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ORIGINAL PAPER

Analysis of the need for realistic circumcision manikin design as a learning resource for medical students in the clinical skills laboratory: Mixed methods study

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Summary

Introduction: *Circumcision is a Level 4A clinical skill in the Indonesian Medical Doctor Competency Standards (Standar Kompetensi Dokter Indonesia [SKDI]) that every medical graduate must master. However, learning is currently hampered by the limited availability of manikins with adequate anatomical and functional realism, resulting in procedural training that is not fully safe, standardized, or meaningful. This study aims to analyse the need for a realistic circumcision manikin design as an effective learning resource by exploring the perspectives of students, lecturers, instructors, experts, and laboratory staff.*

Methods: *This study employed a convergent parallel mixed-methods approach. Quantitative data were collected using Likert-scale questionnaires from 214 third- and fourth-year medical students (total sampling) and analysed descriptively. Qualitative data were obtained through in-depth semi-structured interviews with four lecturers/experts and two laboratory staff members (purposive sampling), along with non-participatory observations and document reviews, and were analysed thematically.*

Results: *Quantitative findings showed that while students found the current manikins helpful, there was a high demand for improvements in anatomical realism (skin elasticity, prepuce variation, mucosal layers, and vascular representation), functional realism (tissue resistance, bleeding simulation, and complication management), and interactive features (objective feedback). Qualitative analysis further emphasized the need for accurate anatomy, functional simulation to support repetitive practice, integration with standardized patients, and considerations related to durability, portability, and cost efficiency.*

Conclusions: *There is a strong need for the development of high-fidelity circumcision manikins that integrate anatomical, functional, and communication-scenario realism. The design blueprint generated from this study provides a foundation for next-generation prototypes aimed at improving the quality of clinical skills training in medical education.*

KEY WORDS: *Circumcision; Realistic manikins; Clinical simulation; Medical education.*

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INTRODUCTION

Clinical skills are a core competency in medical education, alongside knowledge and professional attitudes, and must be mastered by students through structured training in a *Clinical Skills Laboratory* (CSL) before engaging in practice with real patients (1-3). Circumcision is one of the basic procedural skills included in the *Indonesian Medical Doctor Competency Standards* [*Standar Kompetensi Dokter Indonesia* (SKDI)] (4) and is designated at competency level 4A, meaning that graduates must be able to perform Circumcision independently (5), with a very high procedural prevalence (85-92% in Indonesia), yet still associated with the risk of serious complications such as bleeding (0.1-35%) and even amputation (< 0.1%) when performed by incompetent operators (6).

Direct learning on real patients is limited by ethical and patient safety considerations, case availability, and restricted opportunities for repetition; therefore, simulation using manikins becomes an essential approach to ensure safe, standardized, and repeatable training (7).

Currently, circumcision manikins available in many CSL, including at our institution, remain low-fidelity. Their anatomical representation is incomplete (lacking vascular structures and clearly defined tissue layers), they do not simulate bleeding or tissue resistance, and they are not integrated with standardized patients, thereby limiting opportunities for clinical communication training. These limitations prevent the manikins from effectively bridging theory with practice and do not optimally preparing students for exams and clinical practice. To date, no comprehensive needs analysis has been conducted from the perspectives of students, lecturers, instructors, experts, and laboratory staff regarding the ideal design characteristics of a circumcision manikin (1, 8-12).

Therefore, a study is needed to systematically map user needs using a user-centred design approach, focusing on the anatomical, functional, and educational aspects of circumcision manikins, so that the development of next-generation prototypes is truly aligned with the learning context in CSL and the requirements of the SKDI. This study aims to develop a design blueprint for a realistic circumcision manikin as a primary learning resource for medical

students, in order to enhance the quality and safety of circumcision skills training in medical education.

Methods

Study design and setting

This study used a convergent parallel mixed-methods approach. The research was conducted at the CSL of the *Faculty of Medicine, Al Azhar Islamic University Mataram, Indonesia*. The circumcision training sessions observed in this study utilized standard low-fidelity bench-top simulators produced by local manufacturers (Figure 1). These manikins are composed of a rigid base with a replaceable silicone prepuce designed to simulate the dorsal slit and sleeve resection techniques but lack active bleeding simulation or hemodynamic feedback mechanisms.

Figure 1.
Standard low-fidelity bench-top circumcision simulator.
The manikin is composed of a rigid base with a replaceable silicone prepuce, designed to simulate dorsal slit and sleeve resection techniques as utilized in the Clinical Skills Laboratory.

Participants

The population of this study was medical students (thirt and fourth year), lecturers, instructors, experts, and laboratory assistants involved in circumcision skills instruction in the CSL of the *Faculty of Medicine, Al Azhar Islamic University Mataram, Indonesia*. All students who met the inclusion criteria were recruited as quantitative respondents using total sampling (n = 214) (13), while qualitative participants (four lecturers/instructors/experts and two laboratory staff) were selected purposively based on a minimum of two years of experience in teaching or evaluating circumcision skills (n = 6).

Data collection

Quantitative data were collected using a Google Forms-based Likert-scale questionnaire (1-5) consisting of closed- and open-ended questions that had undergone validity testing, reliability assessment, and a pilot study, and were subsequently analyzed descriptively using statistical software. Qualitative data were obtained through semi-structured in-depth interviews, non-participant observation of circumcision training sessions and manikin use, and document review of the existing manikin conditions. All interviews were audio-recorded with participants' consent and transcribed verbatim prior to thematic analysis. All respondents provided informed consent after receiving an explanation of the study objectives and procedures, and the study protocol was approved by the *Ethics Committee of the Faculty of Medicine, Al Azhar Islamic University Mataram* (No. 088/EC-03/FK-06/UNIZAR/VIII/2025).

Results

Quantitative findings

A total of 214 medical students participated in the quantitative survey, the majority of students were female (63.6%) and male 36,4% (Table 1). Most respondents were in the mid-to-late preclinical phase, with 47.2% in semesters 5-6 and 43.5% in semesters 7-8, while 9.3% were in semesters 9-10. The majority reported having completed the circumcision module within the past six months, indicating that their perceptions reflect relatively recent and relevant learning experiences.

Table 1.
Characteristic of respondent.

Variable	Frequency (f)	Percentage (%)
Sex		
Male	78	36.4
Female	136	63.6
Semester		
Semesters 5-6	101	47.2
Semesters 7-8	93	43.5
Semesters 9-10	20	9.3

Students' perceptions of circumcision learning and the quality of the manikins used

The majority of students perceived the current circumcision learning process as adequate, with 67.8% reporting "agree" and 13.6% "strongly agree," while 18.7% indicated only "somewhat agree" (Table 2). However, assessments of manikin quality revealed limitations in realism: 53.3% rated the manikin as "moderately realistic," 30.4% as "realistic," and only 7.5% as "very realistic," whereas 8.9% considered it "not realistic." These findings indicate a discrepancy between overall satisfaction with the learning process and specific dissatisfaction with the quality of the simulation media employed.

Table 2.
Student perceptions of circumcision learning and the quality of the manikins used.

Characteristics of respondents	Frequency (f)	Percentage (%)
Statements regarding current learning		
Somewhat agree	40	18.7
Agree	145	67.8
Strongly agree	29	13.6
Manikin quality		
Not realistic	19	8.88
Quite realistic	114	53.27
Realistic	65	30.37
Very realistic	16	7.48

Students' perceptions of the importance of circumcision manikin design features

The majority of respondents rated the ideal circumcision manikin design features as highly important (Table 3). A total of 44.4% considered the design features to be "very important," while 31.8% rated them as "important."

Regarding physical realism, 40.2% of respondents rated it as "*very important*" and 32.7% as "*important*," whereas functional realism was rated as "*very important*" by 37.4% and as "*important*" by 31.3% of respondents. These findings emphasize that students do not merely require manikin as basic training tools but expect designs that closely approximate real clinical conditions in both physical and functional aspects.

Table 3.
Students' perceptions of the importance of circumcision manikin design features.

Characteristics of respondents	Frequency (f)	Percentage (%)
The Importance of ideal circumcision Manikin design features		
Very unimportant	1	0.5
Unimportant	7	3.3
Moderately important	43	20.1
Important	68	31.8
Very important	95	44.4
Functional realism		
Very unimportant	4	1.9
Unimportant	18	8.4
Moderately important	45	21.0
Important	67	31.3
Very important	80	37.4
Physical realism		
Very unimportant	2	0.9
Unimportant	8	3.7
Moderately important	48	22.4
Important	70	32.7
Very important	86	40.2

Skin realism features of the circumcision manikin

Regarding skin realism, students placed strong emphasis on several key components (Table 4). Approximately 34.6% of respondents rated realistic skin texture as "*very important*" and 29.4% as "*important*," while accuracy of color and visual details was rated as "*very important*" by 33.2% and as "*important*" by 30.8%. Variations in preputial shape were considered "*very important*" by 36.5% and "*important*" by 30.4%, indicating the need to represent the anatomical spectrum of clinical cases. In addition, tissue resistance (35.1% rated as very important) and response to suturing (35.5% rated as very important) were regarded as crucial for training tactile sensation, incision depth control, and precise suturing techniques.

Complication simulation

Students also rated complication simulation features as highly important (Table 5). More than one-third of respondents rated realistic bleeding simulation as "*very important*" (36.0%), while 27.1% rated it as "*important*." Likewise, simulation of other complication scenarios was rated as "*very important*" by 34.1% and as "*important*" by 29.4% of respondents. Given that bleeding is the most common complication of circumcision, these findings highlight that features enabling training in bleeding control and complication management are considered essential components in the design of a new circumcision manikin.

Table 4.
Skin realism of the circumcision manikin.

Characteristics of respondents	Frequency (f)	Percentage (%)
Realistic skin texture		
Very unimportant	5	2.34
Unimportant	19	8.88
Moderately important	53	24.77
Important	63	29.44
Very important	74	34.58
Accuracy of color and visual details		
Very unimportant	6	2.80
Unimportant	17	7.94
Moderately important	54	25.23
Important	66	30.84
Very important	71	33.18
Variation in preputial shape		
Very unimportant	9	4.21
Unimportant	24	11.21
Moderately important	38	17.76
Important	65	30.37
Very important	78	36.45
Tissue resistance		
Very unimportant	8	3.74
Unimportant	21	9.81
Moderately important	43	20.09
Important	67	31.31
Very important	75	35.05
Response to suturing		
Very unimportant	5	2.34
Unimportant	17	7.94
Moderately important	48	22.43
Important	68	31.78
Very important	76	35.51

Table 5.
Complication simulation.

Characteristics of respondents	Frequency (f)	Percentage (%)
Realistic bleeding simulation		
Very unimportant	21	9.81
Unimportant	27	12.62
Moderately important	31	14.49
Important	58	27.10
Very Important	77	35.98
Complication simulation		
Very unimportant	18	8.41
Unimportant	29	13.55
Moderately important	31	14.49
Important	63	29.44
Very important	73	34.11

Students' expectations of the circumcision manikin

Students' expectations of the circumcision manikin, based on the analysis of open-ended responses, centered on the need for high realism and a more meaningful simulation experience. The most dominant theme was "*realistic manikin*," encompassing anatomical realism, tissue texture, clinical simulation realism, and material quality, and was identified by 123 respondents. Other frequently mentioned

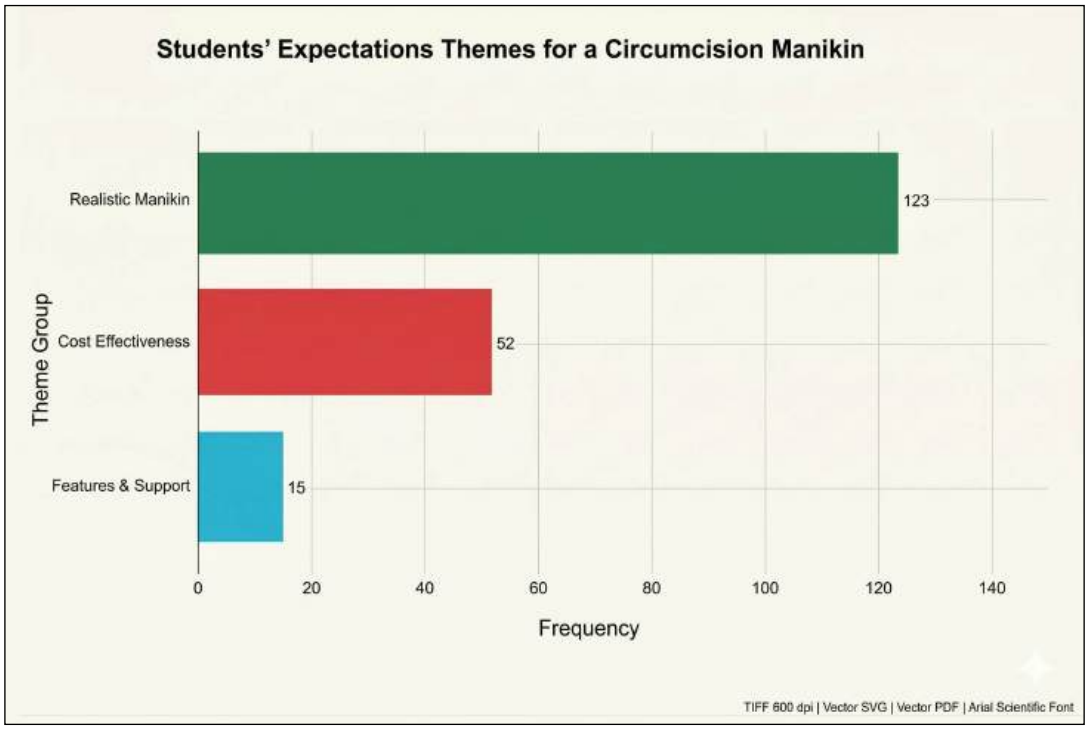


Figure 2.
Frequency distribution of students' expectations for the circumcision manikin.

themes included learning effectiveness using the manikin (52 respondents) and the need for additional features and supporting elements (8 respondents) (Figure 2). Overall, students expressed a desire for a manikin that closely approximates real clinical conditions both physically and functionally, enabling circumcision training in the CSL to be more representative and to better support readiness for clinical practice. As illustrated in the following diagram:

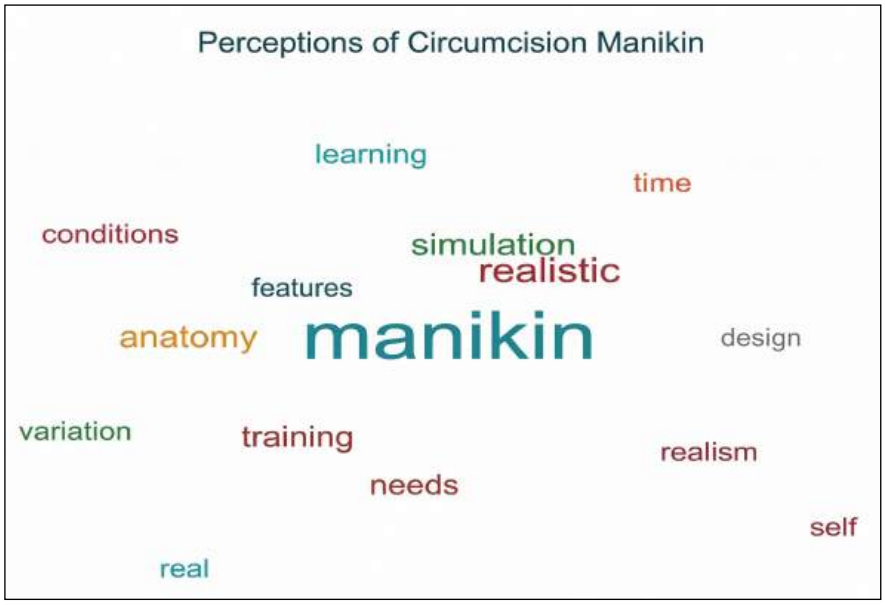
Qualitative findings

Students' expectations of the circumcision manikin (results of analysis from open-ended questionnaire responses, observations, and documentation)

Students' perceptions of the circumcision manikin are illustrated in the following word cloud (Figure 3):

The word cloud depicting students' perceptions highlights keywords such as "*manikin*," "*realistic*," "*simulation*," "*practice*," "*anatomy*," and "*evaluation*" as the most prominent. This pattern reinforces that students perceive a realistic manikin as the core of the learning experience not merely as a teaching aid, but as a simulation medium that should support technical skills training, anatomical understanding, and more objective skill assessment. These findings are consistent with observations in the CSL (Figure 4), where students appeared enthusiastic yet frequently constrained by manikins that were rigid, provided limited tissue feedback, and were prone to damage. This was further supported by the condition of the manikins in the CSL, which demonstrated limited model variation, thereby reducing opportunities for repeated practice.

Figure 3.
Students' perceptions of the circumcision manikin.



Lecturers', instructors', and laboratory staff's perceptions of circumcision skills training using manikins

Lecturers, instructors, and laboratory staff shared a consensus that simulation-based media are essential for circumcision skills training; however, the quality of currently available manikins remains insuffi-

Figure 4.
Observation of students during circumcision skills training in the CSL.

cient to represent real clinical procedures adequately. Respondents noted that existing manikins help students learn the basic procedural sequence but are not yet capable of training critical aspects such as identification of vascular structures, ligation techniques, bleeding control, and tactile tissue feedback. This view is reflected in statements such as, *"manikins provide a safe space for students to practice repeatedly without endangering patients, but the quality of current manikins is still insufficient to represent real clinical conditions"* (R-DE), and *"Students can learn the procedural steps, but they do not truly experience the challenges of vessel ligation or managing bleeding as in the operating room"* (R-AG).

Thematic synthesis of the interview transcripts yielded five interrelated main themes. First, physical realism emphasized the need for accurate anatomical representation, including vascular structures, skin-mucosal layers, and elastic tissue texture, to enable more meaningful practice of ligation and suturing. Second, effective circumcision training requires manikins that support structured, repetitive practice aligned with the curriculum and the SKDI, and that can be integrated with standardized patients to facilitate clinical communication training. Third, the theme of interactive manikin innovation highlighted the importance of sensory features and objective feedback mechanisms – such as incision depth indicators or bleeding alarms – that allow immediate reflection and correction without constant instructor supervision. As one expert stated, "*manikins are very helpful as an initial learning medium; however, without realistic tissue and bleeding simulation, clinical decision-making skills and complication management are difficult to develop*" (R-DI).

Fourth, the theme of manikin management in the CSL underscored the need for durable designs that are easy to clean and maintain, supported by appropriate scheduling and staff training. A laboratory staff member noted, "*manikins deteriorate quickly when used repeatedly, yet students require many repetitions. We often have to repair or even improvise equipment to keep training sessions running*" (R-Q). Fifth, the theme of procurement and development challenges emphasized constraints related to cost, local technological capacity, and human resources, indicating that proposed designs must be feasible to produce and manage within medical faculties with limited resources. The lecturers' word cloud, highlighting terms such as "*manikin*," "*learning*," "*circumcision*," "*skills*," "*training*," and "*evaluation*" as the most prominent, reinforces the view that manikins are perceived as central components of structured training and competency assessment rather than mere teaching aids. Taken together, these findings demonstrate a strong need for a high-fidelity circumcision manikin that is anatomically and functionally realistic, interactive, easy to manage, and feasible to develop within the context of medical education in Indonesia.

Discussion

Realistic manikins

Based on the integration of quantitative and qualitative findings, observations, and documentation in the CSL, realistic manikins emerged as a key component in circumcision skills training. Physical realism plays a crucial role in creating an effective and meaningful practical learning experience for students. Interviews with lecturers, experts, and laboratory staff indicated that the realism of vascular structures is an essential feature for training students to manage clinical complications, particularly intraoperative bleeding. Respondents emphasized that the manikin's ability to display vascularization and bleeding simulation is necessary for students to become accustomed to handling crisis situations in the operating room. This finding was reinforced by coaching observations, which revealed the limitations of currently available manikins in adequately representing these features, potentially compromising students' clinical preparedness. This aligns with the concept of fidelity, which highlights the importance of anatomical and functional accuracy as a prerequisite for effective surgical simulation media (8).

Beyond vascular aspects, tissue texture realism also influences learning effectiveness. Qualitative data showed that manikins made from rigid, less elastic materials limit tactile sensation, thereby hindering the development of fine motor skills, particularly in cutting and suturing techniques. Respondents consistently stressed the importance of using materials that simulate the elasticity and resistance of real skin tissue to provide students with realistic

tactile feedback. These findings support the concept of physical fidelity, particularly the role of tactile feedback in procedural skills training (14).

Another dimension of realism that remains limited is the manikin's ability to provide physiological responses or automatic feedback to medical actions, such as the depth of anesthetic injection and tissue reaction. Instructors noted that real-time feedback features have the potential to accelerate the learning curve, enable more effective independent practice, and allow immediate error correction. The urgency of developing high-fidelity manikins is further underscored by the fact that circumcision is a compulsory skill at competency level 4A in the SKDI and carries a risk of serious complications if not mastered optimally. Therefore, the development of a realistic circumcision manikin that is user-oriented through a user-centered design approach is an important strategy to bridge the gap between theory and actual clinical practice and to enhance students' clinical readiness (15).

Comparative analysis of simulation modalities

To position the proposed design within the current landscape of surgical education, it is necessary to compare it with existing commercial simulators and emerging digital technologies. Currently, high-fidelity commercial models such as those from Limbs & Things and MedEduQuest set the standard for anatomical realism. However, they often present barriers related to cost and specific feature gaps relevant to the SKDI 4A, particularly regarding active bleeding simulation and integrated objective feedback. A detailed comparison between commercial models, digital simulators, and the proposed design is presented in Table 6.

This comparison highlights a critical gap: while commercial models offer excellent anatomical fidelity, they fail to simulate the high-stakes complication of active bleeding, which students in our study identified as a "*very important*" feature (35.98%). Furthermore, digital alternatives like *Virtual Reality* (VR) and *Augmented Reality* (AR), while effective for cognitive training, cannot replace the haptic experience of cutting and suturing tissue.

Integration with digital and hybrid simulation technologies

Recent advancements in digital simulation offer complementary strengths to physical manikins. *Sindu et al.* (16) demonstrated that a VR circumcision simulator using Oculus Quest 2 could significantly improve clinical performance and retention among medical students in Bali. Their study found that while VR is excellent for procedural memorization and reducing cognitive load through "*Guided Mode,*" it suffers from a lack of haptic feedback and can induce simulator sickness [*virtual reality-induced symptoms and effects* (VRISE)] in autonomous settings. Similarly, *Maulana et al.* (17) developed the *Circumcision Augmented Reality Simulation* (CARS), a low-cost mobile application that allows students to visualize the procedure using a smartphone. While CARS solves the issue of accessibility and cost, the authors noted a significant limitation: the "*tactile issue*," where users cannot experience the sensation of injection or suturing.

These findings reinforce the necessity of a physical manikin. As noted in the CARS study, digital tools omit the user's recognition of skin injection or suturing sensation. Therefore, the ideal educational approach is likely a hybrid model. *Dos Santos et al.* (18) introduced the *CIRCumcision Learning Experience using Simulation* (CIRCLES) platform, which succes-sfully combined online didactic learning with hands-on practice using 3D-printed silicone task trainers. Their study confirmed that structured physical simulation, whether supervised in-person or virtually, led to significant improvements in knowledge and self-efficacy.

Synthesis and design implications

The proposed manikin design in this study serves as the physical anchor in this modern educational ecosystem. By integrating the haptic realism missing from VR/AR (as noted by *Sindu et al.* (16) and *Maulana et al.* (17)) and adding the active bleeding/complication simulation missing from commercial models, the proposed design fills a specific niche. It allows students to transition from cognitive mastery (via VR/AR) to psychomotor competence (via

Table 6.
Comparison of commercial circumcision simulators and proposed design features.

Simulator model	Primary features	Advantages	Disadvantages
Limbs & Things (e.g., Adult Male Circumcision Trainer 60395/60392)	· Realistic multilayer foreskin · Supports dorsal slit and sleeve resection · Ring block injection capability	· High anatomical fidelity · Durable construction · Widely validated in surgical training courses	· High acquisition cost, limiting use in low-resource settings · No active bleeding simulation · Absence of electronic performance feedback
MedEduQuest (e.g., Adult Male Circumcision Simulator)	· Silicone-based material · Integrated surgical instrument kit · Replaceable foreskin components	· Comprehensive kit for instrument handling practice · Acceptable tactile realism for incision	· Variable durability · Limited functional realism (no physiological response) · No objective performance metrics
Digital simulators (VR/AR)	· VR: Immersive 3D environments (e.g., Oculus Quest 2) · AR: Mobile-based procedural overlays (e.g., CARS)	· No consumable materials, resulting in low recurring costs · High cognitive fidelity for procedural sequencing · Broad accessibility via smartphones or headsets	· Absence of haptic feedback · Risk of virtual reality-induced symptoms and effects (VRISE) · Inadequate for fine motor skill training (suturing, cutting)
Proposed Prototype (This study)	· Active bleeding simulation modules · Sensor-based feedback for incision depth and pressure · Modular, replaceable consumable components	· Aligned with national competency standards (SKDI level 4A) · Cost-effective long-term maintenance · Ability to simulate complications (e.g., hemorrhage)	· Requires multidisciplinary collaboration for development · Initial prototyping and validation costs

VR: Virtual reality; AR: Augmented reality; CARS: Circumcision augmented reality simulation; SKDI: Standar kompetensi dokter Indonesia; VRISE: Virtual reality-induced symptoms and effects.

high-fidelity physical simulation) before attempting procedures on actual patients. This tiered approach ensures that graduates meet the SKDI Level 4A requirement with a higher degree of safety and confidence.

Effectiveness of learning using manikins

The use of manikins as a learning resource for circumcision clinical skills has been shown to be effective in enhancing students' technical competence and self-confidence.

Integration of quantitative data, qualitative interviews, and observations in the CSL demonstrated that repeated practice on manikins improves procedural accuracy, fine motor skills, and clinical readiness, while providing a safe learning environment without the risk of complications. These findings are consistent with previous studies emphasizing the role of realistic manikins in supporting guided practice and instructor feedback (9, 19).

Theoretically, the effectiveness of manikins is supported by the concepts of the Zone of Proximal Development, deliberate practice, and self-efficacy, where structured practice, instructor scaffolding, and repeated evaluation accelerate the acquisition of skills from the cognitive stage to the autonomous stage. Integration of manikins with standardized patients further enriches learning by training clinical communication and case adaptation, thereby strengthening comprehensive simulation-based clinical skills education (20).

Ideal design features and innovation of manikins

Ideal design features of a circumcision manikin should exhibit high fidelity to accurately represent clinical anatomy and function. This study shows that bleeding simulation, vascular visualization, and elastic skin texture that responds to excision and suturing are critical components for enhancing fine motor skills and students' clinical readiness. Integration of sensor technology with real-time feedback allows objective evaluation of technical errors, applied pressure, and incision depth, supporting deliberate practice and self-regulated learning. Additionally, modular design increases sustainability and flexibility of manikin use in accordance with user-centered design principles. Overall, realistic manikins with innovative features have the potential to bridge the gap between theoretical learning and clinical practice, supporting graduates' competency achievement according to SKDI (20).

Management and development challenges of manikins

The management and development of circumcision manikins should be conducted systematically through clear maintenance protocols (routine cleaning, inspection, repair, and component replacement) to maintain durability and simulation fidelity (21). Funding and technology limitations require collaboration with multiple stakeholders to ensure the development of advanced features such as sensors and real-time feedback remains sustainable and affordable. Moreover, structured scheduling, integration with other learning strategies, and ongoing training for laboratory staff and instructors are essential prerequisites to ensure that manikins effectively support students in achieving clinical competency standards.

Blueprint for circumcision manikin needs analysis

Based on the integration of quantitative and qualitative data analyses, a blueprint was developed to provide design recommendations for an ideal circumcision manikin, encompassing anatomical, functional, and operational aspects (Table 7).

Table 7.
Blueprint for circumcision manikin needs analysis.

Design component	Recommended specifications	Quantitative analysis results (Students, n = 214)	Qualitative analysis results (lecturers, experts, & laboratory technicians)
Anatomical and visual realism	Accurate anatomical representation of penile structures: corpus, glans, preputium, with emphasis on vascular details (frenular artery) and nerves (dorsal nerve of the penis)	40.2% of respondents rated physical realism as "Very Important," and 33.18% emphasized the importance of visual accuracy of tissues	Respondents (R-DE, R-DI) highlighted that vascular details are crucial for training precise anesthesia block and ligation techniques to prevent bleeding.
Tissue texture and resistance	Use of elastic materials (e.g., platinum-based silicone) capable of simulating the density and elasticity of real skin and mucosa	The majority of respondents (34.58%) emphasized the need for realistic skin texture to achieve authentic tissue resistance during cutting and suturing	Respondents (R-AG, R-DI) criticized current manikins for being too rigid and hard, failing to provide students with realistic tactile feedback
Clinical complication simulation	Active bleeding simulation feature that responds to incision errors in critical vascular zones	35.98% of respondents rated the bleeding simulation feature as very important for mental and technical preparation in real-life scenarios	Coaching observations indicated that instructors require this feature to train students to remain calm while managing bleeding complications
Feedback system	Integration of electronic sensors or objective indicators that provide audio/visual notifications for injection or suturing errors	33.64% of respondents expected objective feedback from the manikin to support independent learning	Respondents (R-R, R-AG) suggested interactive innovations to allow students to receive instant correction without constant instructor supervision
Integration with standardized Patients	Wearable manikin design that can be attached to a human for simulation scenarios with standardized patients	31.31% of respondents considered integration with standardized patients important for training communication skills and empathy during procedures	Respondents (R-Q, R-I) emphasized that circumcision competency involves not only technical skills but also the ability to manage patient anxiety simultaneously
Operational aspects and durability	Modular design for consumable parts (preputium), durable materials, and easy maintenance and mobility	High attention to mobility (41.78%) and 38.32% emphasized ease of component replacement (spare parts)	Respondent (R-I) emphasized the importance of materials that are easy to clean and resistant to repeated use over extended periods in the laboratory

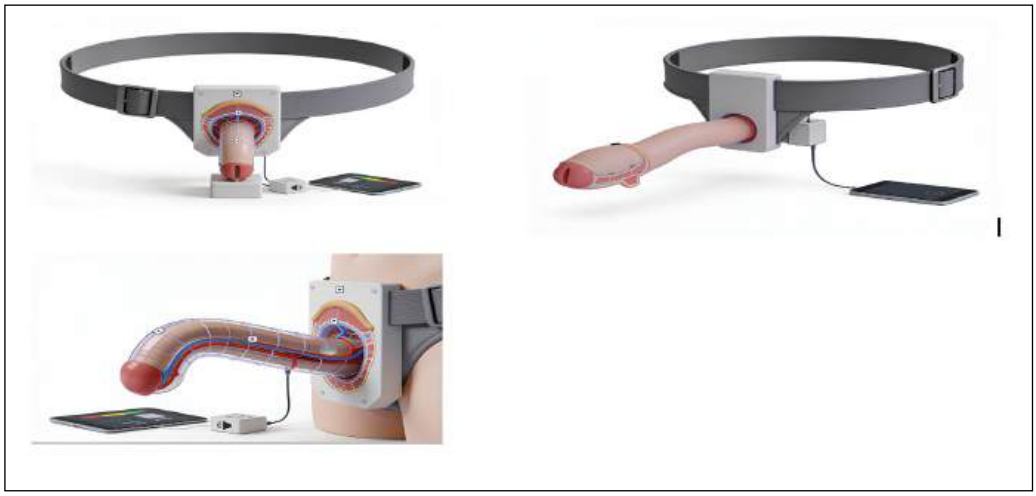


Figure 5.
Prototype design of circumcision manikin according to needs assessment.

Based on the research findings and discussion, the researchers visualized a circumcision manikin model according to user needs analysis (students, lecturers, experts, and laboratory technicians) in the following design (Figure 5).

The manikin design above reflects the results of the needs analysis, where each component represents a feature identified by students and lecturers as a key element to enhance the anatomical and functional realism of circumcision training. This design not only presents a more complete and realistic structure but also considers practical usability in the CSL, making it relevant as an initial user-centered prototype.

This study has several limitations. The population was limited to students and instructors at the *Faculty of Medicine, Al Azhar Islamic University Mataram*, which may reduce the generalizability of the findings to other institutions. Although qualitative methods were triangulated, they remain subjective, highlighting the need for broader quantitative measurements. Additionally, constraints of time and resources meant that the study only covered a needs analysis and conceptual design, without prototype production and evaluation. Therefore, further research is required.

Conclusions

This study demonstrates that circumcision skills training in the CSL requires manikins with high anatomical and functional fidelity, equipped with interactive features such as real-time feedback and integration with standardized patients, to enhance students' clinical readiness and technical skills according to the SKDI. Therefore, manikin development should focus on user-centered design, supported by sustainable capacity building and CSL management. Collaboration among educational institutions, technology developers, and medical device industries, along with further research to validate innovative prototypes, represents a strategic approach that should be supported by policies and curricula aligned with SKDI.

Declarations

Ethical approval and consent for participate: *This study received approval from the Health Research Ethics Committee of the Faculty of Medicine, Al Azhar Islamic University Mataram (No.088/EC 03/FK 06/UNIZAR/VIII/2025). All participants received verbal and written explanations regarding the study objectives, procedures, and potential risks/benefits, and provided informed consent prior to data collection.*

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