possible; (2) an Average Posterior Probability of Assignment (AvePP) > 0.7 for each group; (3) an Odds of Correct Classification (OCC) > 5.0 for each group; and (4) a minimum group membership of 5% of the participants. Second, the shape of each trajectory was determined. After establishing the optimal number of groups, each trajectory was fitted, starting with the highest-order cubic term[29, 30]. The GBTM model was implemented using gbmt package in R(version 4.4.2).

The normality of continuous variables was assessed using the Shapiro-Wilk test. Categorical variables were presented as frequencies and proportions. Normally distributed continuous variables were reported as mean ± standard deviation ($\bar{X} \pm S$), while non-normally continuous variables were presented as medians (interquartile range, IQR). Differences between groups were analyzed using the $\chi^2$ test or Fisher's exact test and the independent two-sample t-test for categorical variables, and the the independent samples t-test or Mann-Whitney U test for continuous variables, depending on normality. Subsequently, the group trajectory categorization derived from the model was used as the dependent variable in an unordered multivariate logistic regression analysis to identify potential influencing factors[29–31]. A *P*-values less than 0.05 was considered statistically significant. Analyses were performed using SPSS (version 25.0) for Windows (IBM SPSS, Chicago, IL, USA).

## 3. Result

### *3.1 Patient characteristics*

Of 323 available patients between November 2024 and February 2025, 234 met met the eligibility criteria, resulting in 209 included in the GBTM analysis(Fig. 1). Most participants were male(68.4%), and aged between 51 and 70 years (56.9%), with over half undergoing major surgery (53.6%). There were 60.8% of patients treated with IMV, and 82.3 % were in status of NPO. The median ICU length of stay was 48 hours (IQR, 24-106.5 hours)(Table 1).

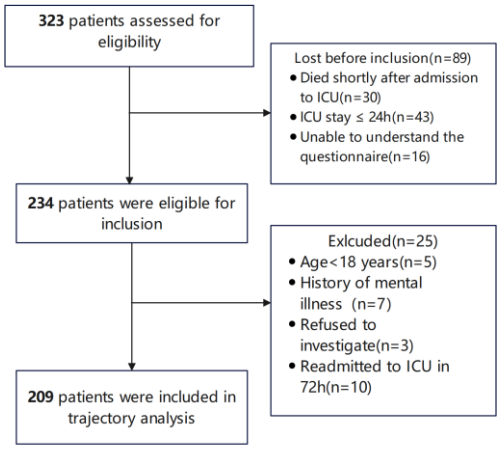


**Fig. 1** Flowchart of participants

**Table 1** Baseline characteristics and clinical outcomes for the total cohort and for each trajectory

| Characteristics | Total(n=209) | Trajectory group | | | | Statistics | *P* |
|---|---|---|---|---|---|---|---|
| | | 1(n=32) | 2(n=90) | 3(n=43) | 4(n=44) | | |
| **Gender** | | | | | | | |
| Male | 143(68.4%) | 21(65.6%) | 63(70%) | 26(60.5%) | 33(75%) | $\chi^2$=21.781 | *P*=0.114 |
| Female | 66(31.6%) | 11(34.4%) | 27(30%) | 17(39.5%) | 11(25%) | | |
| **Age, years** | | | | | | | |
| <30 | 5(2.4%) | 0(0.00%) | 5(5.6%) | 0(0.00%) | 0(0.00%) | *H*=0.420 | *P*=0.930* |
| 31-50 | 32(15.3%) | 5(15.6%) | 12(13.3%) | 9(20.9%) | 6(13.6%) | | |
| 51-70 | 119(56.9%) | 21(65.6%) | 49(54.4%) | 20(46.5%) | 29(65.9%) | | |
| ≥71 | 53(25.4) | 6(18.8%) | 24(26.7%) | 14(32.6%) | 9(20.5%) | | |
| **Diagnosis of ICU admission** | | | | | | | |
| 1=Major surgery | 112(53.6%) | 16(50%) | 43(47.8%) | 28(65.1%) | 25(56.8%) | $\chi^2$=21.781 | *P*=0.114* |
| 2=Sepsis | 11(5.3%) | 4(12.5%) | 5(5.6%) | 1(2.3%) | 1(2.3%) | | |
| 3=Respiratory failure | 15(7.2%) | 1(3.1%) | 9(10.0%) | 0(0.00%) | 5(11.4%) | | |
| 4=Acute Exacerbation of Chronic Disease | 23(11%) | 6(18.8%) | 8(8.9%) | 6(14%) | 3(6.8%) | | |
| 5=Acute Disease | 26(12.4%) | 3(9.4%) | 11(12.2%) | 7(16.3%) | 5(11.4%) | | |
| 6=Other | 22(10.5%) | 2(6.3%) | 14(15.6%) | 1(2.3%) | 5(11.4%) | | |
| **Marital Status** | | | | | | | |
| Single | 6(2.9%) | 32(100%) | 5(5.6%) | 0(0.00%) | 1(2.3%) | $\chi^2$=8.151 | *P*=0.437* |
| Married | 187(89.5%) | 0(0.00%) | 76(84.4%) | 39(90.7%) | 40(90.9%) | | |
| Divorced | 9(4.3%) | 0(0.00%) | 6(6.7%) | 1(2.3%) | 2(4.5%) | | |
| Widowed | 7(3.3%) | 0(0.00%) | 3(3.3%) | 3(7.0%) | 1(2.3%) | | |
| **Medical insurance** | | | | | | | |
| Medical insurance for urban residents | 69(33%) | 10(31.3%) | 34(37.8%) | 14(32.6%) | 11(25.0%) | $\chi^2$=4.769 | *P*=0.574 |
| Medical insurance for urban workers | 58(27.8%) | 8(25%) | 25(27.8%) | 9(20.9%) | 16(36.4%) | | |
| Fully self-financed | 82(39.2%) | 14(43.8%) | 31(34.4%) | 20(46.5%) | 17(38.8%) | | |
| **Smoking**[a] | 45(21.5%) | 3(9.4%) | 28(31.3%) | 8(18.6%) | 6(13.6%) | $\chi^2$=9.529 | ***P*=0.023** |
| **Alcohol taking**[a] | 52(24.9%) | 5(15.6%) | 26(28.9%) | 12(27.9%) | 9(20.5%) | $\chi^2$=2.912 | *P*=0.450 |
| **Denture** | 7(3.3%) | 2(6.3%) | 1(1.1%) | 3(7.0%) | 1(2.3%) | $\chi^2$=4.326 | *P*=0.150* |
| **Invasive Mechanical Ventilation(IMV)** | 127(60.8%) | 17(53.1%) | 52(57.8%) | 30(69.8%) | 28(63.6%) | $\chi^2$=2.734 | *P*=0.434 |
| **NPO** | 172(82.3%) | 25(78.1%) | 74(82.2%) | 35(81.4%) | 38(86.4%) | $\chi^2$=0.906 | *P*=0.824 |
| **Input and output balance** | | | | | | | |
| Negative balance | 45(21.5%) | 4(12.5%) | 26(28.9%) | 6(14.0%) | 9(20.5%) | $\chi^2$=5.920 | *P*=0.116 |
| Positive balance | 164(78.5%) | 28(87.5%) | 64(71.1%) | 37(86.0%) | 35(79.5%) | | |
| **Comorbidities** | 72(34.4%) | 15(46.9%) | 29(32.2%) | 12(27.9%) | 16(36.4%) | $\chi^2$=3.272 | *P*=0.352 |
| Renal | 8(3.8%) | 2(6.3%) | 4(4.4%) | 1(2.3%) | 1(2.3%) | $\chi^2$=1.209 | *P*=0.842* |
| Cardiovascular | 58(27.8%) | 9(28.1%) | 23(25.6%) | 10(23.3%) | 16(36.4%) | $\chi^2$=2.280 | *P*=0.516 |
| Diabetes | 27(12.9%) | 7(21.9%) | 10(11.1%) | 7(16.3%) | 3(6.8%) | $\chi^2$=4.430 | *P*=0.219* |

**Table 1 (continued)**

| Characteristics | Total(n=209) | Trajectory group | | | | Statistics | *P* |
|---|---|---|---|---|---|---|---|
| | | 1(n=32) | 2(n=90) | 3(n=43) | 4(n=44) | | |
| **Medications** | 138(66%) | 20(62.5%) | 61(67.8%) | 27(62.8%) | 30(68.2%) | $\chi^2$=0.592 | *P*=0.898 |
| Antineoplastic drugs[b] | 107(51.2%) | 18(56.3%) | 47(52.2%) | 23(53.5%) | 19(43.2%) | $\chi^2$=1.587 | *P*=0.662 |
| Anesthetics[c] | 111(53.1%) | 15(46.9%) | 50(55.6%%) | 24(55.8%) | 22(50%) | $\chi^2$=1.013 | *P*=0.798 |
| Sedative[c] | 125(59.8%) | 17(53.1%) | 56(62.2%) | 26(60.5%) | 26(59.1%) | $\chi^2$=0.830 | *P*=0.842 |
| Opiates[c] | 118(56.5%) | 17(53.1%) | 50(55.6%) | 25(58.1%) | 26(59.1%) | $\chi^2$=0.348 | *P*=0.951 |
| Diuretic[c] | 32(15.3%) | 7(21.9%) | 13(14.4%) | 4(9.3%) | 8(18.2%) | $\chi^2$=2.592 | *P*=0.459 |
| **Total ICU length of stay, h** | 48(24,106.5) | 32（24,126） | 48（24,114） | 48(24,96) | 46(24,96) | *H*=1.241 | *P*=0.743 |
| **24-hours input and output volume** | 948 (100,1640.5) | 880 (321.5,1438.5) | 1083 (-153.5,1790.5) | 766 (281,1575.0) | 961.5 (137.5,1775.25) | *H*=0.350 | *P*=0.950 |
| **Temperature**[d] | 36.7(36.5,36.9) | 36.55(36.50,36.80) | 36.7(36.40,37.0) | 36.7(36.5,36.8) | 36.7(36.5,37.0) | *H*=1.373 | *P*=0.712 |
| **Systolic blood pressure, mmHg** [e] | 121.7±19.04 | 117.56±19.59 | 122.20±18.96 | 121.44±17.68 | 123.95±20.21 | *F*=0.730 | *P*=0.535 |
| **Diastolic blood pressure, mmHg**[e] | 72.81±11.59 | 72.75±9.88 | 72.40±11.61 | 70.26±11.10 | 76.18±12.70 | *F*=2.004 | *P*=0.115 |
| **BMI, kg/m2** | 22.37 (19.89,24.87) | 22.84 (20.94,26.44) | 21.98 (19.39,24.49) | 22.43 (20.31,26.06) | 22.49 (19.97,25.03) | *H*=2.806 | *P*=0.422 |
| **APACHEII** | 12(9,16) | 11(9.25,15.75) | 12.5(9,17) | 11(8,16) | 12(8.25,16) | *H*=1.701 | *P*=0.637 |
| **VTE** | 6(5,8) | 6(5,7.75) | 7(5,8) | 7(5,8) | 6(4.25,8) | *H*=1.306 | *P*=0.728 |
| **Blood glucose, mmol/L** | 7.56(6.16,9.29) | 8.12(6.37,9.75) | 7.66(6.13,9.81) | 7.28(6.07,8.58) | 8.16(5.82,9.30) | *H*=2.482 | *P*=0.479 |
| **Sodium, mmol/L** | 139.9 (135.20,142.95) | 140.0 (135.68,143.83) | 139.3 (134.35,142.5) | 140.4 (137.3,143.0) | 141.0 (135.58,143.25) | *H*=2.660 | *P*=0.447 |
| **Potassium, mmol/L** | 3.93(3.62,4.25) | 3.95(3.72,4.34) | 4.02(3.64,4.42) | 3.80(3.59,4.17) | 3.91(3.57,4.16) | *H*=4.842 | *P*=0.184 |
| **Ionized calcium, mmol/L** | 1.13(1.09,1.17) | 1.14(1.11,1.18) | 1.12(1.08,1.17) | 1.13(1.10,1.17) | 1.12(1.07,1.18) | *H*=4.954 | *P*=0.175 |
| **Osmolality, mmol/L** | 301.88 (293.93,308.71) | 303.74 (294.71,312.15) | 302.18 (292.57,308.97) | 300.70 (296.05,307.84) | 301.67 (294.63,310.36) | *H*=454 | *P*=0.929 |
| **CRP, mg/L** | 60.56 (8.11,136.45) | 18.21 (3.99,91.07) | 79.2 (9.01,149.75) | 44.18 (4.95,102.04) | 73.0 (9.59,157.75) | *H*=5.732 | *P*=0.125 |
| **Ccr, ml/min/1.73m$^2$** | 96.07 (75.09,106.18) | 97.17 (73.08,104.91) | 94.05 (71.78,106.48) | 97.74 (83.36,111.73) | 98.84 (64.01,104.04) | *H*=2.206 | *P*=0.531 |
| **Duration of IMV, h** | 4(0,9) | 3(0.00,8.75) | 3(0.00,8.25) | 5(0,8) | 6(0,9.75) | *H*=2.286 | *P*=0.515 |
| **Duration of NPO, h** | 24(16.5,48) | 24(13.5,36) | 24(14.25,37.5) | 24(13,48) | 32(24,74.25) | *H*=3.344 | *P*=0.342 |

Note: Data are reported as mean ± SD or median (IQR) for continuous variables and number (percentage) for categorical variables.

Bold indicates statistical significance, * indicates Fisher's exact test;

[a] 1 week before admission to ICU, [b] 3 month before admission to ICU , [c] 12h before admission to ICU to 24h within ICU stay,

[d] maximum body temperature within 24h of ICU stay, [e] when admitted to ICU.

### *3.2 The GBTM analysis of thirst level*

Based on its clinical interpretability and the lowest Bayesian Information Criterion (BIC) score, a four-group trajectory model was selected for further analysis(Table 2). The four trajectories were: trajectory 1

(persistent low-level group; 15.36% of patients, thirst level ≤ 2 throughout 24 hours), trajectory 2 (persistent middle-level group; 42.91% of patients; 2 < thirst level ≤ 4 throughout 24 hours), trajectory 3 (high-level rising group; 20.29% of patients; thirst level ≥5 starting 6 hours post-ICU admission) and trajectory 4 (high-level descending group: 21.43%, 3< thirst level ≤6 with a decreasing trend from ICU admission). Apart from the high-level rising group, the thirst levels in the other three groups peaked upon admission and then gradually decreased to varying degrees as depicted in Fig. 2.

**Table 2** Trajectory evaluation metrics

| Tracks | AIC | BIC | AvePP | OCC | Probability |
|---|---|---|---|---|---|
| 1 | 4444.747 | 4459.603 | 1 | 1 | 1 |
| 2 | 4179.069 | 4223.635 | 0.922/0955 | 17.218/14.357 | 0.406/0.594 |
| 3 | 4091.233 | 4186.451 | 0.906/0.911/0.872 | 32.124/23.349/7.823 | 0.230/0.305/0.465 |
| 4 | 4037.039 | **4173.930** | 0.903/0.906/0.894/0.848 | 51.437/12.800/33.285/20.443 | 0.154/0.429/0.203/0.214 |

Note: The optimal fitting model was bold.

AIC, Akaike Information Criteria; BIC, Bayesian Information Criterion; AvePP, Average posterior probability; OCC, Odds of Correct Classification.

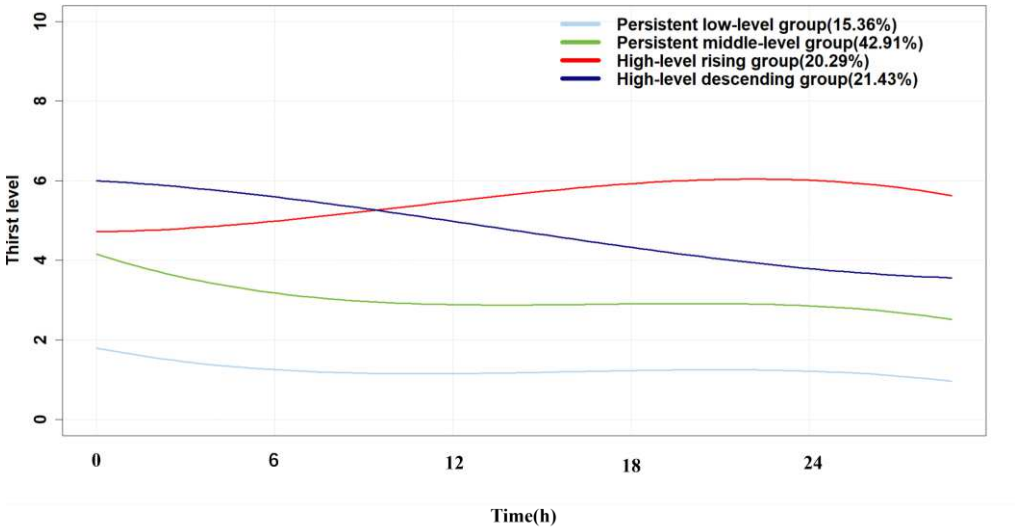


**Fig. 2** Trajectories of thirst level within the first 24-hour ICU stay. Outcome of y-axis indicates the Critically Ill Patient's Thirst Assessment Scale and x-axis represents hours within the first 24-hour.

### *3.3 Predictors of thirst level trajectories*

Univariate analysis revealed a statistically significant difference only for smoking(yes/no)($P$ =0.023), No other variables showed significant differences ($P$ > 0.05) in Table 1. Combined with clinical experience and previous studies, gender, diagnosis of ICU admission, smoking, denture, APACHEII, temperature, input and output balance, potassium, ionized calcium, CRP, invasive mechanical ventilation(yes/no), the duration of NPO,

were selected for inclusion in a multivariate logistic regression model. The goodness-of-fit of the regression model(Supplementary Appendix 2) was adjusted to significant difference (*P*=0.575) by censoring these variables, finally diagnosis ICU admission and temperature remained as an independent predictor of four group membership[32].

With persistent low-level group as the reference category, multivariate logistic regression revealed that patients with a admission diagnosis of sepsis, had a significantly lower likelihood of being classified in either persistent middle-level group(*OR*=0.068, 95% *CI*: 0.006-0.829) or high-level descending group(*OR*=0.032, 95%*CI*: 0.001-0.749); Conversely, a higher body temperature was associated with an increased likelihood of classification in the high-level rising group(*OR*=4.172, 95% *CI*: 1.350-12.897). When the persistent middle-level thirst group was used as the reference, patients admitted to the ICU following major surgery had a significantly higher likelihood of being classified in the high-level rising group(*OR*=8.642, 95 % *CI*: 1.025-72.858 )(Table 3).

**Table 3** Multivariate logistic regression analysis for four-group trajectories

| Group comparison | Coefficient | Standard error | Warld $\chi^2$ | *P* | *OR*(95%*CI*) |
|---|---|---|---|---|---|
| **Persistent middle-level group VS persistent low-level group** | | | | | |
| diagnosis=1 | -0.566 | 0.846 | 0.447 | 0.504 | 0.568(0.108-2.982) |
| diagnosis=2 | -2.687 | 1.275 | 4.442 | **0.035** | 0.068(0.006-0.829) |
| diagnosis=3 | -0.720 | 1.381 | 0.272 | 0.602 | 0.487(0.033-7.287) |
| diagnosis=4 | -1.712 | 1.037 | 2.726 | 0.099 | 0.180(0.024-1.378) |
| diagnosis=5 | -0.121 | 1.105 | 0.012 | 0.913 | 0.886(0.102-7.734) |
| temperature | 0.908 | 0.534 | 2.885 | 0.089 | 2.479(0.870-7.065) |
| CRP | 0.007 | 0.004 | 2.756 | 0.097 | 1.007(0.999-1.014) |
| **High-level rising group VS persistent low-level group** | | | | | |
| diagnosis=1 | 1.381 | 1.297 | 1.134 | 0.287 | 3.977(0.313-50.507) |
| diagnosis=2 | -2.046 | 1.890 | 1.172 | 0.279 | 0.129(0.003-5.250) |
| diagnosis=3 | - | - | - | - | - |
| diagnosis=4 | 0.516 | 1.425 | 0.131 | 0.717 | 1.676(0.103-27.349) |
| diagnosis=5 | 1.831 | 1.492 | 1.506 | 0.220 | 6.237(0.335-116.114) |
| temperature | 1.428 | 0.576 | 6.155 | **0.013** | 4.172(1.350-12.897) |
| CRP | 0.003 | 0.005 | 0.414 | 0.520 | 1.003(0.994-1.012) |
| **High-level descending group VS persistent low-level group** | | | | | |
| diagnosis=1 | -0.145 | 0.922 | 0.025 | 0.875 | 0.865(0.142-5.268) |
| diagnosis=2 | -3.431 | 1.603 | 4.581 | **0.032** | 0.032(0.001-0.749) |
| diagnosis=3 | -0.234 | 1.458 | 0.026 | 0.872 | 0.791(0.045-13.767) |
| diagnosis=4 | -1.493 | 1.176 | 1.613 | 0.204 | 0.225(0.022-2.251) |

**Table 3 (continued)**

| Group comparison | Coefficient | Standard error | Warld $\chi^2$ | *P* | *OR*(95%*CI*) |
|---|---|---|---|---|---|
| diagnosis=5 | -0.250 | 1.225 | 0.042 | 0.839 | 0.779(0.071-8.600) |
| temperature | 0.713 | 0.577 | 1.525 | 0.217 | 2.039(0.658-6.318) |
| CRP | 0.008 | 0.004 | 3.710 | 0.054 | 1.008(1.000-1.016) |
| **High-level rising group VS persistent middle-level group** | | | | | |
| diagnosis=1 | 2.157 | 1.088 | 3.931 | **0.047** | 8.642(1.025-72.858) |
| diagnosis=2 | 0.888 | 1.588 | 0.313 | 0.576 | 2.431(0.108-54.679) |
| diagnosis=3 | - | - | - | - | - |
| diagnosis=4 | 2.264 | 1.194 | 3.595 | 0.058 | 9.623(0.927-99.945) |
| diagnosis=5 | 2.080 | 1.168 | 3.171 | 0.075 | 8.007(0.811-79.040) |
| temperature | 0.479 | 0.307 | 2.427 | 0.119 | 1.614(0.884-2.949) |
| CRP | -0.004 | 0.003 | 1.473 | 0.225 | 0.996(0.991-1.002) |
| **High-level descending group VS persistent middle-level group** | | | | | |
| diagnosis=1 | 0.492 | 0.593 | 0.688 | 0.407 | 1.635(0.512-5.225) |
| diagnosis=2 | -0.619 | 1.280 | 0.234 | 0.629 | 0.538(0.044-6.620) |
| diagnosis=3 | 0.361 | 0.795 | 0.207 | 0.649 | 1.435(0.302-6.812) |
| diagnosis=4 | 0.194 | 0.888 | 0.048 | 0.827 | 1.214(0.213-6.913) |
| diagnosis=5 | -0.081 | 0.789 | 0.011 | 0.981 | 0.922(0.197-4.327) |
| temperature | -0.219 | 0.326 | 0.453 | 0.501 | 0.803(0.424-1.522) |
| CRP | 0.001 | 0.002 | 0.384 | 0.535 | 1.001(0.997-1.006) |
| **High-level rising group VS high-level descending group** | | | | | |
| diagnosis=1 | 1.665 | 1.155 | 2.078 | 0.149 | 5.285(0.550-50.831) |
| diagnosis=2 | 1.508 | 1.882 | 0.642 | 0.423 | 4.516(0.113-180.509) |
| diagnosis=3 | - | - | - | - | - |
| diagnosis=4 | 2.071 | 1.332 | 2.417 | 0.120 | 7.929(0.583-107.863) |
| diagnosis=5 | 2.161 | 1.290 | 2.809 | 0.094 | 8.682(0.693-108.719) |
| temperature | 0.698 | 0.382 | 3.340 | 0.068 | 2.011(0.951-4.253) |
| CRP | -0.005 | 0.003 | 2.432 | 0.119 | 0.995(0.989-1.001) |

Note: Bold indicates statistical significance;

CRP,C-reactive protein; VS, versus; diagnosis=6 was the reference of diagnosis of ICU admission; "-" indicates that odds ratios could not be calculated in the multivariate logistic regression model due to a lack of patients with a diagnosis of respiratory failure.

## 4. Discussion

### *4.1 Main findings*

This is the first study to use objective tool to investigate thirst level in ICU oncology patients throughout their first 24-hour ICU stay, and use GBTM to capture distinct thirst level trajectories within this population. A key finding was the identification of four distinct trajectory groups: persistent low-level group(15.36%), persistent middle-level group(42.91%), high-level rising group(20.29%), and high-level descending group(21.43%). We found that moderate to high of thirst levels was prevalent during 24-hour ICU stay. These

findings suggest a heterogeneity in thirst level trajectories among ICU oncology patients. Several notable differences in baseline characteristics were associated with these trajectory groups such as ICU admission diagnosis, body temperature.

### *4.2 Relationship to literature*

Regarding the distribution of patients within each trajectory group, the majority experienced moderate to high of thirst levels, which is in line with current understanding[5, 20]. This study's finding of the observed gradual decrease in thirst levels over time aligns with findings from previous observational studies using subjective assessment tools[22, 33]. Given that most ICU patients have undergone surgery, this observation may be potentially related to anesthetic drug metabolism and tracheal extubation[21]. Sepsis as an admission diagnosis may be predictive of low thirst levels. This could be related to the development of sepsis-associated acute kidney injury (SA-AKI), a common complication diagnosed early in the ICU course and associated with significant morbidity. A retrospective cohort study across 12 ICUs found that SA-AKI frequently manifests as oliguria[34]. While thirst is a subjective sensation, it is governed by a complex interplay of neurological, hormonal, and behavioral mechanisms[32]. Neuroscience research has demonstrated that fluid balance disturbances frequently occur secondary to sepsis or major surgery. Furthermore, elevated core body temperature can be an anticipatory response promoting thirst, supports our findings[35].

### *4.3 Implications for clinical practice and future research*

Identifying patients with different thirst level during their ICU stay is essential for formulating early thirst management protocols and tailored interventions. This study suggests that early risk stratification upon ICU admission, using indicators such as admission diagnosis and body temperature, is crucial, enabling targeted interventions for patients in high-level thirst trajectory groups. Health caregivers should prioritize interventions that address factors associated with moderate to high thirst levels. Implementing non-pharmacological strategies to reduce thirst symptoms may be a recommended approach. Interventions such as "thirst bundle"[6] "optimize

oral hygiene care"[36], "Saliva substitutes and mucosal moistening agents"[15, 37] have demonstrated effectiveness in reducing thirst symptoms in ICU patients. Conversely, given the low thirst levels observed in patients admitted with a diagnosis of sepsis, careful monitoring of their fluid balance is warranted. Furthermore, we did not observe any effect of antineoplastic drugs such as chemotherapeutic agents or targeted therapies on trajectory groups. It is possible that the widespread use of these drugs influenced the overall incidence of thirst but did not differentiate patients into distinct trajectory groups. This hypothesis requires further investigation, including detailed analysis of specific antineoplastic agents and individual treatment regimens.

## 5. Limitations

This study's investigation period was limited to the first 24 hours following ICU admission due to the varying lengths of stay among patients. This constraint may have influenced the subgroup results. Future research should incorporate longer observation periods and larger sample sizes. Although the objective scale allowed us to assess patients' thirst symptoms prior to regaining consciousness, its clinical utility remains limited, and further validation is required. Furthermore, the complex nature of thirst assessment and the absence of a gold standard necessitate additional investigation into the consistency between the subjective and objective assessment of thirst.

## 6. Conclusion

This study identified four distinct thirst level trajectory groups overtime in critically ill oncology patients using GBTM: persistent low-level group, persistent middle-level group, high-level rising group, and high-level descending group. These trajectories were significantly associated with diagnosis of ICU admission and body temperature of patients. Therefore, early identification and stratification of thirst levels within the first 24 hours after ICU admission represent a crucial first step in developing targeted management strategies to alleviate thirst in this patient population.

**Funding**

Excellent Youth Fund of Sichuan Cancer Hospital(YB2024010)

**Credit authorship contribution statement**

**Xing Shu:** Methodology, Software, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Visualization; **Shuang Yang:** Conceptualization, Methodology, Writing - Original Draft, Funding acquisition; **Aiping Hu:** Conceptualization, Writing - Review & Editing; **Jiang Yuan:** Methodology, Software, Validation, Formal analysis; **Xin Liu:** Conceptualization, Resources, Supervision, Project administration; **Zewen Pan:** Conceptualization, Investigation, Supervision, Project administration; **Zhongjun Cao:** Conceptualization, Investigation, Supervision, Project administration; **Mingfang Xiang:** Conceptualization, Resources, Supervision, Project administration.

**Conflict of interest**

All authors declare no conflicts of interest in this study.

**Data availability statement**

Raw data are available on request from the corresponding author, M. X.

**Acknowledgements**

We thanks all the authors for their contributions in this study.

**Reference**


1. Xia R, Wang D (2018) The option of critical patients with cancer for ICU. Zhonghua Zhong Liu Za Zhi [chinese J Oncol 40:155–159

2. Davis H, Tseng S, Chua W (2024) Oncology intensive care units: distinguishing features and clinical considerations. J Intensive Care Med 8850666241268857. https://doi.org/10.1177/08850666241268857

3. Karagiannis P, Klingler F, Arelin V, et al (2025) Outcome of critically ill patients receiving systemic chemotherapy on the intensive care unit. Front Oncol 14:1508112

4. Çelik S, Şengül M, Karahan E (2023) Evaluation of nonpharmacological nursing practices related to thirst and the thirst of patients in the intensive care unit. Eur J Clin Exp Med 21:458–464. https://doi.org/10.15584/ejcem.2023.3.3

5. Saltnes-Lillegård C, Rustøen T, Beitland S, et al (2023) Self-reported symptoms experienced by intensive care unit patients: a prospective observational multicenter study. Intensive Care Med 49:1370–1382. https://doi.org/10.1007/s00134-023-07219-0

6. Doherty C, Feder S, Gillespie-Heyman S, Akgün KM (2024) Easing Suffering for ICU Patients and Their Families: Evidence and Opportunities for Primary and Specialty Palliative Care in the ICU. J Intensive Care Med 39:715–732. https://doi.org/10.1177/08850666231204305

7. Stoopler ET, Villa A, Bindakhil M, et al (2024) Common Oral Conditions: A Review. JAMA 331:1045. https://doi.org/10.1001/jama.2024.0953

8. (2016) AAOM clinical practice statement. Oral Surg Oral Med Oral Pathol Oral Radiol 122:310–312. https://doi.org/10.1016/j.oooo.2016.04.015

9. Villa A, Epstein JB, Yarom N, et al (2024) MASCC/ISOO clinical practice statement: management of oral complications of targeted therapy. Support Care Cancer 32:549. https://doi.org/10.1007/s00520-024-08689-8

10. Sato K, Okajima M, Taniguchi T (2019) Association of persistent intense thirst with delirium among critically ill patients: a cross-sectional study. J Pain Symptom Manage 57:1114–1120. https://doi.org/10.1016/j.jpainsymman.2019.02.022

11. Mercadante V, Jensen SB, Smith DK, et al (2021) Salivary Gland Hypofunction and/or Xerostomia Induced by Nonsurgical Cancer Therapies: ISOO/MASCC/ASCO Guideline. J clin oncol : off j Am Soc Clin Oncol 39:2825–2843. https://doi.org/10.1200/JCO.21.01208

12. Lin R, Li H, Chen L, He J (2023) Prevalence of and risk factors for thirst in the intensive care unit: an observational study. J Clin Nurs 32:465–476. https://doi.org/10.1111/jocn.16257

13. Liu G, Qiu X, Tan X, et al (2023) Efficacy of a 1% malic acid spray for xerostomia treatment: a systematic review and meta-analysis. Oral Dis 29:862–872. https://doi.org/10.1111/odi.14116

14. Cohen L, Danhauer SC, Garcia MK, et al (2024) Acupuncture for chronic radiation-induced xerostomia in head and neck cancer: a multicenter randomized clinical trial. JAMA Network Open

7:e2410421. https://doi.org/10.1001/jamanetworkopen.2024.10421

15. Clark J, Archer SK (2022) Thirst Interventions in Adult Acute Care-What Are the Recommended Management Options and How Effective Are They?: A Systematic Review. Dimens crit care nurs : DCCN 41:91–102. https://doi.org/10.1097/DCC.0000000000000511

16. Lee YJ, Hwang IC, Choi YS, et al (2024) Association Between Oral Health Status and Survival Time in Terminally Ill Cancer Patients. Am J Hosp Palliat Care 41:1138–1144. https://doi.org/10.1177/10499091231221204

17. Wu C, Luo Q, Fu B, et al (2022) Investigation and analysis of influence factors of thirst in ICU patients with oral tracheal intubation and ventilator assisted ventilation. Chin J Respir Crit Care Med 21:316–321

18. Brant JM, Beck S, Miaskowski C (2010) Building dynamic models and theories to advance the science of symptom management research. J Adv Nurs 66:228–240. https://doi.org/10.1111/j.1365-2648.2009.05179.x

19. Belete KG, Ashagrie HE, Workie MM, Ahmed SA (2022) Prevalence and factors associated with thirst among postsurgical patients at university of gondar comprehensive specialized hospital. Institution-based cross-sectional study. J Patient-rep Outcomes 6:69. https://doi.org/10.1186/s41687-022-00476-5

20. Ho V, Goh G, Tang XR, See KC (2021) Underrecognition and undertreatment of thirst among hospitalized patients with restricted oral feeding and drinking. Sci Rep 11:13636. https://doi.org/10.1038/s41598-021-93048-4

21. Lee C-W, Liu S-T, Cheng Y-J, et al (2020) Prevalence, risk factors, and optimized management of moderate-to-severe thirst in the post-anesthesia care unit. Sci Rep 10:16183. https://doi.org/10.1038/s41598-020-73235-5

22. Zhao P, Luo Y, Xiang L, et al (2024) Dynamic change and risk factors of intense thirst in patients admitted to neuro-intensive care unit: an observational study. Nurs Crit Care. https://doi.org/10.1111/nicc.13184

23. Nagin DS, Jones BL, Passos VL, Tremblay RE (2018) Group-based multi-trajectory modeling. Stat Methods Med Res 27:2015–2023. https://doi.org/10.1177/0962280216673085

24. Faiz KW (2014) VAS--visual analog scale. Tidsskr Nor Laegeforen: Tidsskr Prakt Med Ny Raekke 134:323. https://doi.org/10.4045/tidsskr.13.1145

25. Liao C, Guan Q, Ma X, et al (2024) Construction of an assessment scale for thirst severity in critically ill patients and its reliability and validity. J Clin Nurs. https://doi.org/10.1111/jocn.17385

26. Nagin DS, Odgers CL (2010) Group-based trajectory modeling in clinical research. Annu Rev Clin Psychol 6:109–138. https://doi.org/10.1146/annurev.clinpsy.121208.131413

27. Nagin DS, Jones BL, Elmer J (2024) Recent Advances in Group-Based Trajectory Modeling for Clinical Research. Annual Review of Clinical Psychology 20:285–305.

https://doi.org/10.1146/annurev-clinpsy-081122-012416

28. Wang X, Sun X, Ji Y, et al (2024) Application and case study of group-based multi-trajectory model in longitudinal data research. Zhonghua Liu Xing Bing Xue Za Zhi= Zhonghua Liuxingbingxue Zazhi 45:1590–1597

29. Wu T-T, Lin X-X, Chen G-Y, et al (2025) Muscle strength trajectories and outcomes in critically ill patients: a prospective multicentre cohort study. Intensive Crit Care Nurs 88:103934. https://doi.org/10.1016/j.iccn.2024.103934

30. Hyun D, Ahn JH, Gil H-Y, et al (2023) Longitudinal trajectories of sedation level and clinical outcomes in patients who are mechanically ventilated based on a group-based trajectory model: a prospective, multicentre, longitudinal and observational study in Korea. BMJ Open 13:e072628. https://doi.org/10.1136/bmjopen-2023-072628

31. Raymond J, Darsaut TE (2025) Understanding statistical populations and inferences. Neurochirurgie 71:101608. https://doi.org/10.1016/j.neuchi.2024.101608

32. Fayers P, King M (2008) The baseline characteristics did not differ significantly. Qual Life Res : Int J Qual Life Asp Treat Care Rehabil 17:1047–1048. https://doi.org/10.1007/s11136-008-9382-x

33. Waldréus N, Chung ML, van der Wal MH, Jaarsma T (2018) Trajectory of thirst intensity and distress from admission to 4-weeks follow up at home in patients with heart failure. Patient Prefer Adherence 12:2223–2231. https://doi.org/10.2147/PPA.S167724

34. White KC, Serpa-Neto A, Hurford R, et al (2023) Sepsis-associated acute kidney injury in the intensive care unit: incidence, patient characteristics, timing, trajectory, treatment, and associated outcomes. A multicenter, observational study. Intensive Care Med 49:1079–1089. https://doi.org/10.1007/s00134-023-07138-0

35. Gizowski C, Bourque CW (2018) The neural basis of homeostatic and anticipatory thirst. Nat Rev, Nephrol 14:11–25. https://doi.org/10.1038/nrneph.2017.149

36. Serra R, De Oliveira CS, Roque S, et al (2023) Oral hygiene care and the management of oral symptoms of the cancer patients in palliative care: a systematic review protocol. JBI Evidence Synth. https://doi.org/10.11124/JBIES-23-00096

37. Hong C, Epstein JB, Jensen SB, et al (2024) MASCC/ISOO Clinical Practice Statement: Clinical assessment of salivary gland hypofunction and xerostomia in cancer patients. Support Care Cancer 32:551. https://doi.org/10.1007/s00520-024-08691-0

# Supplementary Files

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