CANADIAN MEDICAL EDUCATION JOURNAL | REVUE CANADIENNE DE L'ÉDUCATION MÉDICALE

2026, In Press: https://doi.org/10.36834/c64gsy46

ORIGINAL RESEARCH

From advocacy to integration: a systems-based roadmap for sustainable simulation-based medical education in resource-constrained settings

Nkechi Oluwakemi Dike[1,2]

*Author information is provided in the back matter of this manuscript

Abstract

Medical education in many low- and middle-income countries (LMICs), including Ghana, remains heavily dependent on didactic instruction and opportunistic patient exposure. While this model has historically produced capable clinicians, the increasing complexity, acuity, and risk profile of modern healthcare demand a shift toward demonstrable, performance-based competence. Growing evidence documents significant rates of preventable adverse events in LMIC health systems, underscoring the urgency of producing graduates with verified, performance-based competency. Simulation-Based Medical Education (SBME) provides a structured, safe, and repeatable environment for deliberate practice, yet its integration across LMIC training systems remains limited, with uptake constrained by pedagogical capacity deficits, infrastructure misconceptions, and policy inertia.

This paper argues that SBME is not merely an educational enhancement, but a systems-level reform required to bridge the persistent 'knowing-doing' gap in clinical training. Using Ghana as a representative LMIC context, I analyze systemic barriers to adoption - including deficits in simulation pedagogy expertise, misconceptions regarding infrastructure cost, and cultural skepticism toward simulation's legitimacy – and propose an integrated, multi-layered model for national SBME adoption. This model comprises three interdependent system layers – Human Capital Development, Context-Adaptive Infrastructure, and Curriculum & Policy Integration – each of which corresponds directly to the stages of a five-step strategic roadmap running from conceptual advocacy through to quality assurance and policy mandate.

This system's roadmap demonstrates how countries with constrained resources can adopt scalable, pedagogically sound SBME models that improve learner competence, strengthen health system resilience, and ultimately enhance patient safety.

De la promotion à l'intégration : une feuille de route systémique pour une formation médicale durable fondée sur la simulation dans les contextes aux ressources limitées

Résumé

Dans de nombreux pays à revenu faible ou intermédiaire (PRFI), dont le Ghana, la formation médicale reste fortement tributaire de l'enseignement magistral et d'une exposition ponctuelle aux patients. Si ce modèle a historiquement permis de former des cliniciens compétents, la complexité, la gravité et le profil de risque croissants des soins de santé modernes exigent une évolution vers des compétences vérifiables et fondées sur la performance. De plus en plus de données attestent de taux significatifs d'événements indésirables évitables dans les systèmes de santé des PRS, soulignant l'urgence de former des diplômés dotés de compétences vérifiées et fondées sur la performance. La formation médicale par simulation (SBME) offre un environnement structuré, sûr et reproductible propice à la pratique ciblée ; pourtant, son intégration dans les systèmes de formation des PRS reste limitée, son adoption étant freinée par des déficits de capacités pédagogiques, des idées fausses concernant les infrastructures et l'inertie politique.

Cet article soutient que la SBME n'est pas simplement une amélioration pédagogique, mais une réforme systémique nécessaire pour combler le fossé persistant entre « savoir » et « faire » dans la formation clinique. En prenant le Ghana comme exemple représentatif d'un pays à revenu faible ou intermédiaire, j'analyse les obstacles systémiques à son adoption – notamment le manque d'expertise en pédagogie de la simulation, les idées fausses concernant le coût des infrastructures et le scepticisme culturel quant à la légitimité de la simulation – et je propose un modèle intégré à plusieurs niveaux pour l'adoption nationale de la SBME. Ce modèle comprend trois niveaux systémiques interdépendants – le développement du capital humain, les infrastructures adaptables au contexte, et l'intégration des programmes d'études et des politiques –, dont chacun correspond directement aux étapes d'une feuille de route stratégique en cinq étapes, allant de la promotion conceptuelle à l'assurance qualité et à l'adoption d'une politique officielle.

Introduction

The foundation of medical education in Ghana and many comparable settings has traditionally relied on lectures, case-based learning, and apprenticeship-style clinical rotations.[1,2] While this approach has produced generations of physicians, it is increasingly misaligned with the demands of contemporary healthcare systems that emphasize patient safety, accountability, and systems-based practice.[3,4] Clinical environments now require immediate procedural competence, high-stakes decision-making, effective inter-professional coordination, and the ability to perform under stress; competencies that are central to modern healthcare delivery.[5,6] Technology-enhanced simulation has become a cornerstone of health professions education, demonstrating significant improvements in knowledge retention, skill acquisition, and overall learner outcomes.[7] Simulation-Based Medical Education (SBME) provides a controlled environment in which high-risk clinical skills can be safely practiced, enhancing clinical performance, technical abilities, teamwork, and decision-making.[8]

Yet learners often struggle to translate theoretical knowledge into verified competence in real clinical settings, illustrating the ongoing challenge of achieving clinical proficiency.[9] This 'knowing-doing' gap is particularly evident in resource-constrained health systems, where supervision ratios, clinical case mixes, and training consistency vary widely.[10] Experiential learning through structured simulation and deliberate practice helps bridge this gap by transforming theory into practice and reinforcing skill development through feedback and repetition.[11] While traditional, opportunistic patient-dependent clinical exposure is inherently variable and inconsistent, simulation-based approaches have been demonstrated to be cost-effective and to produce measurable gains in clinical competence.[12,13] SBME should therefore be understood not as a technological add-on, but as a core mechanism for safeguarding competence and patient safety in modern medical education.

Crucially, the urgency of this reform is not merely educational, it is ethical. Preventable harm attributable to inadequate clinical preparation represents a patient safety crisis in LMIC settings. A landmark global analysis estimated that over 134 million adverse events occur annually in hospitals in low- and middle-income countries, contributing to 2.6 million deaths.[4] Training systems that cannot guarantee consistent, verified competence bear shared responsibility for this burden. SBME addresses this directly: by enabling safe rehearsal of high-risk, high-stakes scenarios before trainees encounter them in clinical practice, it creates a critical buffer between knowledge acquisition and patient contact. The central argument of this paper is therefore not that SBME is without limitations, but that it represents a systems-level necessity for responsible, accountable medical education in resource-constrained settings.

This paper, therefore, first situates SBME within the Competency-Based Medical Education (CBME) paradigm and clarifies the distinction between simulation as pedagogy and simulation as technology. It then describes the Ghanaian context as a representative LMIC case, and analyzes three interrelated systemic barriers to adoption. Drawing on these foundations, I present a three-layer integrated systems model and a five-stage strategic roadmap for sustainable national integration – frameworks that are designed to be read together, with the roadmap stages mapping directly onto the system layers. The paper concludes with implications for patient safety, workforce competence, and future research priorities.

Simulation as the engine of competency-based medical education

Global trends in health professions education increasingly emphasize Competency-Based Medical Education (CBME), which prioritizes observable performance over time-based exposure. SBME aligns directly with this paradigm by enabling deliberate practice, that is, repetitive, feedback-rich training focused on skill refinement.[14] Effective simulation engages all three learning domains - cognitive (clinical reasoning), psychomotor (procedural skills), and affective (communication, teamwork, professionalism). By engaging these domains simultaneously, simulation provides a holistic and integrated environment for skill acquisition.[15]

A distinction that carries significant practical implications is that between simulation as a pedagogical strategy and simulation as technology. The former refers to structured, scenario-based learning approaches underpinned by principles of deliberate practice, feedback, and reflection. The latter refers to the physical tools–manikins, task trainers, virtual reality platforms–that may or may not be employed. This distinction is fundamental; learning effectiveness in SBME depends far less on technological sophistication than on instructional design and the quality of structured debriefing, in which guided reflection consolidates learning and drives behavior change.[16,17] Recognizing simulation primarily as pedagogy, not technology, is the conceptual key that unlocks its applicability in resource-constrained settings, and directly challenges the common misconception that meaningful simulation requires expensive infrastructure. This reframing is foundational to both the barriers analysis and the systems model that follow.

Simulation modalities are diverse, ranging from low-cost task trainers for basic procedural skills to standardized patients (SPs) for communication and interpersonal skill development.[18] Crucially, the most significant learning occurs not during the scenario itself, but during the immediate, structured debriefing session that follows, where trained facilitators guide learners through reflective analysis and corrective feedback.[19] This evidence base positions simulation as a robust and highly adaptable educational tool regardless of fidelity level–fundamentally a pedagogical technique that is adaptable to a wide range of resource contexts.

The Ghanaian context as a representative LMIC case

In Ghana, as in many LMICs, clinical training remains heavily dependent on patient census and case variability. Learners may graduate without consistent exposure to rare but critical events such as severe trauma, obstetric emergencies, or pediatric resuscitation. This variability raises both educational and ethical concerns regarding the use of patients as primary training platforms.[20,21] Current SBME integration is limited, often confined to basic life support or isolated skills stations. Barriers reported across similar settings include limited faculty training, financial concerns, and skepticism regarding simulation's authenticity.[22–25] The COVID-19 pandemic further exposed the fragility of patient-dependent training systems, underscoring the need for resilient, non-patient-dependent educational modalities.[22]

It is important to acknowledge that Ghana's experience, while representative, is not universal. LMICs vary considerably in governance structures, educational system architecture, funding mechanisms, and professional regulatory frameworks. Sub-Saharan African contexts such as Uganda and Nigeria face distinct faculty pipeline challenges compared to South Asian settings such as Pakistan, where simulation uptake has been accelerated by established postgraduate training cultures.[20,28] The model proposed in this paper is therefore intended as a flexible framework, not a prescriptive formula; one that each country should adapt to its own contextual realities in terms of implementation sequence, infrastructure choices, and policy levers.

Simulation-based medical education as a patient safety strategy

Before examining barriers and solutions, it is important to ground the case for SBME integration in its patient safety rationale, that is, the moral and systemic argument that must precede and anchor all advocacy efforts. Training systems that rely exclusively on opportunistic patient contact cannot reliably guarantee competent, safe graduates, and the consequences of this gap are measurable.

Simulation-based training has demonstrated measurable gains in learner performance across a range of outcomes relevant to patient safety. Studies across LMIC contexts have documented improvements in clinical knowledge, procedural skills, team communication, and crisis resource management following structured SBME interventions.[31,32,33] Robinson et al. conducted a systematic review of SBME programs in LMICs and found consistent improvements in provider knowledge and skills, with several studies demonstrating transfer of competencies to clinical settings.[24] Similarly, Chou et al. found that simulation training for obstetric emergencies in low- and lower-middle-income countries produced significant improvements in clinical performance and team coordination.[34]

I acknowledge that the direct evidence linking SBME to improved patient outcomes as distinct from improved learner performance, remains limited, particularly in LMIC settings. As Del Castillo Miranda et al. note in their narrative review of pediatric emergency simulation, future research must include longitudinal studies assessing long-term effects on clinical performance and patient outcomes, and must develop standardized evaluation metrics to enable comprehensive program assessment.[31] This gap in the literature does not diminish the patient safety argument for SBME; rather, it underscores the importance of building evaluation capacity alongside implementation capacity. The argument for SBME integration rests on a combination of strong learner outcomes evidence, established ethical principles of harm prevention, and the logical inference that consistent competency-based training reduces preventable clinical errors.

Systemic barriers to SBME adoption

Analysis across LMIC contexts reveals three interrelated systemic gaps that any integration strategy must explicitly address.[20,21,24,25] The three systemic gaps described in this section are not the findings of a single study, but were identified through a synthesis of peer-reviewed literature on SBME implementation in LMIC and low-resource settings. Drawing on systematic and scoping reviews as well as qualitative studies from sub-Saharan Africa, South Asia, and comparable contexts, I identified the gaps that most consistently prevent SBME from taking root, and organized them into a framework that points toward solutions.

A. **The pedagogical capacity gap -** refers to the shortage of faculty trained in simulation pedagogy, scenario design, crisis resource management, and structured debriefing. Without this human capital, even well-resourced simulation centers fail to produce meaningful learning. This is not a theoretical concern, a scoping review by Ismail et al. across developing-world healthcare education systems identified faculty training deficits as the single most consistently cited barrier to sustainable SBME implementation.[20] Seethamraju et al. found that even after formal faculty training workshops in a low-resource setting in South Asia, contextual and institutional barriers significantly attenuated implementation rates, highlighting that capacity-building must be ongoing rather than episodic.[25]

B. **The infrastructure perception gap -** reflects the widespread misconception that simulation is synonymous with high-fidelity, high-cost simulation centers; a false binary between 'full simulation' and 'none' that prevents institutions from recognizing and deploying effective, low-cost alternatives. Evidence consistently demonstrates that task trainers, standardized patients, and in-situ simulation using existing clinical environments can produce significant educational benefit at a fraction of the cost of high-fidelity centres.[12,13,27] Maboh et al., studying nurse educators in Cameroon, found that once faculty understood simulation as a pedagogical approach rather than a technology investment, willingness to engage increased substantially.[27]

C. **The cultural legitimacy gap -** describes the skepticism of some educators toward simulation as an 'artificial substitute' for real patient care, rather than a preparatory and patient safety-enhancing step. This skepticism has been documented across sub-Saharan Africa, South Asia, and other LMIC regions.[20,21,32] Najjuma et al., in a qualitative study from Uganda, found that institutional culture and senior clinician attitudes were critical determinants of whether newly trained simulation educators were empowered to implement programs.[32] Addressing this gap therefore requires not only faculty training but explicit, evidence-based advocacy targeted at departmental and institutional leadership.

Taken together, these three gaps in pedagogical capacity, infrastructure perception, and cultural legitimacy, define the three domains of the systems model that follows. Each barrier names a problem; each corresponding system layer names its solution.

An Integrated systems model for SBME adoption

Sustainable SBME integration requires coordinated action across three interdependent system layers, each of which reinforces and enables the others.[26–29] The three system layers presented here correspond directly to the three barriers identified in the preceding section: Layer 1 (Human Capital Development) addresses the Pedagogical Capacity Gap; Layer 2 (Context-Adaptive Infrastructure) addresses the Infrastructure Perception Gap; and Layer 3 (Curriculum and Policy Integration) addresses the Cultural Legitimacy Gap. Rather than a rigid sequence, these layers constitute a systems architecture: progress in each layer creates enabling conditions for the others, while stagnation in one constrains progress across the system. This architecture is distinct from – but directly related to – the five-stage roadmap that follows: if the layers describe what must be built to achieve sustainable SBME integration, the roadmap describes how and in what order to build it. (Figure 1)

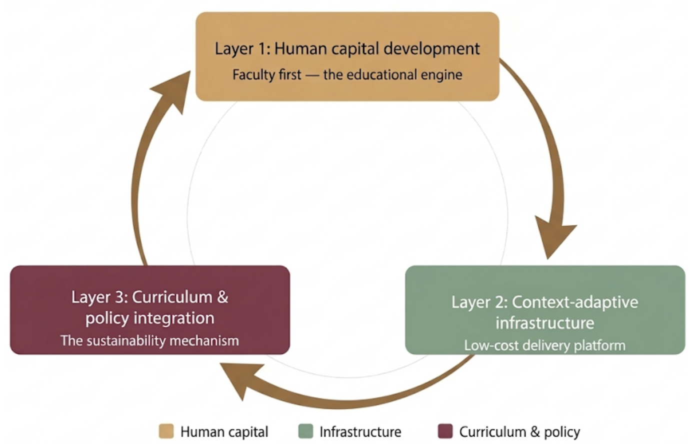

Figure 1. A three-layer integrated systems model for SBME adoption

Layer 1: Human capital development (The educational engine)

The most critical investment is in simulation educators, not equipment. Faculty must be trained in scenario design aligned with learning objectives, facilitation of team-based learning, structured debriefing, human factors, and crisis resource management. Train-the-trainer cascades can rapidly expand local expertise, enabling contextualized content that addresses national priority areas such as trauma, maternal health, and emergency care.[19,26,27] This layer must be established first; neither infrastructure investment nor curriculum reform produces meaningful learning without competent faculty.

Layer 2: Context-adaptive infrastructure (The delivery platform)

Resource realities necessitate adaptive scaling, prioritizing low-cost task trainers for procedural skills, standardized patients for communication training, and in-situ simulation using existing clinical environments. In-situ simulation additionally functions as a systems testing and quality improvement tool by revealing latent safety threats.[10,25] This layer is enabled by, and in turn strengthens, human capital. Trained faculty are the ones who can creatively deploy low-cost infrastructure effectively, and successful low-cost programs generate the evidence base that challenges infrastructure misconceptions at the policy level.

Layer 3: Curriculum & policy integration (The sustainability mechanism)

For SBME to move from optional to essential, integration must occur at the policy level, that is, embedding simulation across the curriculum continuum, recognizing SBME in accreditation standards, and establishing quality assurance mechanisms. Policy endorsement ensures sustained resource allocation and standardization across institutions.[3,4] This layer represents the culmination of the other two, and without demonstrated human capacity and program effectiveness, policy advocacy lacks its strongest arguments.

The dynamic interplay across these layers is critical to understanding why the proposed model is a reinforcing cycle rather than a linear pipeline. Human capital development builds the credibility and demonstrable outcomes needed to make the policy case; infrastructure adaptation generates cost-effectiveness evidence that dismantles the perception barrier and informs policy decisions; and policy integration secures the institutional resources and regulatory mandate needed to sustain and expand Layers 1 and 2. Each layer both depends on and strengthens the others over time.

A strategic roadmap to integration and implementation

The three-layer model describes the architecture of a sustainable SBME system; the five-stage roadmap described here provides the practical implementation sequence through which that architecture is constructed. The stages are ordered to reflect a fundamental principle that human capacity must precede technology investment, and educational reform must be institutionalized before it can be sustained. Drawing on implementation science principles that emphasize staged, stakeholder-engaged change processes,[30] the roadmap is presented as an evidence-based recommended sequence, while acknowledging that real-world implementation benefits from flexibility and contextual adaptation. The roadmap is illustrated in Figure 2.

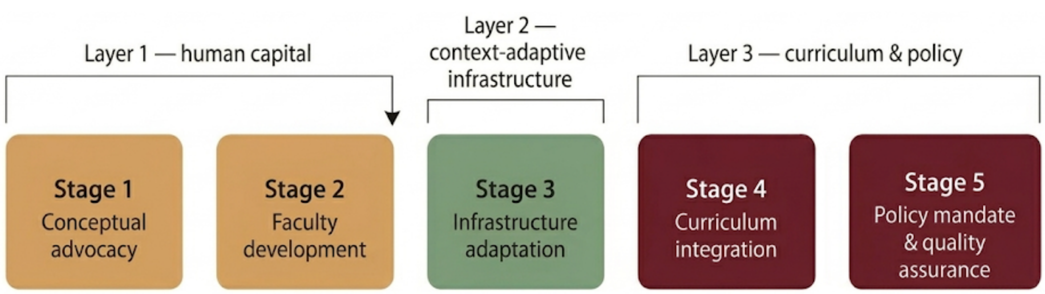

Figure 2. Five-stage Strategic Roadmap for SBME Integration
Legend: *Colors correspond directly to the three layers in Figure 1. Stages are sequential but implementation should be adapted to local context. SBME = simulation-based medical education.*

Stage 1: Conceptual advocacy

The process which activates Layer 1 – Human Capital, begins with establishing awareness and securing buy-in among key stakeholders – policymakers, institutional heads, professional bodies, and senior clinical faculty – regarding the clinical and ethical necessity of SBME. Advocacy must be grounded in evidence and patient safety arguments, not merely enthusiasm. This stage answers the central question: why should we invest in simulation? It is a necessary precondition for resource allocation and must precede implementation.

In Ghana, for example, a national simulation advocacy effort could begin with the Ghana College of Physicians and Surgeons and the Medical and Dental Council, presenting data on competency gaps, international accreditation trends, and the cost-effectiveness of low-technology approaches. Faculty champions who have undergone SBME training can serve as credible voices within their own institutions, translating global evidence into locally resonant narratives. This stage directly targets the Cultural Legitimacy Gap identified above.

Stage 2: Faculty development

Building on the awareness generated in Stage 1, the priority at this stage is the establishment of a central body, a unit, or a team – ideally within a national medical education authority or a leading health sciences university–dedicated to developing simulation training curricula and identifying simulation champions. Through train-the-trainer initiatives, expertise in simulation pedagogy can be rapidly disseminated. This body should eventually evolve into a certifying authority, setting national standards for simulation educator competence.[19,26] The Clinical Skills Laboratory at the University of Cape Coast provides one model of how an institutional simulation unit can anchor regional capacity-building. This stage directly addresses the Pedagogical Capacity Gap.

Stage 3: Infrastructure adaptation

With faculty capacity established, the system can now deploy infrastructure effectively. Rather than waiting for large capital investments, integration should prioritize low-cost, high-impact solutions, such as widespread task trainer deployment for procedural skills, standardized patient programs, and in-situ simulation using existing hospital spaces and equipment. A practical starting point is the establishment of skills stations within existing clinical teaching spaces, equipped with task trainers costing a fraction of a high-fidelity manikin, and staffed by locally trained faculty. In-situ simulation, for example, running monthly emergency scenario drills within a labor ward using existing staff and equipment, simultaneously trains personnel and stress-tests local systems.[10,12] This stage directly dismantles the Infrastructure Perception Gap.

Stage 4: Curriculum integration

SBME cannot be treated as an isolated elective; it should be formally embedded into the core curriculum across the entire training continuum, from preclinical years to postgraduate residency. This requires alignment with CBME frameworks, mapping simulation activities to graduation competencies, and ensuring formal assessment of simulation-based performance. At this stage, SBME transitions from an innovative addition to a curricular expectation, and the documented outcomes of formal curricular embedding begin to build the evidence base for the final stage.

Stage 5: Policy mandate and quality assurance.

Accreditation bodies should, at this stage, consider formally recognizing and mandating SBME as an assessed component of clinical competency training. This commitment, supported by locally generated research evidence, secures long-term sustainability and enables national standardization of clinical performance expectations. I recommend that national medical education regulatory bodies introduce SBME accreditation standards in phases, beginning with minimum standards for faculty training and curriculum integration, before expanding to infrastructure and assessment requirements.[3,26] This stage completes the transition from advocacy to integration, and from innovation to institution.

The correspondence between roadmap stages and system layers is thus as follows: Stages 1and 2 build Layer 1 (Human Capital); Stage 3 builds Layer 2 (Infrastructure); and Stages 4 and 5 build Layer 3

(Curriculum & Policy). The stages are sequenced precisely in that order because human capital must exist before infrastructure can be effectively deployed, and both must be in place before curriculum and policy integration can be successfully argued for and sustained.[30]

Implications and future research priorities

The model and roadmap proposed in this paper carry several implications for institutional practice, national policy, and research. Institutions operating in resource-constrained settings should recognize that the absence of high-fidelity simulation equipment does not preclude effective SBME implementation. The priority investment is in faculty training, not hardware. National medical education authorities should consider incorporating minimum SBME standards into accreditation frameworks, beginning with the phased approach described in Stage 5.

Several frameworks for SBME implementation in resource-constrained settings have been proposed in the literature. Salifu et al. developed a simulation-based clinical nursing education framework for low-resource settings, emphasizing contextual adaptation of educational design.[10] Robinson et al.'s systematic review identified consistent enablers and barriers across LMIC implementation studies, highlighting faculty training and institutional support as critical determinants of success.[24] Ismail et al.'s scoping review similarly foregrounded human resource capacity as the primary bottleneck in developing-world simulation uptake.[20] The framework proposed in this paper builds on and extends these contributions in three ways.

First, it integrates barriers and solutions into a single coherent model, rather than treating them as separate analytical steps. Second, it provides an explicitly sequenced implementation roadmap grounded in implementation science principles, that translates the systems model into actionable stages. Third, it situates the framework within the specific policy and accreditation architecture of Sub-Saharan African LMICs, using Ghana as an illustrative case while acknowledging contextual heterogeneity. In doing so, it responds to Robinson et al.'s call for implementation frameworks that are both theoretically grounded and contextually actionable.

For policymakers, linking simulation-based training to measurable, system-level outcomes, strengthens the investment case. Evidence across LMIC contexts documents improvements in team communication, leadership, procedural accuracy, and crisis management following structured SBME programs.[24,31,33] These gains represent the upstream determinants of reduced medical errors, improved emergency response, and enhanced patient safety. Policy documents and funding proposals that articulate this chain of logic explicitly, connecting simulation investment to healthcare system performance goals, are more likely to secure sustained institutional and national commitment.

Several research priorities emerge from this analysis. First, longitudinal studies evaluating the sustained impact of SBME integration on clinical performance and patient outcomes in LMIC settings are urgently needed, moving beyond immediate post-training assessments to multi-year follow-up. Second, scalable models for faculty development, including distance-based and peer-training approaches, require rigorous evaluation. Third, studies examining the specific contextual factors (governance, institutional culture, accreditation structures) that predict successful policy integration will strengthen the transferability of implementation frameworks across diverse LMIC contexts. Finally, cost-effectiveness analyses accounting for the full spectrum of SBME modalities, including low-technology approaches, are needed to inform resource allocation decisions.

Conclusion

In resource-constrained settings, SBME represents a systems reform strategy rather than an educational add-on, and it can be successfully embedded across the entire spectrum of medical education. The three-layer model and five-stage roadmap presented in this paper are designed to be read as a unified framework where the layers describe what must be built, and the stages describe how and in what order to build it. By investing first in simulation faculty and champions, then adopting adaptive and low-cost infrastructure, then formally embedding SBME within curricula and securing policy and accreditation integration, countries such as Ghana can create resilient training systems that produce clinically competent, confident, and safety-oriented healthcare professionals.

Simulation provides the essential bridge from knowledge to performance, ensuring that future graduates are prepared for the complex realities of modern clinical practice. Future research evaluating the long-term impact of SBME integration in LMICs will be essential in refining this framework. The tools, the evidence, and the roadmap are now available. The only remaining question is whether the systems responsible for training the next generation of clinicians will choose to use them.

Author information:

1- Clinical Skills Laboratory Unit, School of Medical Sciences, University of Cape Coast

2- Department of Medical Education & I.T., School of Medical Sciences, University of Cape Coast

Correspondence to:

Nkechi Oluwakemi Dike

email: n.o.dike@uccsms.edu.gh

Published ahead of issue:

Jul 27, 2026

Conflict of Interest:

The author declares no conflicts of interest.

Funding:

None.

References

1. Mullan F, Frehywot S, Omaswa F, et al. Medical schools in sub-Saharan Africa. *Lancet*. 2011;377(9771):1113–1121. https://doi.org/10.1016/S0140-6736(10)61961-7
2. Ofori-Adjei D. Changing landscape of public health and medical education curriculum. *Ghana Med J.* 2018;52(3):115. https://doi.org/10.4314/gmj.v52i3.1

3. Gonzalo JD, Dekhtyar M, Starr SR, et al. Health systems science curricula in undergraduate medical education: identifying and defining a potential curricular framework. *Acad Med.* 2017;92(1):123–131. https://doi.org/10.1097/ACM.0000000000001177
4. Frenk J, Chen L, Bhutta ZA, et al. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *Lancet*. 2010;376(9756):1923–1958. https://doi.org/10.1016/S0140-6736(10)61854-5
5. Rosen MA, DiazGranados D, Dietz AS, et al. Teamwork in healthcare: key discoveries enabling safer, high-quality care. *Am Psychol.* 2018;73(4):433–450. https://doi.org/10.1037/amp0000298
6. Gaba DM. The future vision of simulation in health care. *Qual Saf Health Care.* 2004;13(Suppl 1):i2–i10. https://doi.org/10.1136/qshc.2004.009878
7. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education. *JAMA*. 2011;306(9):978–988. https://doi.org/10.1001/jama.2011.1234
8. McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. *Acad Med.* 2011;86(6):706–711. https://doi.org/10.1097/ACM.0b013e318217e119
9. Ferris HA, O'Flynn D. Assessment in medical education: what are we trying to achieve? *Int J High Educ.* 2015;4(2):139–148. https://doi.org/10.5430/ijhe.v4n2p139
10. Salifu DA, Heymans Y, Christmals CD. A simulation-based clinical nursing education framework for a low-resource setting: a multimethod study. *Healthcare* (Basel). 2022;10(9):1639. https://doi.org/10.3390/healthcare10091639
11. Yardley S, Teunissen PW, Dornan T. Experiential learning: transforming theory into practice. Med Teach. 2012;34(2):161–164. https://doi.org/10.3109/0142159X.2012.643264
12. Zendejas B, Wang AT, Brydges R, Hamstra SJ, Cook DA. Cost: the missing outcome in simulation-based medical education research: a systematic review. *Surgery*. 2013;153(2):160–176. https://doi.org/10.1016/j.surg.2012.06.025
13. Roussin C, Sawyer T, Weinstock P. Assessing competency using simulation: the SIMZONES approach. *BMJ Simul Technol Enhanc Learn.* 2019;6(5):262–267. https://doi.org/10.1136/bmjstel-2019-000480
14. KJ DP, K R, DGSR KM, Reddy YN, SRA. Impact of simulation-based learning on knowledge and skills among medical students undergoing competency-based medical education. *Cureus*. 2025. https://doi.org/10.7759/cureus.88749
15. Holeman I, Kane D. Human-centered design for global health equity. *Inf Technol Dev.* 2020;26(3):477–505. https://doi.org/10.1080/02681102.2019.1667289
16. Rudolph JW, Simon R, Raemer DB, Eppich WJ. Debriefing as formative assessment: closing performance gaps in medical education*. Acad Emerg Med.* 2008;15(11):1010–1016. https://doi.org/10.1111/j.1553-2712.2008.00248.x
17. Fanning RM, Gaba DM. The role of debriefing in simulation-based learning. *Simul Healthc.* 2007;2(2):115–125. https://doi.org/10.1097/SIH.0b013e3180315539
18. Weller JM, Nestel D, Marshall SD, Brooks PM, Conn JJ. Simulation in clinical teaching and learning. *Med J Aust.* 2012;196(9):594. https://doi.org/10.5694/mja10.11474
19. Soni L, Ramachandran R, Rewari V. Faculty development programmes in simulation-based teaching: an exploration of current practices. *Indian J Anaesth*. 2024;68(1):78–86. https://doi.org/10.4103/ija.ija_1248_23
20. Ismail FW, Ajani K, Baqir SM, et al. Challenges and opportunities in the uptake of simulation in healthcare education in the developing world: a scoping review. *MedEdPublish.* 2024;14:38. https://doi.org/10.12688/mep.20271.1
21. Alayande BT, Forbes C, Masimbi O, et al. The implementation of simulation-based learning for training undergraduate medical students in essential surgical care across Sub-Saharan Africa: a scoping review. *Med Sci Educ.* 2023;34(1):237–256. https://doi.org/10.1007/s40670-023-01898-6
22. Luaces MA, Cochran MS, Finocchario-Kessler S, et al. Impacts, learner diversity, and curricular framework of a virtual global health elective catalyzed by the COVID-19 pandemic. *Ann Glob Health*. 2023;89(1). https://doi.org/10.5334/aogh.4060

23. Rivas JA, Bartoletti J, Benett S, Strong Y, Novotny TE, Schultz ML. Paediatric trauma education in low- and middle-income countries: a systematic literature review. *J Glob Health.* 2022;12:04078. https://doi.org/10.7189/jogh.12.04078
24. Robinson SJA, Ritchie AMA, Pacilli M, et al. Simulation-based education of health workers in low- and middle-income countries: a systematic review. *Glob Health Sci Pract.* 2024;12(6). https://doi.org/10.9745/ghsp-d-24-00187
25. Seethamraju RR, Stone KP, Shepherd M. Factors affecting implementation of simulation-based education after faculty training in a low-resource setting. *Simul Healthc*. 2022;17(1). https://doi.org/10.1097/SIH.0000000000000549
26. Abahuje E, Tuyishime E, Alayande BT. Global surgical simulation education: current practices and future directions. *Surgery*. 2025;180:109050. https://doi.org/10.1016/j.surg.2024.109050
27. Maboh MN, Biaka FN, Andoh MN. Training and implementation of simulation-based education in low-resource settings: nurse educators' experience. *Afr J Health Prof Educ.* 2025;17(2). https://doi.org/10.7196/AJHPE.2025.v17i2.1004
28. Bajwa M, Najeeb F, Alnazzawi H, et al. A scoping review of Pakistani healthcare simulation: insights for lower-middle-income countries. *Cureus.* 2024. https://doi.org/10.7759/cureus.76485
29. Karageorgos S, Hibberd O, Ren D, Hornsby Y, Roland D, Koutroulis I. Training for pediatric sepsis – a medical education perspective and potential role of artificial intelligence. *Children* (Basel). 2025;12(11):1542. https://doi.org/10.3390/children12111542
30. McGaghie WC, Issenberg SB, Barsuk JH, Wayne DB. A critical review of simulation-based mastery learning with translational outcomes. *Med Educ*. 2014;48(4):375–385. https://doi.org/10.1111/medu.12391
31. Del Castillo Miranda JC, Oweidat M, Abady E, et al. Enhancing pediatric emergency care in low-resource settings through simulation-based training: a narrative review. *SAGE Open Med.* 2025;12. https://doi.org/10.1177/30502225251319883
32. Najjuma J, Bajunirwe F, Mbalinda S, et al. Barriers and facilitators of simulation-based education in stroke nursing management at a regional referral hospital in southwestern Uganda: a qualitative study. *Adv Med Educ Pract.* 2025;16:1317–1329. https://doi.org/10.2147/AMEP.S535086
33. Ahmed A, Ali FA. Advancing global nursing education through simulation-based learning: strengthening clinical competence and ensuring patient safety. *ISA J Med Sci*. 2025. Available from: https://isapublisher.com/wp-content/uploads/2025/06/Advancing-Global-Nursing-Education-through-Simulation-Based-Learning-Strengthening-Clinical-Competence-and-Ensuring-Patient-Safety.pdf
34. Chou WK, Ullah N, Arjomandi Rad A, et al. Simulation training for obstetric emergencies in low- and lower-middle income countries: a systematic review. *Eur J Obstet Gynecol Reprod Biol.* 2022;276:74–81. https://doi.org/10.1016/j.ejogrb.2022.07.003