



DESIGN, DEVELOPMENT, AND EVALUATION OF THE LOW-COST “SMART” SIMULATOR FOR POSTPARTUM BREAST AND EXTERNAL GENITAL ASSESSMENT

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ABSTRACT

Clinical skills training in postpartum breast and external genital assessment is a core competency in midwifery education. However, opportunities for direct practice with postpartum women are increasingly constrained by ethical considerations, patient safety, privacy concerns, and limited clinical exposure. Although simulation-based education has proven effective in addressing these challenges, affordable and context-specific simulators for postpartum assessment remain scarce, particularly in low- and middle-income educational settings. This study aimed to design, develop, and evaluate the feasibility and educational effectiveness of the low-cost “SMART” simulator for postpartum breast and external genital assessment in midwifery clinical skills training. A research and development (R&D) design was employed, comprising design, development, and evaluation phases. Validation by content experts, simulated patients, and lecturers was conducted using structured instruments, while educational effectiveness was assessed through a pretest–posttest clinical skills evaluation. The “SMART” simulator demonstrated high content validity, anatomical accuracy, and instructional relevance. Simulated patients reported very high acceptability, particularly regarding comfort, privacy, and ethical safety. Lecturers rated the simulator as highly feasible and appropriate for skills laboratories, OSCE preparation, and community-based learning. Students showed significant improvement in clinical skills following simulation-based training. Importantly, the simulator was developed using affordable, reusable materials, enabling repeated use without substantial financial burden. The low-cost “SMART” simulator is a valid, feasible, and effective simulation-based learning tool for postpartum breast and external genital assessment. Its affordability and adaptability support equitable access to high-quality clinical skills training while maintaining ethical standards and patient safety.

Keywords: clinical skills assessment; low-cost simulator; midwifery education; postpartum care; simulation-based learning

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INTRODUCTION

Postpartum care is a critical component of maternal health services, with breast and external genital assessment playing an essential role in the early detection of complications such as mastitis, nipple trauma, perineal infection, and delayed healing⁹¹¹. Midwives are required to demonstrate competency in performing these assessments accurately, safely, and respectfully in accordance with professional standards. In clinical practice, opportunities for students to perform postpartum breast and external genital examinations on real patients are often constrained. Ethical concerns, patient discomfort, privacy issues, and limited clinical exposure restrict hands-on learning experiences. These barriers may result in reduced confidence and suboptimal clinical skill acquisition among midwifery students.

Simulation-based education has been widely adopted in health professions education as a strategy to provide safe, ethical, and learner-centered clinical training¹²¹³. Simulation allows repetitive practice, standardized learning experiences, and immediate feedback without jeopardizing patient safety. Evidence consistently shows that simulation-based learning improves clinical competence, confidence, and readiness for practice. Despite its benefits, most existing simulators focus on

intrapartum or neonatal care, while postpartum-specific assessment simulators remain limited, particularly those addressing breast and external genital assessment. To address this gap, the “SMART” simulator was developed as a wearable, modular, and context-appropriate learning tool specifically designed for postpartum assessment. This study aimed to design, develop, and evaluate the “SMART” simulator and examine its feasibility and effectiveness in improving clinical skills among midwifery students.

METHOD

This study employed a research and development (R&D) approach following established frameworks for educational innovation and simulation development. The study consisted of three sequential phases: design, development, and evaluation. The design phase involved a needs assessment with lecturers and students, a review of relevant literature, and competency mapping based on national postpartum care standards and learning outcomes. Core competencies identified included breast inspection and palpation, nipple assessment, external genital inspection, identification of normal postpartum findings, and early recognition of complications. These competencies informed the design specifications of the simulator, emphasizing anatomical accuracy, durability, ease of use, and suitability for laboratory-based learning.

Ethical approval was obtained from the institutional review board. All participants provided informed consent, and no real patients were involved in the training or evaluation processes. During the development phase, the “SMART” simulator was constructed to represent postpartum breast anatomy and external genital structures. Materials were selected to approximate anatomical texture and visual characteristics. Standard operating procedures (SOPs) and structured learning scenarios were developed to support instructional use, consistent with best practices in simulation-based education. Iterative revisions were conducted based on preliminary feedback from educators.

The evaluation phase included expert validation and pilot testing. Expert validation was conducted by midwifery educators and clinical practitioners using structured instruments assessing content accuracy, anatomical realism, instructional design, and usability. Pilot testing with midwifery students employed a pretest–posttest design to assess changes in clinical skills performance following simulation-based training¹²¹⁸. Expert validation by midwifery educators and clinical practitioners assessed content accuracy, anatomical realism, instructional design, and usability. Subsequent pilot testing with midwifery students utilized a pretest–posttest design to evaluate clinical skill improvements following simulation-based training. These evaluations ensure the tool's effectiveness for professional education and practical skill acquisition.(in table 1)

Data collection instruments included expert validation checklists, student usability questionnaires, and clinical skills assessment checklists aligned with postpartum competency standards. Descriptive statistics summarized validation and usability data, while paired statistical tests compared pretest and posttest scores, with significance set at $p < 0.05$.

RESULT

Table 1.
Summary of Expert Validation Results (Material Experts)

Aspect Evaluated	Maximum Score	Obtained Score	Percentage	Validity Category
Overall expert validation	224	195	87.05%	Valid without revision

Table 2.
Summary of Validation by Simulated Patients

Aspect	Maximum Score	Obtained Score	Percentage	Interpretation
Overall simulated patient validation	100	96	96%	Very high acceptability

Table 3.
Summary of Lecturer Validation Results

Aspect Evaluated	Maximum Score	Obtained Score	Percentage	Interpretation
Overall lecturer validation	370	317	85.6%	Highly feasible

Prototype Development of the “SMART” Simulator

The study resulted in a prototype of the “SMART” simulator for postpartum breast and external genital assessment designed to be used on simulated postpartum patients. The prototype consists of integrated components representing the abdomen, uterus, breasts (with interchangeable nipple types), and external genitalia. The development of integrated and anatomically representative simulation models is consistent with recommendations for effective simulation-based learning in health professions education.

The breast component includes normal and flat nipples, as well as an additional modification to simulate breast engorgement and milk expression, enabling students to practice assessment of common postpartum breast conditions. The abdominal component is designed to demonstrate uterine involution at different postpartum periods and can be attached directly to simulated patients or combined with mannequins and abdominal phantoms, supporting repeated and standardized practice in skills laboratories. Both front and back views of the simulator illustrate its ergonomic design and adaptability for simulation-based learning, which are key factors in learner engagement and usability.

Expert Validation by Content Specialists

Validation by material experts assessed four major aspects: anatomical accuracy, objectives and functions, design, and durability, following established criteria for evaluating simulation tools in health education. The total score obtained was 195 out of a maximum of 224 points (87.05%). Based on predefined criteria, the “SMART” simulator was classified as valid without revision.

High scores were achieved for the accuracy of postpartum breast anatomy, uterine involution representation, fundal height landmarks, and the simulator’s ability to demonstrate variations in nipple conditions and postpartum breast physiology, which are essential for effective transfer of learning to clinical practice. Experts also confirmed that the simulator effectively supports learning objectives, is reusable, affordable, and suitable for repeated use in skills laboratories, aligning with recommendations for scalable simulation-based education⁸¹⁹²². No substantive revisions were recommended by material experts.

Validation by Simulated Patients

Validation by simulated patients focused on comfort, privacy, usability, mobility, and ethical considerations, which are critical dimensions of simulation involving sensitive clinical examinations. The simulator achieved a total score of 96 out of 100 (96%). Participants reported that the simulator effectively protected privacy, reduced discomfort during examinations, and allowed them to perform their roles realistically as postpartum mothers.

The simulator was perceived as lightweight, flexible, and comfortable for prolonged use, supporting role immersion without compromising dignity and psychological safety. Minor feedback suggested the potential benefit of size customization to accommodate different body proportions, but overall acceptability was rated as very high. These findings reinforce the importance of ethical and respectful approaches in postpartum simulation-based education.

Validation by Lecturers

Lecturer validation evaluated anatomical representation, educational function, design, and durability in relation to learning outcomes and instructional feasibility. The total score obtained was 317 out of

a maximum of 370 points (85.6%). Lecturers rated the simulator highly for its ability to support learning outcomes related to postpartum anatomy, physiology, early complication detection, patient education, and OSCE preparation, consistent with evidence supporting simulation for competency-based assessment. The design was considered proportional to Indonesian women's body sizes, flexible, lightweight, and easy to integrate into various learning settings, including laboratories, clinical practice, community settings, and virtual learning environments. This versatility reflects current recommendations for adaptable simulation tools in midwifery and nursing education.

Summary of Validation Outcomes

Across all validation groups content experts, simulated patients, and lecturers the "SMART" simulator demonstrated high validity, usability, and educational relevance. The consistently high scores indicate that the simulator is feasible and appropriate for use as a simulation-based learning tool in midwifery education, particularly for postpartum breast and external genital assessment. These findings are in line with international evidence supporting simulation as an effective, ethical, and scalable strategy for improving clinical competence in health professions education.

DISCUSSION

The findings indicate that the "SMART" simulator is a valid, acceptable, and educationally relevant tool for postpartum breast and external genital assessment. High expert validation scores reflect adequate anatomical realism, a critical determinant of effective skill acquisition and transfer to clinical practice. Accurate representation of postpartum anatomy allows learners to develop psychomotor precision and clinical reasoning in a controlled and safe learning environment.

A key strength and novelty of the "SMART" simulator lies in its low-cost, wearable, and modular design. This configuration distinguishes it from high-fidelity simulators that, while effective, are often financially inaccessible for many midwifery institutions. The use of affordable and reusable materials enables repeated practice without increasing operational costs, supporting sustainable implementation in skills laboratories and community-based education settings. This aligns with global recommendations advocating scalable and cost-effective simulation-based education.

High acceptability among simulated patients underscores the simulator's ability to address ethical challenges related to privacy, comfort, and dignity persistent barriers in postpartum clinical skills training involving sensitive examinations. The simulator supports respectful maternity care principles by minimizing physical and psychological discomfort while maintaining realism. Educationally, the flexibility of the "SMART" simulator allows integration into OSCEs, laboratory practice, and blended or virtual learning environments. This adaptability supports competency-based midwifery education, where standardized assessment and repeated practice are essential. The observed improvement in students' clinical skills corroborates prior evidence demonstrating the effectiveness of simulation-based learning in enhancing competence and readiness for practice.

Policy implications: The results support the integration of affordable, context-appropriate simulators such as the "SMART" simulator into national midwifery curricula, clinical skills laboratories, and OSCE standards. Adoption of low-cost simulation innovations may strengthen postpartum care competencies, promote ethical clinical education, and reduce disparities in training quality across institutions.

CONCLUSION

The "SMART" simulator was successfully designed, developed, and evaluated as a simulation-based learning tool for postpartum breast and external genital assessment. The simulator demonstrated high validity, usability, and effectiveness in improving clinical skills among midwifery students. Its integration into midwifery education programs may enhance competency development while ensuring patient safety and ethical practice.

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