

Knowledge, attitude, and practice of operating room nurses regarding equipment management and multi-stakeholder needs for an information system: a cross-sectional survey

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Abstract

Objective

To develop and validate a Knowledge-Attitude-Practice (KAP) questionnaire for operating room (OR) nurses regarding equipment management, assess current KAP levels and influencing factors, and identify core information system requirements from multi-stakeholder perspectives to inform the design of a full-lifecycle IoT-based OR equipment management system.

Methods

A cross-sectional survey was conducted between May and June 2026 in multiple tertiary hospitals in Hunan Province, China. Three self-administered questionnaires were developed for OR nurses, head nurses, and equipment administrators. The nurse KAP questionnaire underwent reliability and validity testing including Cronbach's α , exploratory factor analysis (EFA), and confirmatory factor analysis (CFA). A total of 309 valid responses were analysed (211 nurses, 81 head nurses, 17 equipment administrators). Data were analysed using SPSS 25.0 and JASP 0.97.1, employing one-way ANOVA, multiple linear regression, and chi-square tests.

Results

The nurse KAP questionnaire demonstrated good reliability (total Cronbach's $\alpha = 0.899$; subscale $\alpha = 0.886\text{--}0.928$) and acceptable structural validity (CFI = 0.947, RMSEA = 0.081). Nurses scored 4.06 ± 0.65 (knowledge), 4.33 ± 0.65 (attitude), and 4.25 ± 0.65 (practice) out of 5. Over half (51.2%) reported difficulty locating equipment, and 64.0% experienced surgery delays attributed to equipment problems. Regression models identified distinct predictors for each KAP dimension: professional title and duration of surgery delay were independent predictors of the total KAP score (adjusted $R^2 = 0.048$), which collectively explained 4.5–5.0% of the variance. A substantial manager–staff perception gap was observed: 90.1% of head nurses rated training as satisfactory versus 39.8% of nurses. Head nurses' top three system priorities were automatic data reporting (58.0%), HIS integration (50.6%), and preventive maintenance alerts (49.4%). Satisfaction with current information technology support was lowest among all lifecycle stages (overall 38.5%, head nurses 11.1%).

Conclusions

OR nurses demonstrated favourable KAP levels, yet systemic barriers—device searching difficulties and surgery delays—remain prevalent. The manager–staff perception gap and uniformly low IT satisfaction across all roles highlight urgent needs for transformation. Stakeholder priorities converge on three core functions: automatic data reporting, system integration, and preventive maintenance alerts. These

findings provide empirical evidence for developing a full-lifecycle IoT-based OR equipment management system.

1. Introduction

Operating rooms are among the most technology-intensive areas in hospitals, containing a wide variety of expensive medical devices that are frequently moved between surgical suites [1]. Inefficient OR equipment management – such as difficulty locating devices, delayed maintenance, and lack of traceability – has been shown to increase non-operative time, reduce staff satisfaction, and potentially compromise patient safety [2]. A national survey in China revealed that 52.4% of hospitals had no equipment benefit evaluation, 42.9% lacked a policy for idle equipment, 31.6% of OR nurses did not receive pre-use training for new equipment, and only 9.8% had implemented comprehensive digital equipment management[3]. These figures highlight the urgent need for systematic improvement.

The knowledge-attitude-practice (KAP) model is widely used to understand and modify health-related behaviours. In the OR setting, KAP studies have focused on topics such as pressure injury prevention and infection control [4, 5]. However, to our knowledge, no validated KAP questionnaire specifically addresses OR equipment management from the nurses' perspective. Moreover, most existing studies rely on a single role (e.g., nurses only) and ignore the potentially different views of head nurses and equipment administrators. Discrepancies between these stakeholders could lead to suboptimal design of information systems that are intended to support equipment lifecycle management.

With the rapid development of the Internet of Things and artificial intelligence, information systems have been introduced into the management of hospital medical equipment. However, most of these systems focus on hospital-wide equipment integration[6], and there are few reports of dedicated information management systems specifically designed for operating rooms, which contain a large number of medical devices. Only a handful of studies have addressed the information management of surgical instruments[7]. User satisfaction with current information systems remains low, and many systems operate as “information silos”, failing to cover the full lifecycle of equipment – including procurement, training, utilisation, maintenance, and disposal. Crucially, few studies have systematically investigated the priorities of different stakeholders (nurses, head nurses, equipment administrators), making it impossible to guide the design of a truly need-driven system.

Therefore, this cross-sectional multi-role survey aimed to: (1) develop and validate a KAP questionnaire for OR nurses regarding equipment management; (2) assess the current KAP level and its influencing factors; (3) identify the core information system requirements from the perspectives of nurses, head nurses, and equipment administrators; and (4) inform the development of a full-lifecycle IoT-based OR equipment management system.

2. Materials and Methods

2.1. Study design and setting

This cross-sectional survey was conducted between May and June 2026 in multiple tertiary hospitals in Hunan Province, China. The study was carried out in accordance with the Declaration of Helsinki. Formal ethical approval was not required because the survey was anonymous, non-interventional, and involved no patient data. All participants provided informed consent by completing and submitting the questionnaire.

2.2. Participants and sampling

A convenience sampling method was used. Inclusion criteria: (1) registered nurses, head nurses, or equipment administrators currently working in the operating room; (2) had worked in the OR for at least 6 months; (3) voluntary participation with informed consent. Exclusion criteria: nurses on rotation, internship, or orientation; staff who had been on leave for more than 3 months during the study period.

A total of 326 questionnaires were distributed, and 309 valid responses were returned (response rate 94.8%). The valid sample comprised 211 OR nurses, 81 head nurses, and 17 equipment administrators. Owing to the small sample size of equipment administrators ($n = 17$), their data were treated as exploratory and presented descriptively, without being included in the inferential statistical comparisons between nurses and head nurses.

2.3. Questionnaire development

Three self-administered questionnaires were developed based on literature review and a three-round Delphi expert consultation (4 experts from surgical nursing and equipment management)[1, 8]. The Delphi experts were asked to rate the relevance, clarity, and comprehensiveness of each item on a 5-point scale. Content validity indices (CVI) were calculated; items with an item-level CVI < 0.78 were revised or removed. The final questionnaire had a scale-level CVI (S-CVI) of 0.92, indicating excellent content validity. The questionnaires were pilot-tested with 10 participants from each role, and wording adjustments were made accordingly.

2.3.1. Nurse KAP questionnaire

The KAP questionnaire consisted of three dimensions: Knowledge (6 items), Attitude (3 items) and Practice (4 items). All items were rated on a 5-point Likert scale (1 = strongly disagree/never/completely unaware to 5 = strongly agree/always/very aware).

To facilitate presentation in subsequent tables, items were coded as follows: Knowledge items were labelled K1 to K6, Attitude items A1 to A3, and Practice items P1 to P4. These codes are used consistently throughout the results section. The full wording of all KAP items is provided in Additional file 1.

2.3.2. Head nurse questionnaire

This questionnaire covered responsibility performance (5 items), evaluation of current management (7 dimensions), information system needs and attitudes (7 statements on a 5-point agreement scale), improvement priorities (multiple choice, up to 3 items)

2.3.3. Equipment administrator questionnaire

This questionnaire included functions performed, current recording methods, most time-consuming tasks (multiple choice, up to 3 items), perceived quality (8 dimensions), expected improvement from an information system (8 dimensions), overall adoption intention, and satisfaction with the seven lifecycle stages.

2.3.4. Common section: satisfaction with the full lifecycle

All three questionnaires shared a common section that assessed satisfaction with seven equipment lifecycle stages: procurement, training, utilisation, maintenance, servicing, disposal, and information technology support. Each stage was rated on a 5-point scale (1 = very dissatisfied/very poor to 5 = very satisfied/very good).

2.4. Data collection

The questionnaires were created on the Questionnaire Star platform and distributed through the Hunan Nursing Association and the nursing/equipment departments of participating hospitals. The first page of the questionnaire contained an informed consent statement and a guarantee of anonymity (no IP addresses were collected). Each questionnaire took approximately 5–8 minutes to complete.

2.5. Statistical analysis

Data were analysed using SPSS 25.0 and JASP 0.97.1. Continuous variables are presented as mean $\pm$ standard deviation (SD), and categorical variables as frequencies and percentages.

2.5.1 Reliability and validity

Internal consistency was assessed by Cronbach's α . Structural validity was examined by exploratory factor analysis (EFA; principal component extraction with Varimax rotation) and confirmatory factor analysis (CFA; maximum likelihood estimation). The Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test of sphericity were used to evaluate sampling adequacy.

2.5.2. Univariate and multivariate analyses

One-way ANOVA or independent t-tests were used for univariate comparisons. Variables with $p < 0.05$ in univariate analysis were entered into a multiple linear regression to identify independent predictors of the KAP total score. Standardised coefficients (β), and variance inflation factors (VIF) were reported.

2.6. Ethical considerations

This study was conducted in accordance with the Declaration of Helsinki. According to the Measures for the Ethical Review of Life Science and Medical Research Involving Humans (National Health Commission of the PRC, 2023), Article 32, research using anonymised information data that does not involve human biological samples, medical interventions, or identifiable personal information may be exempt from ethical review. The study protocol was reviewed by the Institutional Review Board of Xiangya Hospital, Central South University, which determined that formal ethical approval was not required because this study is a survey of healthcare professionals (operating room nurses, head nurses, and equipment administrators) using an anonymised questionnaire, does not involve patients or their data, does not collect sensitive personal information, and poses no more than minimal risk to participants. All participants provided informed consent by completing and submitting the questionnaire; the first page of the questionnaire contained a clear description of the study purpose, the voluntary nature of participation, and a guarantee of anonymity.

3. Results

3.1. Participant characteristics

A total of 309 valid questionnaires were included, comprising 211 OR nurses (68.3%), 81 head nurses (26.2%), and 17 equipment administrators (5.5%). As summarised in Table 1, head nurses were significantly older, more experienced, and held higher professional titles than nurses (all $p < 0.001$). No significant differences were observed in education level across the three groups ($p = 0.576$).

Table 1
Demographic characteristics of participants across the three groups

Characteristic		Nurses (n = 211)	Head nurses (n = 81)	Equipment administrators (n = 17)	p- value*
Age(years) n(%)	≤ 25	9(4.3)	0(0)	0(0)	<0.001
	26–30	42(19.9)	1(1.2)	0(0)	
	31–35	42(19.9)	2(2.5)	6(35.3)	
	36–40	55(26.1)	26(32.1)	3(17.6)	
	> 40	63(29.9)	52(64.2)	8(47.1)	
Gender n(%)	Male	25(11.8)	2(2.5)	9(52.9)	0.013
	Female	186(88.2)	79(97.5)	8(47.1)	
Education n(%)	Diploma	22(10.4)	10(12.3)	1(5.9)	0.576
	Bachelor's degree	179(84.8)	65(80.2)	13(76.5)	
	Master's degree or higher	10(4.7)	6(7.4)	3(17.6)	
Professional title n (%)	Nurse	13(6.2)	0(0)	0(0)	<0.001
	Nurse practitioner	50(23.7)	1(1.2)	2(11.8)	
	Supervisor nurse	125(59.2)	32(39.5)	13(76.5)	
	Associate chief nurse or above	23(10.9)	48(59.3)	2(11.8)	
Years of OR experience n (%)	< 3	15(7.1)	5(6.2)	1(5.9)	<0.001
	3–5	25(11.8)	1(1.2)	3(17.6)	
	6–10	55(26.1)	6(7.4)	3(17.6)	
	11–15	35(16.6)	11(13.6)	5(29.4)	
	> 15	81(38.4)	58(71.6)	5(29.4)	

Note: Data are presented as n (%). Percentages may not sum to 100% due to rounding. *p-values were calculated using the chi-square test (or Fisher's exact test when expected frequencies were < 5), comparing nurses and head nurses only. The equipment administrator group (n = 17) was not included in the inferential statistical comparisons due to its small sample size and is presented for descriptive purposes only. Bold p-values indicate statistically significant differences (p < 0.05).

3.2. Reliability and validity of the nurse KAP questionnaire

3.2.1. Reliability analysis

The Cronbach's α coefficient for the total nurse KAP scale was 0.899, and the α coefficients for the knowledge, attitude, and practice subscales were 0.886, 0.928, and 0.783, respectively, all exceeding the acceptable threshold of 0.7, indicating good internal consistency.

3.2.2. Exploratory factor analysis (EFA)

The Kaiser–Meyer–Olkin (KMO) measure was 0.884, and Bartlett's test of sphericity was significant ($\chi^2 = 1649$, $df = 78$, $p < 0.001$), confirming the suitability of the data for factor analysis. Principal component analysis extracted two factors with eigenvalues > 1.0 , cumulatively accounting for 55.69% of the total variance (Factor 1: 43.14%; Factor 2: 12.56%).

As shown in Table 2, all knowledge items (K1–K6) and practice items (P1–P4) loaded highly on Factor 1 (loadings ranging from 0.511 to 0.767), while the three attitude items (A1–A3) loaded on Factor 2 (loadings ranging from 0.822 to 0.926).

Table 2
Rotated factor loadings matrix for the KAP questionnaire items (n = 211)

Item	Factor 1	Factor 2	Uniqueness
K1	0.675		0.463
K2	0.628		0.472
K3	0.767		0.357
K4	0.709		0.457
K5	0.695		0.437
K6	0.622		0.547
P1	0.511		0.736
P2	0.601		0.625
P3	0.613		0.606
P4	0.717		0.485
A1		0.878	0.181
A2		0.926	0.108
A3		0.822	0.286
Eigenvalue	5.608	1.632	
% of variance explained	43.14	12.56	
Cumulative %	43.14	55.69	
Note: Factor loadings < 0.40 are not displayed. K = Knowledge, P = Practice, A = Attitude. Extraction method: principal component analysis with Varimax rotation.			

3.2.3. Confirmatory factor analysis (CFA)

As shown in Table 3, a two-factor model (knowledge + practice combined as one factor, attitude as the other) was tested using CFA. All items had standardised factor loadings > 0.50 on their respective factors ($p < 0.001$), indicating acceptable model fit and good structural validity.

Table 3
Model fit indices for the confirmatory factor analysis

Fit index	Value
χ^2	147.848
df	62
χ^2/df	2.38
CFI	0.947
TLI	0.933
RMSEA	0.081
RMSEA 90% CI	[0.064, 0.098]
SRMR	0.045

Note: χ^2 = chi-square; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardised root mean square residual. Acceptable model fit was defined as $\chi^2/\text{df} < 5.00$, CFI/TLI ≥ 0.90 , RMSEA ≤ 0.08 , and SRMR ≤ 0.08 . The model demonstrated acceptable to good fit on all indices.

3.3. Nurses' KAP scores and equipment management pain points

3.3.1. KAP subscale scores

The mean item scores for the KAP questionnaire are summarised as follows. Item-level scores varied across dimensions; K2 (4.40 ± 0.66) and P3 (4.44 ± 0.68) scored highest within their respective dimensions, while K6 (3.68 ± 0.94) and P1 (4.12 ± 0.85) scored lowest. Attitude items showed minimal variation (range: 4.31–4.34). Overall, the mean scores for the knowledge, attitude, and practice dimensions were 4.06 ± 0.65 , 4.33 ± 0.65 , and 4.25 ± 0.65 , respectively. The complete item wording is available in Additional file 1.

3.3.2. Equipment searching difficulties and surgery delays

As shown in Fig. 1a, 51.2% of nurses reported at least one episode of difficulty locating equipment in the past week, with 41.7% experiencing this 1–2 times. Regarding surgery delays (Fig. 1b), 64.0% of nurses experienced delays attributable to equipment problems, with 43.1% reporting delays of 1–5 minutes and 20.9% reporting delays exceeding 6 minutes.

3.4. Factors influencing nurses' KAP scores

3.4.1. Univariate analysis

Univariate ANOVA was performed to identify demographic and clinical factors associated with each of the four outcome variables: knowledge, attitude, practice, and total KAP scores.

For the knowledge score, significant associations were found with training frequency ($p = 0.039$), frequency of equipment searching difficulty ($p < 0.001$), and duration of surgery delay ($p < 0.001$). No significant associations were found for age, gender, education, professional title, or years of OR experience (all $p > 0.05$).

For the attitude score, only professional title ($p = 0.002$) showed a significant association; age, gender, education, years of experience, training frequency, and the two equipment-related variables were not significant (all $p > 0.05$).

For the practice score, significant associations were found with gender ($p = 0.014$) and duration of surgery delay ($p < 0.001$); frequency of equipment searching difficulty was marginally significant ($p = 0.054$). Other variables were not significant.

For the total KAP score, significant associations were found with professional title ($p = 0.004$), frequency of equipment searching difficulty ($p = 0.005$), and duration of surgery delay ($p < 0.001$). Age, gender, education, years of experience, and training frequency were not significantly associated (all $p > 0.05$).

Variables that reached statistical significance ($p < 0.05$) in each univariate model were then entered into separate multiple linear regression models for each outcome. Detailed univariate analysis results, including F-values, degrees of freedom, and p-values for all variables, are presented in Additional file 2.

3.4.2. Multiple linear regression analysis

As summarised in Table 4, separate regression models revealed distinct predictors for each outcome. Training frequency and equipment searching difficulty independently predicted knowledge, with opposite directions of effect ($\beta = 0.167$ vs. -0.169 , both $p < 0.05$). Professional title was the sole predictor for attitude ($\beta = 0.234$, $p < 0.001$). Gender and surgery delay duration predicted practice ($\beta = 0.149$ and -0.160 , both $p < 0.05$), while professional title and surgery delay duration predicted total KAP ($\beta = 0.167$ and -0.160 , both $p < 0.05$). Equipment searching difficulty was excluded from the total KAP model due to collinearity with delay duration ($r = 0.62$). The models explained modest variance (adjusted $R^2 = 0.045$ – 0.050), and all VIF values were below 2.

Table 4

Multiple linear regression analysis of factors influencing knowledge, attitude, practice, and total KAP scores

Independent variables	Knowledge (β)	Attitude (β)	Practice (β)	Total KAP (β)
Equipment searching difficulty	-0.169*	—	—	—
Training frequency	0.167*	—	—	—
Professional title	—	0.234*	—	0.167*
Gender (female vs. male)	—	—	0.149*	—
Duration of surgery delay	—	—	-0.160*	-0.160*
Adjusted R ²	0.05	0.05	0.045	0.048
F (p)	4.85 (0.009)	12.12 (< 0.001)	6.17 (0.002)	8.67 (< 0.001)
Note: Only independent variables that reached statistical significance ($p < 0.05$) in each model are presented. “—” indicates the variable was not entered into that specific model or was not significant. Standardised coefficients (β) are reported. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. VIF values for all variables were < 2, indicating no multicollinearity.				

Pearson correlation analysis revealed that knowledge was moderately positively correlated with both attitude ($r = 0.473$, $p < 0.001$) and practice ($r = 0.611$, $p < 0.001$). Attitude was weakly positively correlated with practice ($r = 0.282$, $p < 0.001$). The relatively weak correlation between attitude and practice suggests that positive attitudes toward information systems do not necessarily translate directly into routine checking and reporting behaviours, and may be influenced by external factors such as workflow design and supervisory support.

3.5 Head nurses' perspectives on current management and information system needs

3.5.1. Priorities for information system functions

The top three priorities for information system functions identified by head nurses (Fig. 2) were: “automatic generation of equipment utilisation reports” (58.0%, 47/81), “integration with the HIS/anaesthesia information system” (50.6%, 41/81), and “automatic reminders for preventive maintenance” (49.4%, 40/81).

3.5.2. Evaluation of current management

Head nurses were asked to rate seven dimensions of current OR equipment management on a 5-point scale (from “very poor” to “very good”). The highest satisfaction rates (“good” + “very good”) were observed for nurses' proficiency in equipment operation (87.7%) and coverage and effectiveness of new equipment training (90.1%). Responsiveness of equipment fault reporting also achieved a relatively high

satisfaction rate of 77.8%. Moderate satisfaction rates were reported for routine maintenance compliance (65.4%) and cross-OR equipment scheduling (77.8%). The lowest satisfaction rates were found for control of equipment-related adverse events (75.3%) and, notably, traceability of equipment information (67.9%). These findings suggest that information transparency and record-keeping remain key areas for improvement.

3.6. Equipment administrators' perspective (exploratory, n = 17)

Due to the small sample size (n = 17), these results are exploratory and should be interpreted with caution. The three most time-consuming tasks reported by equipment administrators were: fault report follow-up (82.4%, 14/17), routine inspections (58.8%, 10/17), and equipment inventory (58.8%, 10/17). Current record-keeping methods were distributed as follows: hospital HRP asset management system (35.3%, 6/17), paper records (23.5%, 4/17), independent information system (23.5%, 4/17), and Excel spreadsheets (17.6%, 3/17). Overall, 82.4% (14/17) of administrators expressed willingness or strong willingness to adopt an information management system.

3.7. Multi-role satisfaction with the seven lifecycle stages

The satisfaction rates for the seven equipment lifecycle stages across the three roles are presented in Table 5 and visualised in Fig. 3. Overall, the satisfaction rates (from highest to lowest) were: training (74.4%), maintenance/repair (60.8%), utilisation (56.0%), procurement (47.6%), disposal (47.6%), servicing (47.6%), and information technology support (38.5%). Information technology support had the lowest satisfaction rate among all stages, and head nurses consistently reported lower satisfaction than nurses across most stages.

Table 5
Satisfaction rates with the seven lifecycle stages across the three groups

Lifecycle stage	Nurses (n = 211)	Head nurses (n = 81)	Equipment administrators (n = 17)	Overall (N = 309)
Procurement	48.34	41.98	64.71	47.57
Training	73.93	74.07	82.35	74.44
Utilisation	54.98	56.79	64.71	55.98
Maintenance & repair	55.45	70.37	82.35	60.84
Servicing	53.08	30.86	58.82	47.58
Disposal	51.66	33.33	64.71	47.58
Information technology support	48.34	11.1	41.18	38.51

Note: Data are presented as percentages of participants who rated each stage as “good” or “very good” on a 5-point scale. The highest overall satisfaction rate was observed for the training stage (74.44%), while the lowest overall satisfaction rate was observed for information technology support (38.51%). Due to the small sample size of the equipment administrator group (n = 17), their data are presented for descriptive purposes only and were not included in inferential statistical comparisons.

4. Discussion

Effective OR equipment management is critical for patient safety and staff efficiency, yet remains a major challenge in many healthcare settings. While previous studies have often focused on single-role perspectives or isolated management issues, few have systematically examined the current state of equipment management from a multi-stakeholder KAP approach. This study provides empirical evidence from nurses, head nurses, and equipment administrators, revealing three key findings: (1) OR nurses demonstrated favourable KAP levels, yet over half reported difficulty locating equipment and nearly two-thirds experienced surgery delays; (2) a substantial manager-staff perception gap existed regarding training effectiveness; and (3) stakeholder priorities converged on three core information system functions. These findings collectively highlight the need for a full-lifecycle IoT-based OR equipment management system.

4.1. High KAP scores coexist with systemic equipment management barriers

OR nurses in this study scored relatively high on the knowledge (4.06/5), attitude (4.33/5), and practice (4.25/5) dimensions, indicating sound individual competence in equipment management. This pattern aligns with previous KAP studies among OR staff, where positive attitudes often accompany relatively good knowledge[9]. Li et al. (2026) reported that orthopedic OR nurses in China held positive attitudes

toward occupational protection when using power tools, though their knowledge was insufficient and practice behaviour was poor.

Despite this favourable individual profile, the prevalence of equipment searching difficulties (51.2%) and surgery delays (64.0%) indicates that individual competence alone is insufficient to guarantee efficient equipment management. This “knowing-doing gap” may be explained by external factors: workload, time constraints, and limited resources as the main obstacles to protocol compliance among OR staff, despite positive attitudes. This suggests that even knowledgeable and motivated nurses may struggle to perform optimally when the system-level support—such as device traceability, streamlined workflows, and real-time locating—is inadequate.

4.2. The knowledge-practice fusion: implications for intervention design

Our exploratory factor analysis yielded a two-factor rather than the classical three-factor KAP structure, with knowledge and practice items loading on the same factor. This suggests that in the highly standardised OR environment, “knowing” and “doing” are empirically inseparable—a finding that challenges the conventional KAP sequential model in this context. A similar pattern was observed by a study of 272 orthopedic OR nurses found that knowledge was insufficient while practice behaviour was poor, suggesting a close coupling between these two dimensions[10].

This structural finding has important implications for intervention design: if knowledge and practice are fused, then knowledge-oriented interventions (e.g., traditional lectures, written materials) alone are unlikely to change behaviour. Instead, interventions must target the attitudinal component (which emerged as a separate factor) and the systemic environment. This interpretation is consistent with the weak correlation between attitude and practice ($r = 0.282$) observed in our study—positive attitudes toward information systems did not automatically translate into routine checking and reporting behaviours. Cramer et al. noted that current paper-based manuals in ORs create practical barriers, with sterile users unable to handle non-sterile manuals, missing details, and excessive text information potentially delaying procedure performance[11]. Replacing such inefficient tools with well-designed digital solutions could bridge the attitude–practice gap by embedding guidance directly into workflows.

4.3. The manager–staff perception gap: a hidden barrier to effective training

One of the most striking findings of this study is the large discrepancy between head nurses’ and staff nurses’ perceptions of training effectiveness: 90.1% of head nurses rated training as satisfactory, compared with only 39.8% of nurses who felt training was adequate. This 50-percentage-point gap warrants attention and may reflect different evaluation criteria between the two groups: head nurses may assess training based on completion rates and formal attendance, whereas frontline nurses may focus on practical utility, accessibility of SOPs, and applicability to real-world scenarios.

It is clear that training programmes cannot be evaluated solely through managerial lenses. Objective, quantifiable metrics—such as those enabled by an information system that tracks training completion, knowledge assessments, and skill verification—are essential to ensure that training translates into actual competence.

4.4. Convergent stakeholder priorities inform system design

The multi-role design of this study revealed that stakeholder priorities converged on three core functions rather than diverging by role, a finding that directly informs system design. The top three functions identified by head nurses—automatic generation of equipment utilisation reports (58.0%), integration with HIS/anaesthesia information systems (50.6%), and automatic reminders for preventive maintenance (49.4%)—were closely aligned with the pain points reported by other roles.

Equipment administrators identified fault report follow-up (82.4%) as their most time-consuming task, directly supporting the need for an integrated system that tracks repair requests transparently and automates status updates. Similarly, the high prevalence of device searching difficulties (51.2%) among nurses justifies the inclusion of real-time locating functionality, which has been shown to significantly reduce search time and improve staff satisfaction[12, 13].

4.5. Low satisfaction with current IT support: a call for transformation

Across all seven lifecycle stages, information technology support had the lowest overall satisfaction rate (38.5%), with head nurses expressing especially low satisfaction (11.1%). This finding is particularly noteworthy given that head nurses are the primary decision-makers regarding system adoption and resource allocation. Their extreme dissatisfaction suggests that current systems are not merely suboptimal but fundamentally failing to meet management needs.

Three factors may account for this low satisfaction: the lack of integration with existing HIS platforms, the hospital-wide rather than OR-specific focus of current systems, and the absence of full-lifecycle functionality.

4.6. Limitations

Several limitations should be acknowledged. First, the equipment administrator group ($n = 17$) was small, and their data were therefore treated as exploratory and presented descriptively. Future studies with larger administrator samples are needed to confirm these findings. Second, the cross-sectional design precludes causal inference; longitudinal or interventional studies would be valuable to establish whether the identified KAP factors and satisfaction patterns change following system implementation. Third, this study was conducted in tertiary hospitals in Hunan Province, which may limit generalisability to other regions or lower-level facilities. Fourth, the modest adjusted R^2 values (0.045–0.050) in our regression models indicate that other unmeasured factors—such as organisational culture, training quality, and peer

support—may also influence KAP levels and should be explored in future research. Finally, as with all self-reported survey data, social desirability bias may have influenced responses, particularly for practice items.

Despite these limitations, our findings have several practical implications. First, healthcare administrators should recognise that high individual KAP scores do not compensate for inadequate systemic support; investments in real-time locating systems, integrated information platforms, and automated maintenance alerts are necessary to translate individual competence into organisational efficiency. Second, training programmes should be evaluated using objective, system-tracked metrics rather than managerial perception alone; this would enable early detection of the manager–staff perception gap and allow timely corrective action. Third, future research should adopt a full-lifecycle perspective when designing information systems, ensuring coverage from procurement through disposal and integration with existing HIS/anaesthesia systems.

5. Conclusions

This survey of 309 OR staff revealed favourable KAP levels among nurses, yet systemic barriers remain prevalent. Device searching difficulties and surgery delays were particularly common. A substantial perception gap exists between head nurses and frontline nurses regarding training effectiveness, and satisfaction with current IT support is uniformly low across all roles. Stakeholder priorities converge on three core information system functions: automatic data reporting, system integration, and preventive maintenance alerts. These findings provide robust empirical evidence for the development of a full-lifecycle IoT-based OR equipment management system, with the potential to bridge the gap between individual competence and systemic support.

Abbreviations

KAP	
Knowledge-Attitude-Practice	
OR	
operating room	
EFA	
exploratory factor analysis	
CFA	
confirmatory factor analysis	
CVI	
Content validity indices	
SD	
standard deviation	
KMO	
Kaiser–Meyer–Olkin	

Declarations

This study was conducted in accordance with the Declaration of Helsinki. According to the Measures for the Ethical Review of Life Science and Medical Research Involving Humans (National Health Commission of the PRC, 2023), Article 32, research using anonymised information data that does not involve human biological samples, medical interventions, or identifiable personal information may be exempt from ethical review. The study protocol was reviewed by the Institutional Review Board of Xiangya Hospital, Central South University, which determined that formal ethical approval was not required because this study is a survey of healthcare professionals (operating room nurses, head nurses, and equipment administrators) using an anonymised questionnaire, does not involve patients or their data, does not collect sensitive personal information, and poses no more than minimal risk to participants. All participants provided informed consent by completing and submitting the questionnaire; the first page of the questionnaire contained a clear description of the study purpose, the voluntary nature of participation, and a guarantee of anonymity.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. The questionnaire used in this study is provided as supplementary material.

Competing Interests

The author of this article declares no conflict of interest.

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Authors' contributions

1. Huandong Zhao wrote the main manuscript text.
2. Jiqun He prepared figures and tables.
3. Fujuan Xi analyzed and summarized the data.
4. Xiuwen Chen reviewed and polished the manuscript.

All authors declare that this manuscript has no conflicts of interest.

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Figures

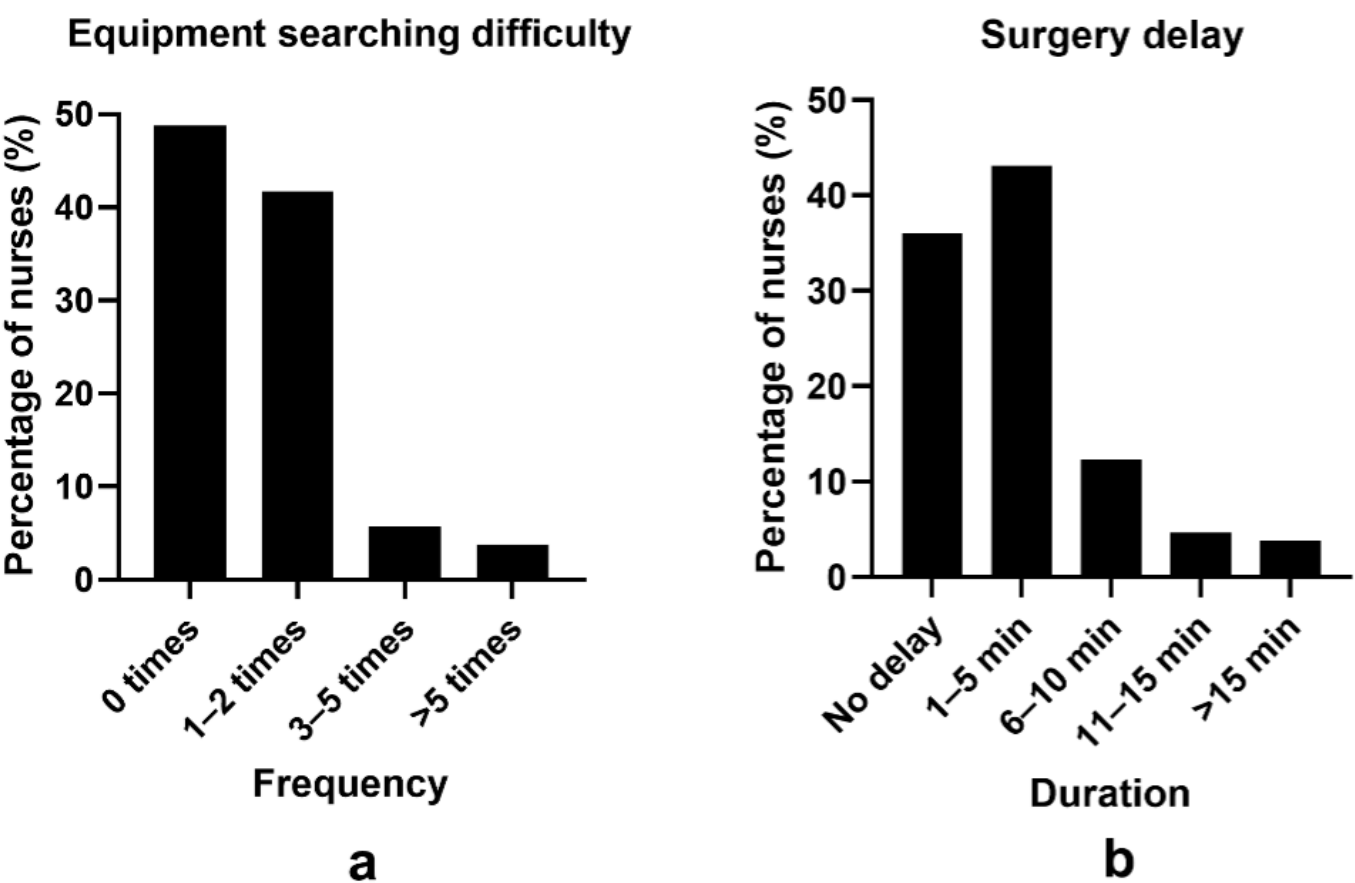


Figure 1

Equipment-related challenges among OR nurses (n = 211). (A) Frequency of difficulty in locating equipment in the past week. (B) Duration of surgery delays attributed to equipment problems. Data are presented as percentages, with absolute numbers (n) shown above each bar.

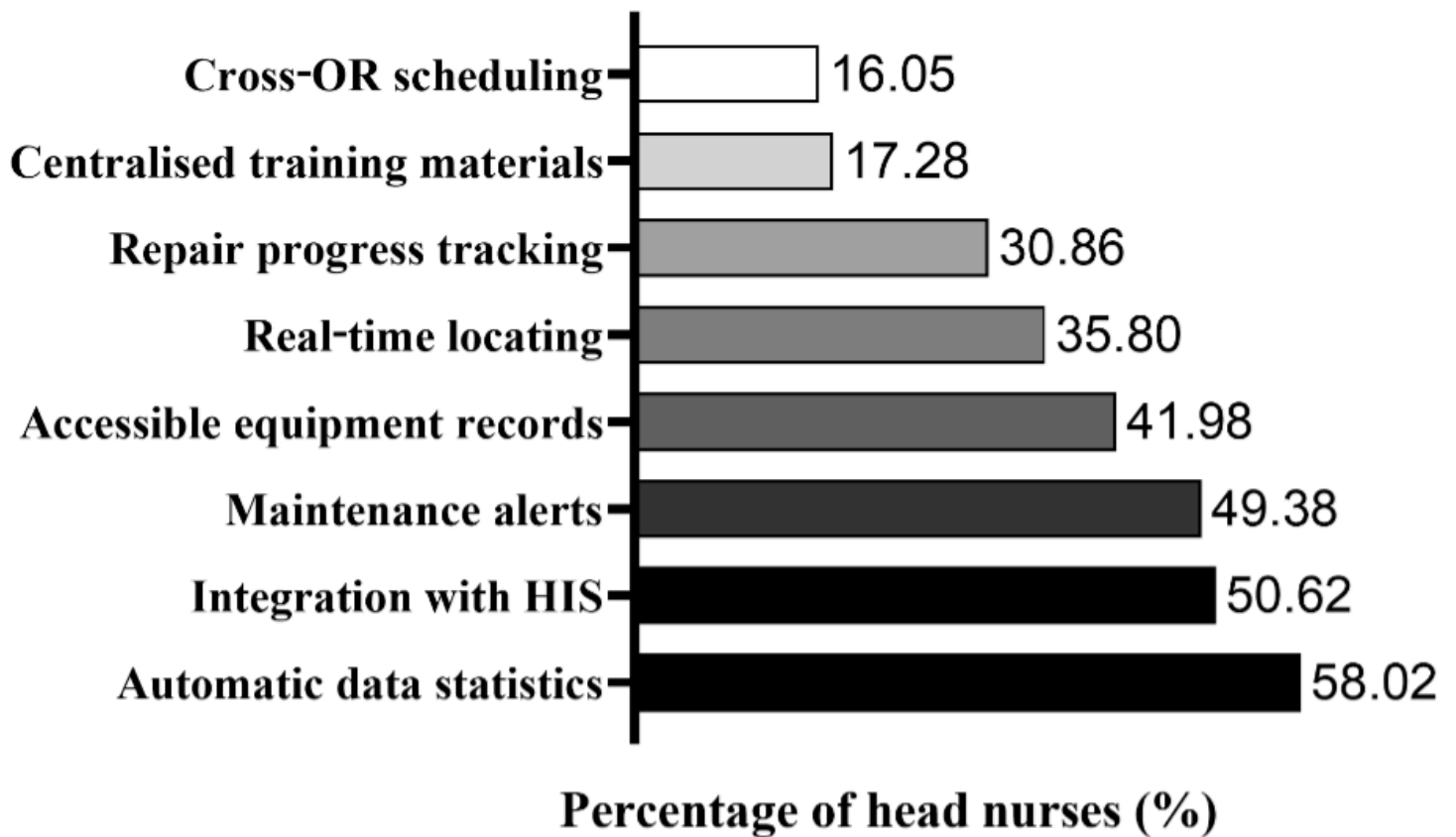


Figure 2

Priorities of head nurses for information system functions (n = 81). Head nurses were asked to select up to three priority functions from eight options. Data are presented as the percentage of head nurses who selected each function. The top three priorities were: automatic generation of equipment utilisation reports (58.0%), integration with HIS/anaesthesia information systems (50.6%), and automatic reminders for preventive maintenance (49.4%).

— Nurses — Head nurses — Equipment administrators

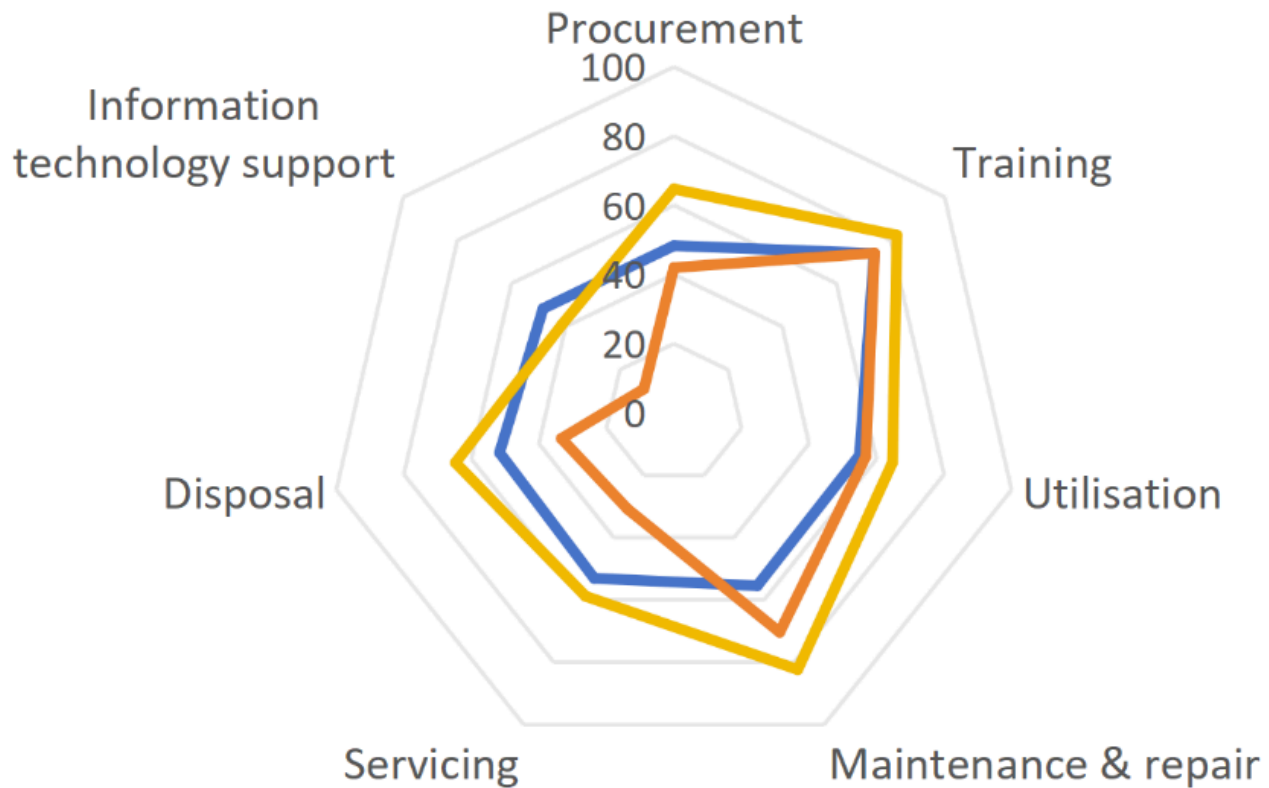


Figure 3

Satisfaction rates with the seven lifecycle stages across the three groups. Data are presented as percentages of participants who rated each stage as “good” or “very good” on a 5-point scale. The radar chart shows that information technology support had the lowest satisfaction rate across all stages, with the largest gap between nurses and head nurses (48.3% vs. 11.1%).

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