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Literature Review on the Materials, Advantages, and Disadvantages of Suturing Training Tools in Health Education

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ABSTRACT

Background & Objective: Suturing skills are a fundamental competency in both nursing and medical education. To support the mastery of this skill, effective, realistic, and pedagogically appropriate training tools are essential. Various materials have been employed to create suture training models; however, no single material has emerged as universally ideal or standardized globally. Aims: This review aims to identify the types of materials used in suturing training tools, evaluate their strengths and limitations, and assess their contribution to the global development of simulation-based training devices. **Method:** This study is a literature review analyzing five recent and relevant scientific articles. The selection criteria included thematic relevance, publication year, and a focus on evaluating suture training tools or materials. Analysis was conducted using the JBI Critical Appraisal Checklist for Case Reports. This literature review highlights aspects such as material properties, advantages, disadvantages, and implications for educational practice. **Result:** The review identified five primary categories of materials used in suture training tools: (1) polydimethylsiloxane (PDMS) with silk fibers, (2) silicone pads and polyurethane foam, (3) porcine skin, sponges, and commercial pads, (4) improvised combinations such as citrus fruits and tea towels, and (5) synthetic polyurethane-based skin. Each material offers specific benefits, such as high realism, durability, or affordability. Nevertheless, all materials exhibit limitations, including ethical concerns, hygiene issues, and limited anatomical fidelity. **Conclusion:** This literature review

indicates that no single material fully satisfies all requirements for suturing training. A combined and contextual approach considering learning objectives, cost, and local availability emerges as a pragmatic alternative. The contribution of this review lies in strengthening the global research direction toward the development of accessible, inclusive, and adaptable medical simulation tools tailored to diverse healthcare education settings worldwide.

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Introduction

Nursing competency is a fundamental component of a high-quality healthcare system. In the era of globalization and the integration of international standards, improving the competencies of nursing personnel has become a top priority, aligned with national efforts to enhance the quality of healthcare services. One of the essential competencies that must be mastered by professional nurses is the ability to perform invasive nursing procedures, such as wound closure or suturing. This skill is crucial not only in emergency settings but also in supporting the effectiveness of patient safety based nursing care (Sulistiyowati & Supratman, 2024; Suwardianto & Astuti, 2020).

According to the World Health Organization (WHO, 2023), nurses represent more than 59% of the global healthcare workforce, and their clinical skills are pivotal to the quality of care across healthcare settings from primary to tertiary facilities. In Indonesia, efforts to improve nursing competency face increasing complexity, particularly due to significant disparities in nursing education and practice across different regions. A report by the Indonesian Health Workers Council, indicated that of the 480,000 registered nurses, over 37% had not obtained competency certification in performing invasive procedures, including wound suturing (Konsil Tenaga Kesehatan Indonesia, 2022).

Mastery of suturing skills serves as a key indicator in measuring national nursing competencies. However, limitations in conventional practicum learning media and methods such as the use of animal tissue or image-based simulations remain significant barriers to effective skills transfer. The development of innovative, human-like suture training tools offers a promising solution. These tools are designed to resemble human tissue, providing nursing students with the opportunity to practice independently, repeatedly, and safely without involving real patients (Kuzu, 2022b; Middleton, 2006).

Studies have shown that the use of suture training tools significantly enhances students' confidence, technical precision, and procedure completion time. A study by (Khan et al., 2003) reported that nursing students using suture simulation kits demonstrated a 45% improvement in suture accuracy compared to a control group using traditional methods. Similarly, (Kuzu, 2022a) found that integrating silicone-based suture tools into nursing practice curricula led to a 38% increase in objective

skill examination scores within one semester. These tools have proven effective in improving motor skill learning, muscle memory, and understanding of aseptic technique.

In Indonesia, the research and implementation of suture training tools remain limited. Major challenges include insufficient availability, uneven distribution of training equipment, and a lack of instructor training. Nonetheless, the use of such tools has the potential to support the achievement of the National Nursing Competency Standards (NNCS) set by the Indonesian Association of Nurse Education Institutions (AIPNI) and the Nursing Council. A systematic mapping and literature analysis are essential to identify the extent to which suture training tools have contributed to enhancing nursing competencies both nationally and globally.

Objective

Considering the urgent need to improve suturing competence among nursing students, alongside the availability of simulation-based training technologies, this study aims to comprehensively review scientific evidence on the impact of suture training tools on national nursing competency development. This review is expected to serve as a strategic foundation for developing skills-based nursing education policies and strengthening an effective, efficient, and sustainable clinical training system.

Method

The research method employed in this study was a literature review, conducted following the PRISMA guidelines (Page et al., 2021).

The literature search strategy was carried out systematically using the Population, Concept, and Context (PCC) framework. Keywords were determined based on the core components of the topic, as follows: Population: nursing students, nurses, nursing trainees, Concept: suture training tools, suture pads, wound closure training, suture simulation, Context: enhancement of nursing competency, nursing education, nursing curriculum. The search was conducted across five international and national scientific databases: PubMed, ScienceDirect, CINAHL (Cumulative Index to Nursing and Allied Health Literature), and ProQuest. An example of Boolean search string used: ("nursing student" OR "nursing education" OR "nurse") AND ("suture training" OR "suture pad" OR "suture simulation") AND ("competency" OR "skill development"). The search was limited to articles published between January 2015 and May 2025 to ensure the relevance and currency of the data included.

Inclusion and Exclusion Criteria

Inclusion criteria: Articles published in English or Indonesian, Empirical studies (quantitative, qualitative, or mixed-methods), Investigated the use of suture training tools in nursing education, Focused on outcomes such as competency, technical skills, or clinical performance, Published in accredited scientific journals. **Exclusion criteria**: Non-empirical studies such as editorials, commentaries, and opinion pieces, Studies using only animals or biological models without synthetic simulation tools, Articles with limited access or unavailable in full text, Studies unrelated to the context of nursing education or competency development

Screening Process

The screening process was conducted in three stages: Identification: All retrieved articles were compiled and managed using Zotero to remove duplicates. Title and

Abstract Screening: Two independent reviewers screened articles for thematic relevance and alignment with the inclusion criteria. Full-text Screening: Articles that passed the previous stage were read in full. Any discrepancies in selection were resolved through discussion or, if necessary, adjudicated by a third and fourth reviewer. The selection process was documented using the PRISMA flow diagram, providing a transparent account of the inclusion pathway.

Quality Assessment

The methodological quality of the articles was assessed using the JBI Critical Appraisal Checklist. The instruments were the JBI Critical Appraisal Checklist for case reports, which comprised eight questions. The JBI Critical Appraisal Checklists are instruments used to assess the methodological quality of a study and evaluate the extent to which the review addresses potential bias in the design, intervention, and analysis (Barker et al., 2023).

TABLE 1. Quality assessment for Case Report studies

Authors	**Checklist Criteria for Case Report Studies**							
	1	2	3	4	5	6	7	8
(Khantasa-ard, 2024)	Y	Y	Y	Y	Y	Y	Y	Y
(Baillie et al., 2020)	Y	Y	Y	Y	Y	Y	Y	Y
(Gonzalez-Navarro et al., 2021)	Y	Y	Y	Y	Y	Y	Y	Y
(Antonopoulos et al., 2023)	Y	Y	Y	Y	Y	Y	Y	Y
(Prasomsin et al., 2021)	Y	Y	Y	Y	Y	Y	Y	Y

Y=Yes, N=No, U=Unclear, NT=Not applicable. 1. Were patient's demographic characteristics clearly described?. 2. Was the patient's history clearly described and presented as a timeline?. 3. Was the current clinical condition of the patient on presentation clearly described?. 4. Were diagnostic tests or assessment methods and the results clearly described?. 5. Was the intervention(s) or treatment procedure(s) clearly described?. 6. Was the post-intervention clinical condition clearly described?. 7. Were adverse events (harms) or unanticipated events identified and described?. 8. Does the case report provide takeaway lessons?.

Data Extraction

Data from the selected articles were extracted using a systematic tabular format, encompassing the following components: Article identification (authors, year of publication, country), Research objectives, Study design and methodology, Population and sample characteristics, Type of suture training tool used. Main outcomes (related to improvements in competency, technical skills, or learner perceptions), Additional findings (e.g., learning motivation, self-efficacy), The extraction process was conducted independently by two researchers, with discrepancies resolved through discussion and mutual consensus.

Data Synthesis

Data synthesis was performed using a narrative synthesis and descriptive thematic approach, grouping study findings based on: Type of suture training tools used, Training methods (self-directed, face-to-face, or blended learning), Competency indicators assessed (e.g., precision, speed, confidence, skill retention), Facilitating and hindering factors, In addition, the findings were mapped against the National Nursing Competency Framework and linked to recommendations for nursing education policy. Graphs or matrices were utilized to illustrate relationships among variables and identify trends across the literature.

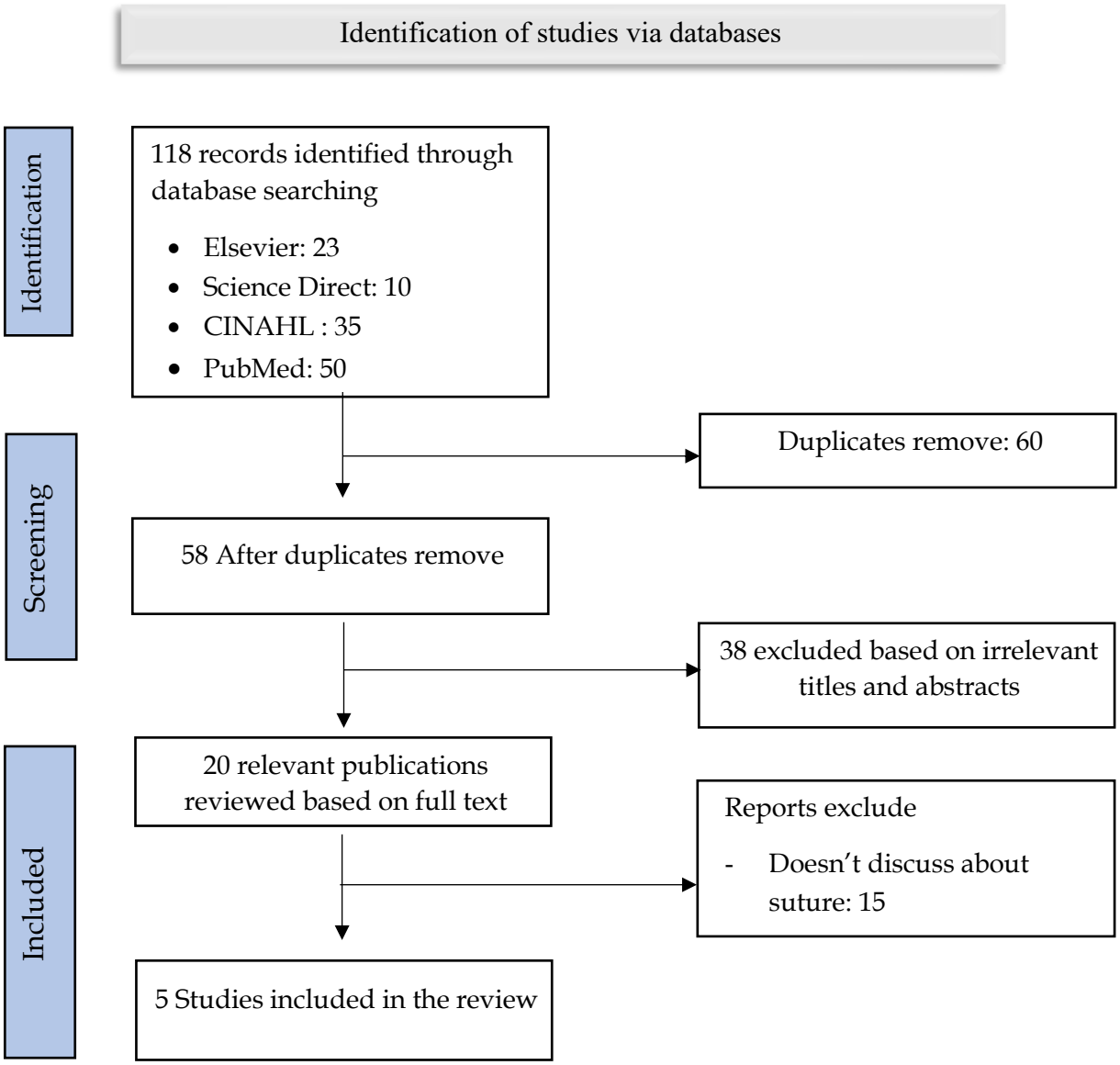

FIGURE 1. The flowchart in the article selection

TABLE 2. Suture Training

No	*Author (Year)*	*Study Aim*	*Material Suture*	*Findings*
1.	Panuwat Khantasa Ard (2024)	This study aimed to describe a new suture training model made from polyurethane leather (PUL) as a replacement for the previous simulators	Polyurethane Leather	The new suture training model of PUL is cost-effective, easy to self-assemble, and eliminates the need for complex production, making it a suitable replacement for the original models.
2.	Sarah Baillie, Rachel Christopher, Alison J. Catterall, Adam	This study aimed to determine if training on a low-cost, easy to make suturing model	Silicon skin pad, and a tea towel (with a check pattern) folded and stapled to represent an incision.	The tea towel was as effective as the silicon skin pad, but it was cheaper, simpler to make, and the materials were more readily

	Kruydenberg, Karen Lawrenson, Katharine Wonham, Peter Kilfeather, Sheena Warman (2020)	(a tea towel) would result in the same learning outcome as a higher-fidelity model (a silicon skin pad)		available. In addition, both models were used effectively with an instruction booklet illustrating the value of self-directed learning to complement taught classes.
3.	Alejandro Rafael Gonzalez-Navarro, Alejandro Quiroga-Garza, Adriana Sharai Acosta-Luna. (2021)	The objective was to determine it's fidelity impact	Pigskin, sponge, commercial pad, and orange	Eighty-two medical students participated. Suturing quality was better in pigskin and sponge, which were also the preferred models ($p < 0.001$). Significant differences in quality between the insertion and exit point, and firmness of knots ($p < 0.05$) in both simple and continuous sutures, as well as between length and distance in continuous ones ($p < 0.001$) were identified. Conclusions: Acquisition and quality of BSS are influenced by the intrinsic characteristics of SM. An adequate degree
4.	Ioannis Antonopoulos, Andrianos-Serafeim Tzortzis, Evmorfia Pechlivanidou, Theodore Troupis. (2023)	This studi aim for designed a simplified and easy-to-assembly suturing training pad for undergraduate medical students, which would be both cost effective and reusable.	Silicone sponge sheet and polyurethane foam	the vast majority of trainees have shown a positive reception toward these tools. More specifically, a total of 410 (50.59% females; mean age: 21 years; SD: 1.43) undergraduate medical students participated in those workshops. A 5-scale Likert anonymous questionnaire assessed workshop participants' opinions. Regarding the question rating the training pad described, 301 (73.41%) expressed that the pad was exceptional, as shown

				by a perfect rating of 5 out of 5 on the Likert scale, while 88 (21.46%) rated the pad as very good (4/5).
5.	Wassika Prasomsin, Radhitya Prastowo, Manunya Okhawilai, Chanchira Jubsilp, and Sarawut Rimdusit. (2021)	The aim of this research is to develop a suture pad simulating human skin for suturing practice.	Polydimethylsiloxane with silk fiber	the hardness of the composites was improved with the addition of silk fiber. It was found that polydimethylsiloxane composite reinforced with 2 phr of silk fiber with an aspect ratio of 1000 showed a hardness value similar to that of human skin. These results indicate that silk fiber reinforced polydimethylsiloxane composites can realistically simulate human skin and have the potential to be used as suture pads for medical training.

Results

Theme 1. Suture Training Material

Suturing skill training is a critical component of nursing and medical education. In this context, the selection of appropriate suture training materials greatly influences the effectiveness and efficiency of the learning process. Various types of materials have been developed and utilized to simulate human tissue, taking into account factors such as texture, durability, and anatomical resemblance.

1. Polydimethylsiloxane with Silk Fiber

   Polydimethylsiloxane (PDMS) is a type of silicone elastomer known for its biocompatibility, transparency, and flexibility. When combined with silk fibers, PDMS forms a material with enhanced tensile strength, improving durability and resistance to thread tension during suturing. This combination realistically simulates human skin characteristics (Prasomsin et al., 2021). The silk fibers contribute additional structural integrity and improve surface texture to resemble the dermis layer.

2. Silicone Sponge Sheets and Polyurethane Foam

   Silicone sponge sheets are selected for their ability to replicate the consistency of subcutaneous tissue. When combined with polyurethane foam, the resulting layered material simulates the skin's multi-layered structure. Research by (Antonopoulos et al., 2023) suggests that this combination is effective for developing fine motor skills and suturing accuracy, although the materials tend to be relatively expensive.

3. Pigskin, Sponges, Commercial Pads, and Citrus Fruits

Pigskin has long been used as a biological training material due to its structural and thickness similarity to human skin. However, ethical, religious, and availability concerns often limit its use. As alternatives, household sponges and citrus fruits are frequently employed for basic suturing practice due to their low cost and accessibility, though they lack realism in terms of durability and tactile feedback (Gonzalez-Navarro et al., 2021). Commercial pads, typically made from silicone or layered plastics, offer greater portability and durability despite their higher cost.

4. Silicone Skin Pads with Checkered Tea Towels

   A simple yet innovative method involves combining silicone skin pads with folded and clipped checkered tea towels to simulate incisions. This low-cost, improvised technique is particularly useful in low-resource settings. While less realistic than commercial pads, it provides valuable foundational training (Baillie et al., 2020).

5. Polyurethane Leather

   Polyurethane leather is a synthetic material that mimics natural leather. It possesses adequate flexibility and elasticity to simulate human skin, especially in terms of needle penetration and thread resistance. It is widely used in commercial suture training kits due to its durability and ability to withstand repeated use without significant damage (Khantasa-ard, 2024).

Theme 2. Advantages of Suture Training Tools

Suturing is a fundamental clinical skill in nursing and medical education. To optimize learning outcomes, it is essential to use high-quality and appropriate suture training tools. In addition to material considerations, the advantages of each training tool, such as anatomical realism, durability, accessibility, and cost effectiveness, play a crucial role. Various studies have examined the benefits of different types of suture training materials.

1. Anatomical and Textural Realism

   Materials such as PDMS with silk fiber, pigskin, and polyurethane leather are known for their high degree of realism in mimicking human skin. PDMS with silk fiber excels at replicating dermal resistance to needle penetration and thread tension (Prasomsin et al., 2021). Pigskin is widely regarded as the biological material most similar to human skin in terms of thickness, texture, and surgical response (Gonzalez-Navarro et al., 2021). Polyurethane leather allows for repeated suturing with realistic tactile feedback.

2. Durability and Reusability

   Materials such as silicone pads, polyurethane leather, and polyurethane foam offer durability and the capacity for repeated use. According to (Antonopoulos et al., 2023), polyurethane leather can endure multiple training sessions without significant damage, making it a cost-effective option for educational institutions. Similarly, factory-made silicone pads retain incision shapes and suture holes even after repeated use.

3. Availability and Accessibility

   Household materials such as sponges, citrus fruits, and tea towels are advantageous in terms of accessibility, affordability, and ease of procurement. These materials are especially useful in settings with limited resources. (Gonzalez-Navarro et al., 2021) highlighted that using simple items such as folded and clipped

tea towels to simulate incisions provides a creative and educational solution for beginner-level learners, albeit with limited realism.

4. Cost-Effectiveness and Innovation

   An additional advantage of suture training tools is the ability to combine different material layers to simulate realistic conditions at a lower cost. For instance, combining silicone sponge sheets with polyurethane foam creates a multi-layered structure that represents epidermal to subcutaneous tissue without the high cost of biological materials like animal skin (Antonopoulos et al., 2023). This enables more comprehensive training, including wound creation and closure.

5. Portability and Hygiene

   Commercial or synthetic suture training tools such as silicone skin pads and polyurethane leather are notable for their portability and ease of cleaning. These tools are easy to store, transport, and sanitize, and they pose no biological contamination risk or odor, unlike natural materials such as pigskin. This is essential for maintaining hygiene and comfort in educational environments.

Theme 3. Limitations of Suture Training Tools

Despite the numerous advantages of suture training tools, several limitations persist and warrant careful consideration in health education. These limitations may relate to realism, cost, accessibility, safety, and long-term effectiveness. Understanding these shortcomings is essential for designing optimal and context-appropriate training models, especially in resource-limited educational institutions.

1. Lack of Functional Realism in Synthetic Materials

   Synthetic materials such as silicone sponge sheets, polyurethane foam, and silicone skin pads often fail to simulate the physiological responses of human tissue, such as bleeding, tissue resistance during needle penetration, or the consistency of subcutaneous layers. According to (Chao et al., 2022), while these materials are durable and reusable, they may not be sufficiently challenging for advanced learners who require realistic simulation scenarios. This may lead to inaccurate perceptions of clinical procedures.

2. Ethical and Hygiene Concerns in Biological Materials

   Although pigskin offers high anatomical realism, it presents ethical, religious, and hygiene challenges. In countries with predominantly Muslim populations, the use of pigskin is generally unacceptable. Additionally, pigskin is perishable, emits odor, and poses a risk of microbial contamination, limiting its use to short durations (Gonzalez-Navarro et al., 2021).

3. Physical and Functional Limitations of Improvised Materials

   Training models using citrus fruits, household sponges, or tea towels, while accessible and inexpensive, are functionally limited and anatomically inaccurate. (Gonzalez-Navarro et al., 2021) reported that such materials are unsuitable for practicing advanced suturing techniques such as subcutaneous stitching or complex knot tying, and they fail to provide tactile feedback similar to human tissue.

4. High Cost and Limited Access to Commercial Pads

   Commercial suture training tools made from materials like PDMS with silk fibers or multi-layered synthetic pads are often costly, restricting access in institutions with limited budgets (Prasomsin et al., 2021). Moreover, some models

are compatible only with specific suture threads or needles, increasing operational costs.

5. Limited Anatomical Variation and Wound Simulation

   Most suture training tools whether synthetic or improvised do not offer varied wound conditions, such as lacerations, deep tissue injuries, or contaminated wounds. Polyurethane leather and silicone pads generally present only straight and superficial incisions, limiting learners' exposure to complex clinical scenarios (Khantasa-ard, 2024). This may reduce preparedness for real-world cases.

Discussion

Should emphasize the new and important aspects of the study without repeating issues already presented in the Results section. It should review the study findings in light of the published literature with the format of arguments and counterarguments. The limitations and strengths of the study and the implications of the findings for future research or clinical practice should be explored (Byrne et al., 2019; Khan et al., 2003).

In the field of nursing and medical education, mastery of fundamental clinical skills such as wound suturing is essential. This skill not only requires theoretical understanding but also intensive and repetitive hands-on practice. Therefore, the selection of appropriate training tools is a crucial factor that determines the success of learning outcomes. A literature review reveals that a wide range of materials has been utilized to develop suture training tools, including synthetic substances such as polydimethylsiloxane (PDMS) with silk fibers, silicone sheets, sponges, polyurethane foam, as well as biological materials like pigskin, and even improvisational items such as citrus fruits and tea towels.

Each type of training model presents its own advantages and limitations. Commercial silicone pads and polyurethane leather, for example, provide a relatively realistic training experience. Students can simulate the sensation of needle insertion and thread tension akin to suturing human skin, which is vital for developing muscle memory and precise hand skills. Synthetic tools are generally durable and reusable without significant deterioration, making them a cost-effective investment for educational institutions (Chao et al., 2022; Prasomsin et al., 2021; Regula & Yag-Howard, 2015).

Despite their strengths in durability and hygiene, not all training tools can fully replicate real-life clinical scenarios. Many commercially manufactured devices still fall short in mimicking the complexity of living tissue, such as varying wound depths, tissue consistency, or the dynamic response to excessive thread tension. Consequently, students who have completed laboratory-based training often still experience hesitation or lack of confidence when performing suturing on actual patients. In this regard, biological materials such as pigskin are considered more representative in terms of texture and tissue resistance. Nonetheless, their use poses challenges, including hygiene concerns, limited shelf-life, and ethical or religious considerations particularly in predominantly Muslim populations (Alves de Oliveira et al., 2024; Baillie et al., 2020; Szabelski & Karpiński, 2024; Szarmach et al., 2017).

Improvised tools such as citrus fruits and household sponges can serve as practical solutions for initial exposure to suturing techniques. Due to their low cost and easy accessibility, they are suitable for introductory sessions or self-directed practice at home. However, these materials are inadequate substitutes for more

realistic tools when it comes to advanced training. Students trained solely with simple materials are likely to struggle with complex wounds or denser tissue structures in clinical settings (Gonzalez-Navarro et al., 2021; Gusman, 2012; Hilton & Monaghan, 2018; Kang et al., 2019)

Another prominent issue involves cost and availability. Commercial multi-layered training pads with realistic textures are often priced beyond the reach of institutions in resource-limited areas. This underscores the need for creative and collaborative approaches among educators, medical device developers, and policymakers to ensure the availability of effective yet affordable training tools.

Findings from this literature review suggest that no single suture training model is entirely ideal. Some models excel in realism but are limited by cost and accessibility, while others are economically viable yet lack the depth of clinical simulation. Therefore, the development of training tools should adopt a combinative approach integrating the advantages of various materials while compensating for their weaknesses. Moreover, training tools should be tailored to the learner's stage of education: simple models for beginners and more realistic simulators for advanced training. In practice, such a stratified and integrated approach appears to be the most feasible and pedagogically sound.

Conclusion

Based on the review of five relevant scientific articles, it can be concluded that suturing practice tools have been developed using a wide range of materials, including synthetic components such as polydimethylsiloxane (PDMS), silicone, and polyurethane; biological materials such as pigskin; as well as improvised items such as oranges and tea towels. Each material presents its own distinct advantages and limitations. Synthetic materials generally offer durability and hygiene benefits but often lack anatomical realism. In contrast, biological materials provide a more life-like tactile experience yet raise concerns regarding ethics, hygiene, and availability. Improvised materials are accessible and low-cost, making them suitable for beginners, but they fall short in replicating realistic clinical conditions.

This literature review reveals that no single material or model can be considered universally ideal for suturing practice. Therefore, a contextual and integrative approach is essential when selecting or designing suture training tools—taking into account educational objectives, learner competency levels, available resources, as well as cultural and ethical considerations. The findings from this review contribute to the ongoing global discourse on the development of more effective, affordable, and context-sensitive medical simulation tools, particularly for use in resource-limited educational settings.

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