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Research Article

# Designing and Evaluating the Applicability of a Web-Based Training Program for Anesthesiology Staff and Students in Burn Patients

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**ABSTRACT**

**Background:** Burn patients present unique anesthetic challenges: massive fluid shifts, airway edema, and hypermetabolism that demand rapid, evidence-based management. Although web-based learning can deliver standardized, on-demand education, anesthesia technologists rarely have access to rigorously developed burn-specific resources. To design, implement, and evaluate the usability and short-term educational impact of a web-based burn-anesthesia program for practicing anesthesia technologists.

**Methods:** We conducted a four-phase mixed-methods study (September 2023 – April 2025). Phase 1 mapped required content through a scoping review (2014–2024) and a two-round Delphi survey of 15 experts. Phase 2 converted the validated content into a conceptual model and low-fidelity prototype, iteratively refined by two focus groups. Phase 3 produced the final application using a Python/Django back-end, a React front-end, and a PostgreSQL database. Phase 4 assessed real-world use over four weeks by 45 technologists at two Iranian teaching hospitals. Outcomes included the 27-item Questionnaire for User Interaction Satisfaction (QUIS; 0–9) and 20-item pre/post knowledge tests, analyzed with paired t-tests ($\alpha = 0.05$).

**Results:** Forty-eight learning objects spanning eight modules (airway, fluid therapy, analgesia, pharmacology, burn pathophysiology, monitoring, nutrition, and postoperative care) met Delphi validity thresholds. The mean overall QUIS was 7.12 ± 0.78 ("good"), with subdomain means of 7.25 (overall reaction), 7.09 (screen design), 7.07 (terminology), 7.18 (learnability), and 7.00 (system capabilities). Knowledge increased from 63.4 ± 9.2 to 83.1 ± 7.6 ($\Delta = 19.7 \pm 8.5$ points; $t = 14.2$; $p < 0.001$; Cohen's $d = 2.29$). No serious technical issues arose; the median weekly log-ins per user was four.

**Conclusion:** A systematically developed, user-centered web curriculum produced high usability scores and substantial knowledge gains among anesthesia technologists. The model offers a scalable solution for closing critical educational gaps in burn anesthesia, particularly where formal training is limited. Future research

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should examine long-term retention, effects on clinical performance, and patient outcomes.

## Introduction

Severe burns trigger complex physiologic derangements: massive fluid shifts, hypermetabolism, airway edema, and frequent comorbid inhalation injury that dramatically alter anesthetic management. Fast, accurate calculation of drug doses and vigilant titration of analgesia and ventilation are mandatory. Yet access to contemporary educational materials remains uneven, especially outside tertiary burn centers [1–5]. These physiologic upheavals demand precise drug dosing, moment-to-moment ventilatory adjustments, and meticulous hemodynamic monitoring, leaving little margin for error. Consequently, anesthesia personnel, especially anesthesia technologists who provide front-line medication delivery and ventilatory support, must possess up-to-date knowledge, validated clinical guidelines, and sharpened decision-making skills. Traditional classroom teaching and scattered printed resources seldom keep pace with the dynamic, time-critical nature of burn care. In this context, web-based learning platforms that deliver standardized, interactive, and readily accessible content have become an indispensable strategy for enhancing the safety and quality of anesthesia services for burn patients [6–11].

Smartphone penetration and fourth-generation cellular coverage have transformed how clinicians learn. More than 350000 health-related mobile apps are now available, and anesthesia has historically been an early adopter of digital tools [6–9,12–14]. Nevertheless, the literature shows that many existing resources lack editorial oversight, learner engagement features, or rigorous outcome data [10,11,15,16]. Recent Iranian studies echo these concerns and highlight variability in both the acceptance and effectiveness of anesthesia apps [17–20]. Accordingly, we designed "BurnAnes-Web," a purpose-built application with the aim of equipping anesthesia technologists with the essential competencies required for optimal burn-anesthesia management [21-22]. Grounded in this evidence gap, we posed the following research questions:

- Which data elements and instructional features are essential for a web-based program on burn anesthesia for anesthesia technologists?
- How should such a program be designed and developed to maximize usability and learner engagement?
- Does the final application meet established usability criteria and improve short-term knowledge?

## Methods

### Study Design

We conducted a pragmatic, mixed-methods study (descriptive developmental + semi-experimental) between September 2023 and April 2025 (ethics approval IR.IUMS.REC.1402.312). (Figure 1) summarizes the four-phase workflow.

### Phase 1- Content Identification

#### Literature Review

Databases (PubMed, Scopus, Embase, Cochrane, and Web of Science) were searched for English-language articles (2014-2024) using combinations of *anesthesia*, *burns*, *e-learning*, *mobile application*, and *education*. Clinical practice guidelines from the American Burn Association and the International Society for Burn Injuries were also screened.

#### Delphi Survey

Fifteen experts rated each potential learning object on a 5-point Likert scale for relevance and necessity. Content Validity Ratio (CVR) ≥ 0.49 (Lawshe) and Content Validity Index (CVI) ≥ 0.79 were set as inclusion thresholds.

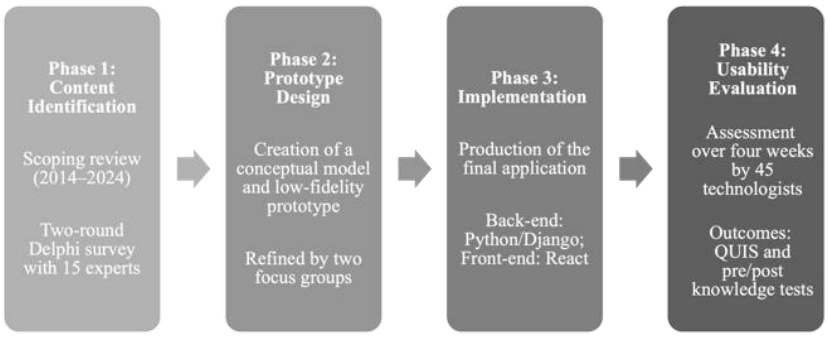


**Figure 1- The four-phase workflow of the study.**

### Phase 2- Prototype Design

Using Enterprise Architect v15, we created UML use-case, sequence, activity, and class diagrams.

A clickable Figma mock-up illustrated navigation, quizzes, case videos, and calculators. Two moderated focus groups (90 min each) gathered iterative feedback until thematic saturation.

### Phase 3- Implementation

The production system employed:

- **Back-end**: Python 3.11 / Django 4.2, PostgreSQL database.
- **Front-end**: React 18 with Tailwind CSS for responsive design.
- **Security**: JWT-based authentication, SSL, and OWASP Top-10 hardening.
- **Analytics**: Matomo on-premise tracking for log-ins, dwell time, and item completion.

Multimedia assets (videos ≤ 8 min, interactive drug calculators, and infographics) were compressed for low-bandwidth environments (< 1 Mbps).

### Phase 4- Usability Evaluation

#### Participants

A convenience sample of 45 anesthesia technologists (27 female, 18 male; mean age 31.4 ± 5.8 y) from Iran University of Medical Sciences and Velayat Burn Hospital, Rasht, were enrolled. Inclusion criteria: ≥ 1 year clinical experience, Android/iOS smartphone, consent to use the app for four weeks.

#### Instruments

- **QUIS 7.0** (Persian-validated): 27 items, 10-point scale (0 = low, 9 = high).
- **Knowledge Test**: 20 MCQs, KR-20 reliability = 0.81, covering all modules.

#### Procedure

After on-site orientation, participants self-directed their study. At week 4 they completed the post-test and QUIS online. Google Forms exported data to SPSS 28 for analysis.

#### Statistical Analysis

Means ± SD described continuous variables. Paired *t*-tests compared pre-/post-knowledge scores. QUIS sub-scores were categorized as poor (< 3), moderate (3-<6), and good (6-9).

## Results

### Phase 1- Outcomes

The literature review screened 412 titles; 67 met inclusion. Together with expert input, 52 initial learning objects were generated; 48 achieved the CVR/CVI cut-offs.

### Phase 2- Feedback

Key design requirements emerging from focus groups included:

- "patient-journey" organization rather than organ-system taxonomy,
- bite-sized (≤ 15 min) modules,
- case-based branching scenarios,
- offline HTML5 cache for poor connectivity, and
- single sign-on via institutional Google Workspace.

### Phase 3- Product

The final application ("BurnAnes-Web") comprises eight modules, 96 knowledge checks, four calculators (opioid conversion, Parkland formula, ventilatory tidal volume, and antibiotic dosing), and a personalized dashboard (gamified badges and progress heatmap). Median page load time on 4G was 1.3 s.

### Phase 4- Usability and Knowledge Gains

All domains fell in the "good" range (Table 1). The most frequent qualitative praise concerned intuitive navigation; the top criticism was occasional video buffering (n = 6, 13%). Knowledge scores significantly increased from a pre-test mean of 63.4 ± 9.2 to a post-test mean of 83.1 ± 7.6 (t = 14.2; p < 0.001). As detailed in (Figure 2), this represents a mean improvement of 19.7 points, and the calculated Cohen's d of 2.29 indicates a very large effect size. No participant withdrew; error logs captured three minor issues (password reset loop, dark-mode styling glitch, and duplicate notification).

**Table 1- Mean scores for the Questionnaire for User Interaction Satisfaction (QUIS) domains.**

| QUIS Domain | Mean ± SD |
|---|---|
| Overall reaction | 7.25 ± 0.81 |
| Screen design | 7.09 ± 0.82 |
| Terminology & info | 7.07 ± 0.87 |
| Learnability | 7.18 ± 0.76 |
| System capabilities | 7.00 ± 0.68 |

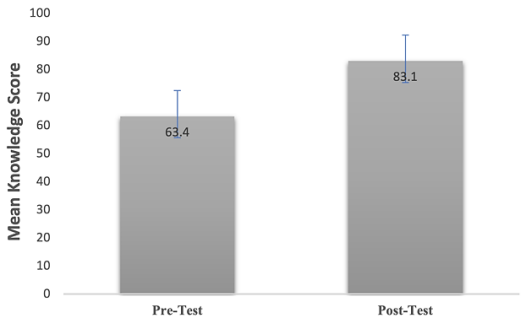


**Figure 2- Comparison of mean knowledge scores before and after the web-based training intervention.**

**Table 2- A feature comparison of BurnAnes-Web with other existing applications.**

| Feature | BurnAnes-Web | ASA My Learning App | Anesthesiologist (Android) | FireSync EMS (TBSA) | Burn tele-consult/triage apps |
|---|---|---|---|---|---|
| Primary focus | Comprehensive burn-anesthesia curriculum | CME modules (broad anesthesia topics) | Weight-based drug doses | Burn-surface estimation | Remote wound review |
| Target audience | Anesthesia technologists | Physicians / residents | All clinicians | EMS providers | Burn surgeons / ED staff |
| Content validation | Delphi + expert review | ASA peer review | None published | Pilot accuracy study | None or limited |
| Interactive cases & quizzes | ✓ | Limited | ✕ | ✕ | ✕ |
| Built-in calculators | 4 anesthesia-specific | Few (course-dependent) | Basic drug list | TBSA only | ✕ |
| Offline capability | ✓ (HTML5 cache) | Partial | ✓ | ✓ | Variable |
| Published usability data | QUIS 7.12 | Not reported | Not reported | Not reported | Not reported |

## Discussion

Our results demonstrate that a systematically designed, standards-compliant web application can achieve high usability and substantial knowledge gains in a specialized anesthesia domain. The large knowledge effect size exceeds those reported for traditional lectures or passive video portals [6–11]. The final usability score (QUIS 7.12) exceeds the average reported for anesthesia or intubation apps (6.1–6.8) and compares favorably with prior mobile or web tools for anesthesiology, approaching the "good" benchmark for health apps in general (≈ 7.0–8.0) [15–17] (Table 2). Unlike ASA My Learning, which offers high-quality but subscription-based CME modules with limited burn focus, BurnAnes-Web tailors every object to the burn context and is freely deployable on institutional servers. Compared with the popular Anesthesiologist dosage app, BurnAnes-Web adds validated educational pathways and assessment, not merely reference data. Burn-specific utilities such as FireSync EMS or triage photo-messaging platforms provide valuable point solutions (surface-area calculation, remote consultation) yet address only single decision nodes and omit instructional scaffolding. To our knowledge, no previously published tool for burn anesthesia reports both a validated usability metric and a large knowledge-gain effect, positioning BurnAnes-Web as a unique, comprehensive solution in this niche.

The success of BurnAnes-Web can be attributed to several key factors. First, it was built on a rigorous, learner-centered process rarely reported in similar apps; content was filtered through a scoping review plus a two-round Delphi, ensuring both breadth and consensus validity. The interface was then iteratively refined with end-user focus groups. Pedagogically, the program combines micro-learning, branching cases, spaced quizzes, and gamified progress maps; elements linked to higher engagement and retention. Functionally, four embedded calculators allow just-in-time decision support, and an optional offline cache addresses bandwidth constraints common in low-resource settings.

### Practical implications

Hospitals can deploy BurnAnes-Web on existing intranets without new hardware, and its analytics enable targeted remediation. For low-resource regions lacking formal burn-anesthesia fellowships, the program offers scalable upskilling.

### Limitations

Single-month follow-up precludes long-term retention analysis; there was no randomized control group; results may not generalize beyond Iranian teaching centers; and clinical performance or patient outcomes were not measured.

### Future research

should incorporate objective structured clinical examinations, multi-center RCTs, and cost-effectiveness analyses. Integration with electronic anesthesia records could allow just-in-time decision support and bedside prompts.

## Conclusion

BurnAnes-Web successfully filled an identified educational gap by providing an evidence-based and user-friendly web application. Wider adoption and longitudinal evaluation of this platform could contribute to safer anesthetic care for burn patients worldwide.

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