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ORIGINAL RESEARCH

Knowledge, Attitudes, and Practices Regarding the Prevention and Management of Acute Kidney Injury Among ICU Physicians: Association with Burnout

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Background: Acute kidney injury (AKI) poses significant challenges to patient outcomes in intensive care units (ICUs). This study aims to examine the knowledge, attitudes, and practices (KAP) of ICU physicians regarding AKI prevention and management, as well as to explore the potential association between burnout levels and KAP performance.

Methods: : We conducted a cross-sectional study among physicians working at 18 ICUs in Taizhou, Zhejiang Province, from 26 September 2023 to 18 March 2024. Data were collected using a self-administered KAP questionnaire (knowledge: 18 items [score range: 18–36]; attitude: 8 items [score range: 8–40]; practice: 13 items [score range: 13–65]) and the Maslach Burnout Inventory-General Scale (MBI-GS).

Results: The study enrolled 220 ICU physicians with valid questionnaires. The mean scores were: knowledge 29.92±3.42, attitude 30.94±5.49, practice 46.28±5.65, and burnout 2.13±0.63. Physicians certified by the Chinese Critical Care Certified Course (5C) demonstrated significantly higher KAP levels (K: 30.46±3.20, p=0.008; A: 31.37±5.40, p<0.001; P: 46.76±5.35, p=0.013) despite higher burnout levels (2.18±0.63, p=0.002). Those with resignation intentions had significantly lower KAP scores (K: 27.78±3.81, P=0.001; A: 28.48±4.97, P=0.023; P: 43.83±5.35, p=0.027) and higher burnout (2.51±0.44, p=0.003). Correlation analyses revealed that knowledge was significantly associated with both attitude (r=0.614, p<0.001) and practice (r=0.538, p<0.001). Total Burnout was negatively correlated with attitude ($r = -0.223$, $p < 0.001$) and practice ($r = -0.238$, $p < 0.001$). Multivariable logistic regression further confirmed that attitude was the strongest modifiable independent predictor of practice behaviors (OR = 1.413, $p < 0.001$).

Conclusion: ICU physicians demonstrate adequate knowledge, positive attitude and proactive practices toward AKI prevention and management, despite experiencing moderate burnout levels. Attitude is the strongest modifiable predictor of practice, underscoring the importance of fostering positive attitudes to enhance AKI management among ICU physicians. Targeted interventions aimed at enhancing knowledge, fostering positive attitudes, and addressing burnout are needed for effective AKI management in ICU settings.

Keywords: knowledge, attitude, practice, ICU physician, acute kidney injury, burnout, maslach burnout inventory-general scale, MBI-GS

Background

The rising prevalence and mortality associated with acute kidney injury (AKI) pose significant threats to the survival of critically ill patients globally. AKI, a major health concern in intensive care units (ICU), is characterized by the rapid loss of renal excretion.[1] AKI is the principal cause of elevated mortality rates in patients suffering from acute illnesses, with mortality rates estimated at approximately 50%.[2,3] Various factors can induce AKI, including drug use, ischemia/reperfusion injury, and infections.[4–6] For instance, contrast-induced AKI (CI-AKI) ranks as the third leading cause of hospital-acquired AKI.[7,8] Early identification, timely prevention, and appropriate treatment of AKI are crucial to improving patient prognosis, particularly in ICU settings.[8] ICU physicians, being on the frontline of critical care, play

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a pivotal role in recognizing risk factors, implementing evidence-based preventive strategies, and initiating early interventions to mitigate kidney injury progression.

The Knowledge, Attitude, and Practice (KAP) survey is a key tool for assessing individuals' understanding, beliefs, and behaviors regarding specific health issues. It is based on the premise that knowledge shapes attitudes, which in turn influence practices.[9–11] Additionally, the sequential model of KAP is vital for modifying the practice patterns of physicians.[12] Because ICU professionals' KAP levels are closely linked to patient disease progression and prognosis, this assessment is particularly relevant in critical care.

Burnout is a prevalent occupational phenomenon in medicine, characterized by emotional exhaustion, depersonalization, and reduced personal accomplishment.[13] Burnout commonly arises globally from heavy workload, emotional strain, and resource limitations, subsequently impairing cognition and motivation.[14] It adversely affects physicians' well-being, quality of care, and patient safety,[15] while lower burnout and stronger professional engagement are linked to better clinical performance.[16] High job demands coupled with insufficient resources lead to burnout, reducing engagement and performance.[17] Empirical evidence also links excessive cognitive load to burnout and poor decision-making.[18,19] These models suggest that burnout may undermine ICU physicians' KAP application. Supporting this, a recent study in Zhejiang Province reported that higher KAP scores correlated with lower burnout, suggesting that better knowledge and proactive practices may protect against burnout.[20] Understanding the principles of AKI detection and management is a core competency for all medical staff, as emphasized in existing recommendations for AKI awareness, recognition, and treatment.[13] However, to our knowledge, no studies have investigated the interplay between occupational burnout, KAP, and AKI management among ICU physicians.

Therefore, this study aims to assess ICU physicians' KAP and burnout related to AKI prevention and management, identify misconceptions, and promote effective practices to better integrate these competencies into routine care and improve outcomes for critically ill patients.

Methods

Study Design and Subjects

This cross-sectional study was conducted at 18 ICUs of tertiary and secondary hospitals from 26 September 2023 to 18 March 2024 in Taizhou, Zhejiang Province, China, focusing exclusively on ICU physicians as the research subjects.

The inclusion criteria were: (1) physicians with ≥1 year of independent working experience in ICU (including probation period) to ensure sufficient clinical experience; (2) senior resident physician rank or higher, as higher professional titles typically indicate completion of standardized training and independent decision-making ability; (3) currently working full-time in an adult general ICU, not on temporary rotation or short-term assignment; and (4) voluntary participation with electronic informed consent. Exclusion criteria included: (1) residents in standardized training programs or interns with <1 year of ICU rotation; (2) physicians in non-clinical positions (eg, full-time research or administrative roles); and (3) those who refused participation or withdrew during the survey.

Sample Size Calculation

The sample size was determined based on Cochran's proportion formula ($Z=1.96$, $d=0.05$) with a conservative estimate of "adequate practice" proportion ($p=0.60$) from preliminary surveys, requiring 384 subjects initially. After finite population correction for the approximately 300 ICU physicians in Taizhou, the required sample size was reduced to 168. Power analysis indicated that a minimum of 84 participants was needed to detect a moderate correlation ($r=0.30$) between knowledge, attitude, and practice with 80% power at $\alpha=0.05$. For multivariable logistic regression, assuming a 60% event rate for adequate practice (practice score ≥45) and requiring at least 10 events per predictor variable, a minimum of 220 participants was needed to accommodate up to 13 covariates. Considering a 10% non-response rate and a design effect of 1.3 for the sampling approach, we aimed for at least 200 valid questionnaires.

Instruments

KAP Questionnaire

The KAP questionnaire was developed specifically for this study based on the Kidney Disease: Improving Global Outcomes (KDIGO) Clinical Practice Guidelines for Acute Kidney Injury, the Chinese Clinical Practice Guideline for Acute Kidney Injury,[21] and relevant literature on AKI management in ICU settings. The initial draft was reviewed and revised based on feedback from a panel of 8 experts in critical care medicine and nephrology. Content validity was established through expert consultation and pilot test participant feedback, ensuring the questionnaire covered key areas of AKI prevention and management based on the guidelines. The Cronbach's α coefficients for the pilot study (N=31) were: total scale 0.775, knowledge subscale 0.556, attitude subscale 0.751, and practice subscale 0.800. These results suggested acceptable internal consistency, supporting the feasibility of proceeding with formal data collection. Following the formal study, the Cronbach's α coefficients improved to: total scale 0.887, knowledge subscale 0.751, attitude subscale 0.849, and practice subscale 0.714, further confirming the questionnaire's internal consistency and reliability across a larger sample. The Kaiser-Meyer-Olkin (KMO) value was 0.878, indicating good sampling adequacy.

The final version encompasses four sections: demographic information (including education level, gender, nature of unit, professional title, resignation intentions, frequency of contact with AKI patients, and training status), knowledge, attitude, and practice dimensions. The knowledge dimension focused on AKI definition, diagnostic criteria, risk factors, prevention strategies, and management approaches. It consisted of 18 items, each scored as 2 points for a correct answer and 1 point for an incorrect or "unsure" answer, with a total score range of 18 to 36. Higher scores indicated a better understanding of AKI-related knowledge. The attitude dimension assessed perceptions regarding the importance of early identification, prevention, and treatment of AKI. It included 8 items rated on a 5-point Likert scale (1 = very negative to 5 = very positive), with a total score range of 8 to 40. Higher scores reflected more positive attitudes toward AKI management. The practice dimension examined self-reported adherence to recommended AKI management guidelines in clinical settings. It contained 13 items, also rated on a 5-point Likert scale (1 = never to 5 = always), with scores ranging from 13 to 65. Higher scores denoted more proactive and guideline-consistent clinical practices. A score of more than 70% of the maximum possible score in each dimension was considered adequate knowledge, attitude and practice (knowledge ≥25.2 points, attitude ≥28 points, practice ≥45.5 points).[22]

Maslach Burnout Inventory-General Scale

Additionally, the 15-item Chinese version of the Maslach Burnout Inventory-General Scale (MBI-GS) was employed to assess burnout.[23] This scale includes subscales for emotional exhaustion (EE) with five items, cynicism (CY) with five items, and reduced personal accomplishment (PA) with five items. Each item is rated on a 7-point Likert scale ranging from 0 ("never") to 6 ("every day"). PA items were reverse-scored so that higher scores indicate greater burnout across all dimensions. Burnout scores were calculated using a weighted six-point system formula: Total score = 0.4 × Average score of EE + 0.3 × Average score of CY + 0.3 × Average score of PA, a total score of more than 1.5 was considered to be the presence of burnout.[24] The KMO value for the MBI-GS was 0.889, indicating excellent sampling adequacy.

Data Collection and Quality Control

Based on estimates, approximately 300 ICU physicians across the selected hospitals met the inclusion and exclusion criteria. A convenience sampling method was employed to recruit participants. Questionnaire distribution was conducted primarily via WeChat departmental groups We acknowledge that convenience sampling may introduce potential selection bias, which could limit the generalizability of our findings. During the six-month data collection period (September 2023–March 2024), no major healthcare policy changes, guideline updates, or social events occurred that might have influenced ICU physicians' KAP or burnout levels, ensuring the temporal stability of the data. Electronic questionnaire links were distributed via departmental WeChat groups after coordination with department heads. A total of 252 physicians completed and submitted the questionnaires. Privacy protection measures included de-identification of data and secure data storage on password-protected servers. Prior to accessing the questionnaire, participants reviewed an electronic informed consent form detailing the study purpose, voluntary nature of participation, confidentiality protections, and the right to withdraw at any time.

The recovered questionnaires were checked by the research team members for completeness, internal consistency, and plausibility of all questionnaires. Questionnaires that were incomplete and had logical problems were eliminated. Questionnaires were eliminated if: (1) respondents did not accept the informed consent (n=2); (2) completion time was less than 90 seconds (n=10), suggesting insufficient attention to questions; (3) completion time exceeded 1800 seconds (n=17), indicating potential interruptions that might affect response coherence; (4) logical inconsistencies were detected, such as age minus years of work experience less than 18 years (n=1), which is biologically implausible; or (5) years working in ICU exceeded total years of professional experience (n=2), which is logically impossible.

Ethical Approval

This study was approved by the Ethics Committee of Taizhou Central Hospital (Taizhou University Hospital) (Approval NO.: 2023-LL-0913). Electronic informed consent was obtained from all participants prior to data collection. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical Analysis

Data analysis was performed using SPSS 22.0 (IBM, Armonk, NY, USA), with quantitative variables presented as means and standard deviations (SD). Normality of distributions was assessed using the Shapiro–Wilk test. Differences across groups were analyzed using the independent samples *t*-test for two-group comparisons and one-way analysis of variance (ANOVA). For non-normally distributed data, we employed the Mann–Whitney *U*-test or the Kruskal–Wallis test.

Pearson correlation analysis was utilized to evaluate the relationships between knowledge, attitude, practice, and burnout scores when the assumption of bivariate normality was met; otherwise, Spearman's rank correlation was applied.

To identify independent predictors of proactive practice (defined as practice scores ≥45), multivariable logistic regression was conducted. Variables with a P-value less than 0.1 in univariate analyses were included in the multivariable model to ensure comprehensiveness while maintaining model parsimony. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. All P-values were reported to three decimal places, with a value less than 0.05 considered statistically significant.

Results

Participant Characteristics

Out of 252 questionnaires returned, 32 were excluded following quality control procedures, resulting in 220 valid questionnaires (effective response rate: 87.30%). Participants were predominantly male (64.09%), with a mean age of 38.28±8.23 years, and most worked in public tertiary hospitals (72.73%) (Table 1).

Table 1 Baseline Characteristics of ICU Physician Participants

	N (%)
Total	220
Age	38.28±8.23
Gender	
Male	141 (64.09%)
Female	79 (35.91%)
Education level	
College and undergraduate	105 (47.73%)
Master degree and above	115 (52.27%)
Job title	
Junior and below	59 (26.82%)
Intermediate	63 (28.64%)
Deputy Senior	67 (30.45%)
Senior	31 (14.09%)

(*Continued*)

Table 1 (Continued).

	N (%)
The nature of the organization	
Public secondary and other	58 (26.36%)
Public tertiary	160 (72.73%)
Private hospital	2 (0.91%)
Work experience	
5 years and below	52 (23.64%)
5-15 years	92 (41.82%)
More than 15 years	76 (34.55%)
Do you have critical care medicine (5C) qualifications?	
Yes	180 (81.82%)
No	40 (18.18%)
Do you have any further education experience in the past 3 years?	
Yes	84 (38.18%)
No	136 (61.82%)
Whether the department has a critical nephrology subspecialty	
Yes	30 (13.64%)
No	190 (86.36%)
Do you engage in the subspecialty of critical care nephrology?	
Yes	29 (13.18%)
No	191 (86.82%)
Do you have any intention to resign?	
Yes	23 (10.45%)
No	197 (89.55%)
How often do you encounter patients with acute kidney injury?	
Monthly, quarterly or longer	66 (30%)
Weekly	50 (22.73%)
Daily	104 (47.27%)

Abbreviations: ICU, Intensive Care Unit; 5C, Chinese Critical Care Certified Course.

Overall KAP and Burnout Levels

ICU physicians demonstrated adequate Knowledge, Attitude, and Practice, as all dimensions met the pre-defined adequacy criteria (over 70% of the maximum possible score for each dimension: ≥25.2, ≥28, ≥45.5). The mean scores for Knowledge, Attitude, and Practice were 29.92±3.42 (range 18–36), 30.94±5.49 (range 8–40), and 46.28±5.65 (range 13–65), respectively, ICU professionals recorded a mean burnout score of 2.13±0.63, indicating moderate burnout as this score exceeded the threshold of 1.5. Participants' Knowledge scores were significantly associated with gender ($p = 0.005$), 5C qualifications ($p = 0.008$), critical care nephrology subspecialty involvement ($P = 0.040$), engagement in the subspecialty ($p = 0.003$), intention to resign ($p = 0.001$), and frequency of encountering AKI cases ($p < 0.001$).Attitude scores varied significantly based on 5C qualifications ($p < 0.001$), critical care nephrology subspecialty involvement ($p = 0.034$), engagement in the subspecialty ($P = 0.034$), intention to resign ($p = 0.023$), and frequency of encountering AKI cases ($p < 0.001$).Practice scores were significantly associated with the type of organization ($p = 0.013$), 5C qualifications ($p = 0.013$), further education experience in the past three years ($p = 0.012$), intention to resign ($p = 0.027$), and frequency of encountering AKI cases ($p < 0.001$).Burnout scores varied significantly depending on job title ($p = 0.007$), work experience ($p < 0.001$), 5C qualifications ($p = 0.002$), further education experience ($P = 0.004$), and intention to resign ($p = 0.003$) (Table S1 and Figure 1).

Distribution of Responses on Individual Items

Analysis of knowledge dimension responses revealed specific areas of uncertainty among participants. As detailed in Table S2, the highest rates of "Unsure" responses were observed for items related to pharmacological interventions for

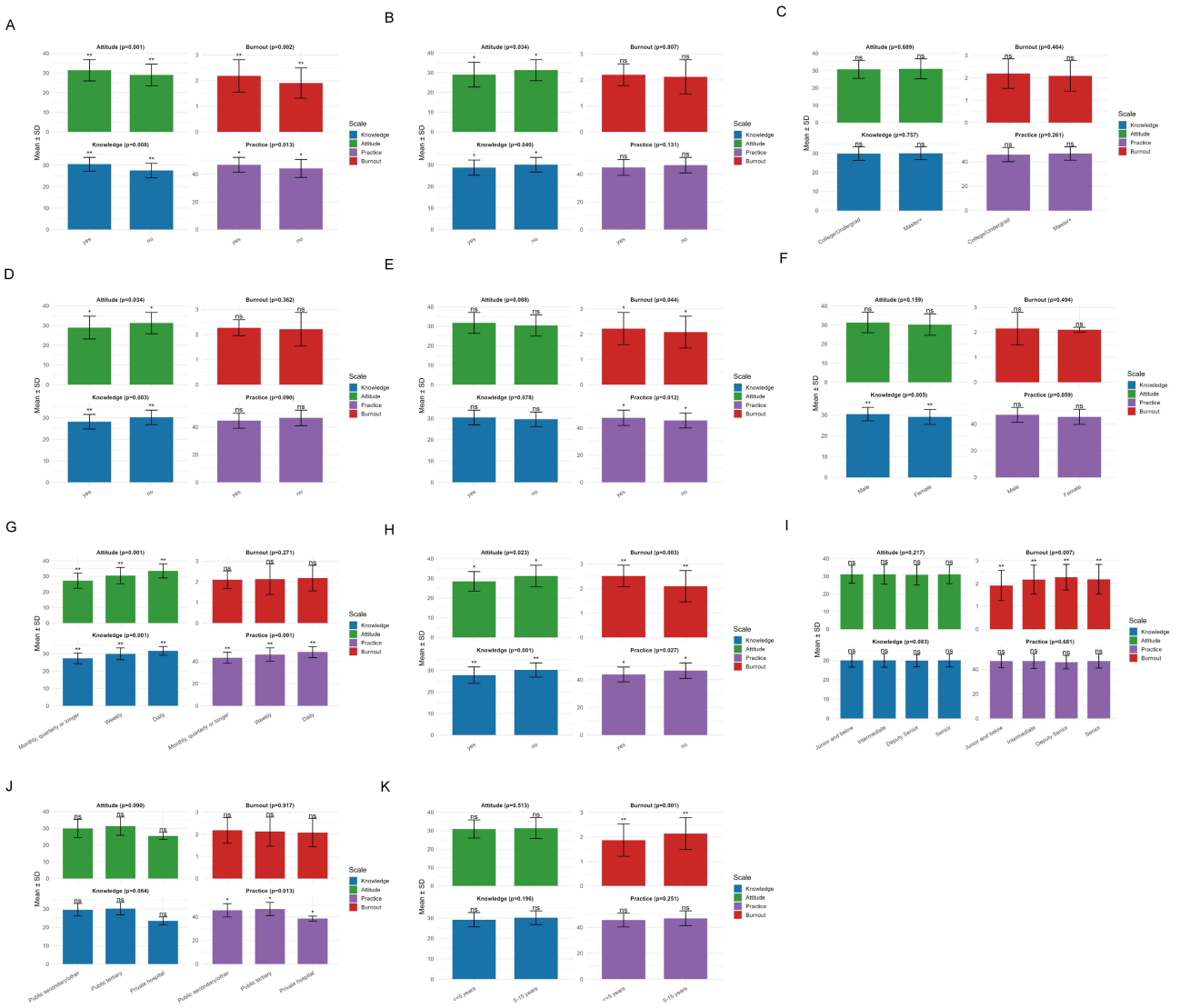

Figure 1 Comparisons of Knowledge, Attitude, Practice, and Burnout scores across demographic and professional characteristics. (**A**) Qualification level (5C certification); (**B**) Critical care nephrology subspecialty involvement; (**C**) Education level; (**D**) Engagement in the subspecialty; (**E**) Further education experience; (**F**) Gender; (**G**) Frequency of encountering AKI cases; (**H**) Intention to resign; (**I**) Job title; (**J**) Type of organization; (**K**) Work experience. Bars represent mean ± standard deviation (SD). *p < 0.05, **p < 0.01.

Abbreviations: K, Knowledge; A, Attitude; P, Practice; B, Burnout; Master+, Master degree and above; ns, not significant.

AKI prevention. Specifically, 24.09% of participants were uncertain about the recommendation "not to use N-acetylcysteine (NAC) to prevent AKI in critically ill patients with hypotension" (K11), 23.18% were uncertain about the recommendation "to use theophylline and fenoldopam to prevent contrast agent-related AKI (CI-AKI)" (K7), and 21.82% were uncertain about the recommendation "to combine oral N-acetylcysteine (NAC) with intravenous infusion of isotonic crystalloid solution to prevent AKI for patients at high risk of CI-AKI" (K10).

With regard to attitudes toward AKI management (Table S3), concerning proportions of participants endorsed statements that contradict best practice guidelines. Notably, 21.82% of participants (5.91% strongly agreed, 15.91% agreed) endorsed the statement "Patients with acute kidney injury do not need to be treated based on grade and cause" (A2). Similarly, 20.46% (5.91% strongly agreed, 14.55% agreed) endorsed the view that "Because there is no specific treatment that can reverse the clinical course of AKI, early identification of AKI is of little significance" (A5). Additionally, 16.36% (5.00% strongly agreed, 11.36% agreed) considered

"providing early preventive treatment to patients with suspected AKI or even those who are only at risk of AKI" to be "a medical waste" (A6).

Regarding practice behaviors (Table S4), several areas of suboptimal adherence to evidence-based recommendations were identified. A majority of participants (60.00%; 40.91% rarely, 19.09% never) reported not using the recommended combination of oral NAC with intravenous infusion of isotonic crystalloid solution for CI-AKI prevention in high-risk patients (P7). Concerningly, 15.91% (5.00% always, 10.91% often) continued to use diuretics and low-dose dopamine for AKI prevention and treatment (P8) despite evidence against this practice. Additionally, 14.09% (4.09% always, 10.00% often) reported never using aminoglycosides to treat infections (P9), reflecting appropriate awareness of their nephrotoxicity risk. Regarding dialysis access, 63.63% (16.36% always, 47.27% often) prioritized femoral vein placement for intravenous dialysis catheters in AKI patients without relevant contraindications (P11), which aligns with current practice guidelines.

The distribution of responses on the Maslach Burnout Inventory-General Scale (Table S5) revealed notable levels of emotional exhaustion and reduced personal accomplishment among participants. In terms of emotional exhaustion, 37.73% of participants reported that work often made them feel physically and mentally exhausted (Q1), and 37.27% often felt exhausted when leaving work (Q2). Regarding personal accomplishment, 13.18% of participants seldom felt very happy due to completing their work (Q13), and 12.73% seldom felt that they had accomplished valuable work (Q14), indicating diminished professional satisfaction in a subset of participants.

Correlation Analysis

Attitude was strongly positively correlated with Practice ($r = 0.730$, $p < 0.001$), and moderately positively correlated with Knowledge ($r = 0.614$, $p < 0.001$). Knowledge also showed a moderate positive correlation with Practice ($r = 0.538$, $p < 0.001$). Regarding the relationships with burnout, the total Burnout scale was negatively correlated with Attitude ($r = -0.223$, $p < 0.001$) and Practice ($r = -0.238$, $p < 0.001$). However, there was no statistically significant correlation between Knowledge and the total Burnout scale ($r = -0.049$, $p = 0.470$). Further analysis with the burnout sub-dimensions revealed that Attitude was negatively correlated with Cynicism ($r = -0.234$, $p < 0.001$) and Personal Accomplishment ($r = -0.283$, $p < 0.001$), but not significantly correlated with Emotional Exhaustion ($r = -0.071$, $p = 0.296$). Similarly, Practice was negatively correlated with Cynicism ($r = -0.217$, $p < 0.001$) and Personal Accomplishment ($r = -0.283$, $p < 0.001$), with no statistically significant correlation observed with Emotional Exhaustion ($r = -0.132$, $p = 0.051$). Knowledge did not demonstrate statistically significant correlations with any of the burnout sub-dimensions (Emotional Exhaustion: $r = -0.009$, $p = 0.900$; Cynicism: $r = -0.085$, $p = 0.209$; Personal Accomplishment: $r = -0.042$, $p = 0.533$). As expected, the burnout sub-dimensions were all positively and significantly inter-correlated ($p < 0.001$ for all pairs), and each sub-dimension was strongly positively correlated with the total Burnout scale ($p < 0.001$ for all) (Table 2).

Table 2 Correlation Analysis of KAP Scores

	Knowledge	Attitude	Practice	Burnout Scale	EE	CY	PA
Knowledge	1						
Attitude	0.614 (<0.001)	1					
Practice	0.538 (<0.001)	0.730 (<0.001)	1				
Burnout scale	−0.049 (0.470)	−0.223 (<0.001)	−0.238 (<0.001)	1			
EE	−0.009 (0.900)	−0.071 (0.296)	−0.132 (0.051)	0.844 (<0.001)	1		
CY	−0.085 (0.209)	−0.234 (<0.001)	−0.217 (<0.001)	0.901 (<0.001)	0.674 (<0.001)	1	
PA	−0.042 (0.533)	−0.283 (<0.001)	−0.283 (<0.001)	0.832 (<0.001)	0.464 (<0.001)	0.686 (<0.001)	1

Abbreviations: KAP, Knowledge, Attitude, and Practice; EE, Emotional Exhaustion; CY, Cynicism; PA, Personal Accomplishment.

Factors Associated with Higher Practice Scores: Logistic Regression Analysis

Univariable logistic regression was conducted to assess the individual association of various factors with higher practice scores (defined as ≥45). Factors significantly associated with higher practice scores in the univariable analysis ($p < 0.05$) included Knowledge score, Attitude score, Cynicism, Personal Accomplishment, gender, possession of critical care medicine (5C) qualifications, recent further education experience (in the past 3 years), presence of a critical nephrology subspecialty in the department, and frequency of encountering AKI patients. Additionally, engaging in the subspecialty of critical care nephrology showed a borderline significant association (P = 0.053). These variables, along with others with a p-value < 0.1, were included in the multivariable model (Table 3).

Table 3 Factors of Practice Based Univariable and Multivariable Logistic Regression

Cutoff: ≥45/<45	**Univariable**		**Multivariable (p<0.1)**	
	OR (95% CI)	**p value**	**OR (95% CI)**	**p value**
Knowledge score	1.552 (1.376–1.750)	<0.001	1.181 (0.993–1.404)	0.060
Attitude score	1.540 (1.383–1.714)	<0.001	1.413 (1.248–1.600)	<0.001
EE	0.977 (0.915–1.043)	0.479		
CY	0.933 (0.873–0.998)	0.043	1.039 (0.904–1.194)	0.591
PA	0.925 (0.873–0.981)	0.009	0.938 (0.835–1.053)	0.278
Age	0.999 (0.967–1.032)	0.954		
Gender				
Male	1.755 (1.005–3.068)	0.048	1.257 (0.517–3.056)	0.614
Female	Ref		Ref	
Education level				
College and undergraduate	0.993 (0.581–1.698)	0.980		
Master degree and above	Ref			
Job title				
Junior and below	0.802 (0.326–1.974)	0.631		
Intermediate	0.688 (0.283–1.671)	0.408		
Deputy Senior	0.721 (0.299–1.738)	0.466		
Senior	Ref			
Work experience				
Less than 5 years	0.767 (0.378–1.558)	0.464		
5-15 years	1.372 (0.736–2.557)	0.319		
More than 15 years	Ref			
Do you have critical care medicine (5C) qualifications?				
Yes	3.208 (1.566–6.570)	0.001	1.968 (0.589–6.574)	0.271
No	Ref		Ref	
Do you have any further education experience in the past 3 years?				
Yes	1.778 (1.010–3.128)	0.046	1.467 (0.602–3.574)	0.399
No	Ref		Ref	
Whether the department has a critical nephrology subspecialty				
Yes	0.361 (0.163–0.802)	0.012	0.438 (0.119–1.608)	0.214
No	Ref			

(*Continued*)

Table 3 (Continued).

Cutoff: ≥45/<45	Univariable		Multivariable (p<0.1)	
	OR (95% CI)	p value	OR (95% CI)	p value
Do you engage in the subspecialty of critical care nephrology?				
Yes	0.456 (0.206–1.010)	0.053	2.525 (0.579–11.019)	0.218
No	ref		ref	
Do you have any intention to resign?				
Yes	0.515 (0.215–1.232)	0.136		
No	ref			
How often do you encounter patients with acute kidney injury?				
Monthly, quarterly or longer	0.102 (0.050–0.209)	<0.001	1.036 (0.293–3.658)	0.957
Weekly	0.274 (0.132–0.570)	<0.001	0.560 (0.198–1.583)	0.274
Daily	Ref		Ref	

Abbreviations: EE, Emotional Exhaustion; CY, Cynicism; PA, Personal Accomplishment; 5C, Chinese Critical Care Certified Course; OR, Odds Ratio.

After controlling for other factors in the model, only Attitude score remained a statistically significant independent predictor of higher practice scores (OR = 1.413, 95% CI: 1.248–1.600, $p < 0.001$). Knowledge score, while showing a positive trend, did not reach statistical significance in the multivariable model (OR = 1.181, 95% CI: 0.993–1.404, $p = 0.060$). Other factors that were significant in the univariable analysis, such as Cynicism, Personal Accomplishment, gender, 5C qualifications, further education, departmental subspecialty, frequency of AKI encounters, and engagement in the subspecialty, were not significant independent predictors in the multivariable model (Table 3).

Discussion

This study examined the knowledge, attitudes, and practices regarding AKI prevention and management among ICU physicians in Taizhou, China, and investigated the level of ICU doctors' job burnout and its correlation with KAP. Our findings revealed that ICU physicians generally demonstrated adequate knowledge, positive attitudes, and proactive practices regarding AKI management, despite experiencing moderate levels of burnout. Importantly, we identified significant correlations between knowledge, attitudes, and practices, with attitude emerging as an independent predictor of practice behaviors in multivariate analysis. These findings provide valuable insights into the complex interplay between professional competence, psychological well-being, and clinical practice in ICU settings.

Knowledge, Attitudes, and Practices Levels and Associated Factors

Significant disparities in KAP were evident across different demographics and professional backgrounds. Males displayed higher knowledge scores compared to females, a difference that has been observed in other healthcare settings.[25,26] This gender disparity could be influenced by various factors, including differential access to training and professional development opportunities. Healthcare professionals with critical care qualifications showed better scores across all three domains (knowledge, attitudes, and practices), underscoring the impact of specialized training on clinical competence. Additionally, frequent encounters with AKI patients were associated with higher KAP scores, suggesting that clinical exposure plays a vital role in shaping healthcare professionals' competence and engagement. However, intentions to resign were associated with lower KAP scores, as well as higher burnout, reinforcing the need to address workplace dissatisfaction and psychological well-being to optimize AKI management practices. However, departments specializing in critical nephrology exhibited lower attitude scores, which might reflect the high-stress environments associated with specialized units potentially leading to burnout.[27,28] Although knowledge was positively correlated with both attitudes and practices, it did not emerge as an independent predictor of practice in the multivariate model. One possible explanation is that attitudes may serve as a mediating factor between knowledge and behavioral implementation, suggesting that knowledge alone does not directly translate into clinical actions without a corresponding positive attitude.

Another potential reason is that the knowledge items assessed in this study primarily focused on foundational understanding rather than the higher-order clinical reasoning and procedural judgment required for complex ICU practices. Therefore, the influence of knowledge might be indirect and partially mediated through attitudinal or motivational components.

Burnout Levels and Associated Factors

Burnout levels varied significantly across job titles, with deputy senior staff experiencing the highest levels, a statistically significant difference compared to other roles. This heightened burnout is likely due to their increased responsibilities, decision-making burdens, and the challenge of balancing dual clinical and administrative duties, which is common in mid-level management positions.[29,30] Furthermore, higher burnout scores among those with longer work experience, particularly exceeding 15 years, underscore the cumulative impact of stress over time[31,32] aligning with observations in other high-pressure healthcare settings where sustained high stress can lead to higher burnout rates as emotional reserves are depleted. Interestingly, physicians certified by the Chinese Critical Care Certified Course (5C) exhibited higher KAP scores but also higher burnout levels. This paradox may reflect the dual impact of professional competence and workload intensity. 5C-certified physicians are typically assigned to manage more complex, high-acuity cases and often shoulder greater teaching and administrative responsibilities. These expanded duties can enhance expertise and adherence to best practices while simultaneously increasing job demands, fatigue, and emotional strain. Moreover, their higher self-expectations and professional standards may heighten sensitivity to perceived underperformance or systemic limitations, further predisposing them to burnout. Similar patterns have been reported in other studies, where highly skilled critical care professionals demonstrated elevated burnout due to disproportionate workload and responsibility.[33,34] Our study also found that professionals with intentions to resign exhibited significantly higher burnout scores, reflecting a critical level of job dissatisfaction or emotional exhaustion, well-documented as a precursor to resignation in healthcare settings.[35,36] This aligns with alarming findings from a study involving ICU physicians where nearly 70% harbored intentions to resign, influenced by factors such as income, years of work, satisfaction with the work environment, career prospects, and psychological well-being.[37] While specific burnout components like emotional exhaustion and depersonalization were not independently associated with practice, their negative correlations with attitude suggest an important indirect influence, highlighting the necessity of addressing burnout through targeted interventions. Enhancing resilience and stress management among ICU staff can help mitigate these adverse effects, fostering a more supportive and efficient work environment.

Additionally, high cynicism (CY) and reduced personal accomplishment (PA) may directly weaken physicians' positive attitudes toward AKI management. CY reflects emotional detachment and loss of empathy, which can lead to disengagement from patient care, while low PA reduces self-efficacy and motivation for guideline adherence. In contrast, emotional exhaustion (EE) mainly affects energy rather than belief, as many physicians continue to value evidence-based care despite fatigue. These mechanisms may explain why CY and PA, but not EE, were significantly associated with negative attitudes.

Interestingly, only cynicism (CY) and reduced personal accomplishment (PA) were significantly associated with negative attitudes, while emotional exhaustion (EE) showed no direct correlation. This pattern suggests that different burnout dimensions may influence physicians' attitudes through distinct psychological mechanisms. CY, reflecting detachment and depersonalization toward work and patients, can directly erode positive professional engagement, thereby diminishing physicians' motivation to adhere to evidence-based AKI management. Similarly, reduced personal accomplishment, characterized by feelings of inefficacy and diminished self-worth, may weaken physicians' confidence and willingness to improve practice behaviors. In contrast, EE primarily represents a state of physical and mental fatigue rather than a change in cognitive beliefs. ICU physicians may feel exhausted due to workload yet still recognize the importance of AKI management, suggesting that professional responsibility buffers EE' s attitudinal impact. This multidimensional pattern aligns with previous research indicating that EE mainly predicts performance decline and medical errors, whereas CY and PA are more closely related to motivational and attitudinal outcomes.[38,39]

Relationship Between KAP

Our study found a positive correlation between knowledge and attitudes and behaviors. Multivariable logistic regression analysis further confirmed that attitude was an independent predictor of proactive behavior which is similar to the recent KAP study. In acute kidney injury management, positive correlations were found between knowledge and both attitudes and practices, with attitudes being an independent predictor of proactive practice.[40] Similarly, for diabetic kidney disease management, healthcare workers' knowledge influenced their practices, and additional training correlated with better engagement.[41] In palliative care, healthcare staff's knowledge and attitudes were positively correlated with their practices, with knowledge, attitudes, personal experiences, and professional background being major predictors of practices.[42] These findings consistently demonstrate the interrelated nature of KAP in healthcare settings, emphasizing the importance of education and training in improving patient care across various specialties.

Clinical Implications and Practical Recommendations

The knowledge of AKI among participants is generally strong concerning basic diagnostic and management principles, yet there are notable deficiencies in understanding more nuanced treatment strategies. Based on our findings, targeted interventions should focus on the identified weak areas, such as pharmacological prevention of contrast-induced AKI and adherence to guideline-based fluid management. Educational modules could be designed to emphasize case-based learning, simulation of AKI risk assessment, and scenario training for early intervention decisions. Moreover, organizational strategies such as structured peer discussions, mentorship programs, and recognition mechanisms for good AKI management performance may help foster positive attitudes toward evidence-based practice. Given the observed negative association between burnout and both attitudes and practices, interventions addressing emotional exhaustion and professional fulfillment should be integrated. For instance, implementing regular psychological support sessions, optimizing shift schedules, and providing adequate staffing and rest opportunities could mitigate burnout-related barriers to guideline adherence. Combining educational enhancement with psychosocial support may yield a synergistic effect in promoting sustainable behavioral change among ICU physicians. In addition, the use of low-dose dopamine and specific agents like theophylline and fenoldopam for the prevention of contrast-induced AKI remains poorly grasped. Strategies to prevent contrast-induced AKI should include minimizing the use of iodinated contrast agents and opting for low or iso-osmolar contrast media and isotonic intravenous fluids.[43,44] Furthermore, the administration of acetylcysteine (NAC), whether intravenously or orally, has shown effectiveness in preventing CI-AKI,[45,46] and statins have been noted to have a protective effect in preventing contrast-associated nephropathy.[47,48] To enhance understanding in these lesser-known areas, targeted educational initiatives would be advantageous. Hosting interactive online courses and live webinars on social media platforms or through professional bodies could bolster comprehension.[49] Incorporating these topics into continuous medical education sessions,[50] and utilizing infographics and quick-reference guides distributed through hospital intranets, could also improve knowledge retention. Clinicians need to prioritize these learning opportunities amidst their demanding schedules or participate in department-organized focused learning sessions to strengthen their proficiency in these critical areas.[51]

The attitudes towards the importance of early detection and the overall management of AKI show a spectrum of engagement, with some skepticism noted particularly about the impact of early detection on outcomes. To address this, developing internal campaigns that showcase successful case studies and evidence supporting early intervention could alter perceptions positively. Organizing quarterly AKI-focused symposiums and inviting experts to discuss recent advancements and success stories can also motivate staff.[52]

Practices related to AKI management are inconsistent, particularly in proactive measures like using alternative imaging modalities for high-risk patients and adhering to recommended prophylactic treatments. Enhancing practice can be achieved through simulation-based training that allows healthcare professionals to practice decision-making in risk-free environments. Regularly scheduled practice audits and feedback sessions could also identify areas of non-compliance and provide corrective actions in real-time. Additionally, the development of mobile applications that provide guidelines and decision support tools at the point of care could ensure best practices are followed more consistently. Implementing checklist systems for AKI risk patients and providing visual reminders in key clinical areas might also promote adherence to best practices.[53]

Limitations

This study has several limitations. First, its cross-sectional design precludes causal inferences between healthcare professionals' KAP and the outcomes of AKI prevention and management. Reverse causality is also possible—clinicians facing heavier workloads, greater psychological strain, or lower practical competence may be more prone to burnout, rather than burnout being the sole antecedent of poorer KAP performance. Longitudinal or interventional research is warranted to clarify these temporal relationships. Second, the reliance on self-reported questionnaires may have introduced response and social desirability biases, as participants could overestimate their knowledge or adherence to best practices. Although an "unsure" option was included to minimize random guessing, the categorical scoring approach may not capture subtle variations in knowledge, and test–retest reliability was not formally assessed. Third, the use of convenience sampling via WeChat may have favored the recruitment of digitally active or academically engaged physicians. The limited representation of private hospitals (n = 2) and the single regional scope further restrict the generalizability of findings to other healthcare settings or regions with differing institutional characteristics. Finally, the burnout threshold (total score > 1.5), derived from international literature, has not been locally validated among Chinese ICU physicians. Nevertheless, this cutoff was adopted as a pragmatic criterion in the absence of a standardized national benchmark.

Conclusions

ICU physicians generally have adequate knowledge and a positive attitude towards the prevention and control of AKI, and engage in proactive practices despite experiencing moderate levels of burnout. Our findings highlight the importance of attitudes as independent predictors of practice behaviors, suggesting that interventions aimed at fostering positive attitudes toward AKI management may be particularly effective in improving clinical practices. Targeted educational interventions should address specific knowledge gaps, such as advanced AKI prevention strategies and guideline-based management, while integrating psychological support and workplace improvement programs to alleviate burnout and enhance professional engagement. The negative correlations between burnout dimensions and both attitudes and practices underscore the potential impact of psychological well-being on patient care. Future research should adopt longitudinal and interventional designs to explore the effectiveness of these integrated strategies and to clarify causal pathways between knowledge, attitudes, practices, and burnout. Comparative studies across hospitals of different levels and regions may further reveal contextual variations in KAP and occupational well-being among ICU physicians. Overall, these findings provide a practical framework for developing evidence-based interventions to improve both clinical performance and physician well-being in intensive care settings.

Abbreviations

KAP, knowledge, attitudes, and practices; AKI, acute kidney injury; MBI-GS, Maslach Burnout Inventory-General Scale; ICU, intensive care units; CRE, serum creatinine; EE, emotional exhaustion; DP, depersonalization; PA, personal accomplishment; SD, standard deviations; NAC, N-acetylcysteine.

Data Sharing Statement

All data generated or analysed during this study are included in this published article.

Ethics Approval and Consent to Participate

This work has been carried out in accordance with the Declaration of Helsinki (2000) of the World Medical Association. This study was approved by the Ethics Committee of Taizhou Central Hospital (Taizhou University Hospital) (2023-LL -0913), and informed consent was obtained from all participants.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically

reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

All authors declare that they have no any conflict of interests.

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