Enhancing quality of medical care in low income and middle income countries through simulation-based initiatives: recommendations of the Simnovate Global Health Domain Group

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ABSTRACT

Background Quality of medical care in low income and middle income countries (LMICs) is variable, resulting in significant medical errors and adverse patient outcomes. Integration of simulation-based training and assessment may be considered to enhance quality of patient care in LMICs. The aim of this study was to consider the role of simulation in LMICs, to directly impact health professions education, measurement and assessment.

Methods The Simnovate Global Health Domain Group undertook three teleconferences and a direct face-to-face meeting. A scoping review of published studies using simulation in LMICs was performed and, in addition, a detailed survey was sent to the World Directory of Medical Schools and selected known simulation centres in LMICs.

Results Studies in LMICs employed low-tech manikins, standardised patients and procedural simulation methods. Low-technology manikins were the majority simulation method used in medical education (42%), and focused on knowledge and skills outcomes. Compared to HICs, the majority of studies evaluated baseline adherence to guidelines rather than focusing on improving medical knowledge through educational intervention. There were 46 respondents from the survey, representing 21 countries and 28 simulation centres. Within the 28 simulation centres, teachers and trainees were from across all healthcare professions.

Discussion Broad use of simulation is low in LMICs, and the full potential of simulation-based interventions for improved quality of care has yet to be realised. The use of simulation in LMICs could be a potentially untapped area that, if increased and/or improved, could positively impact patient safety and the quality of care.

INTRODUCTION

Background

Quality of medical care is variable in low income and middle income countries (LMICs).[1] While there is an increased focus on improving access to healthcare services, attention must also be directed towards addressing the quality of inpatient and outpatient services provided.[1] According to Jha *et al*,[2] LMICs, which have five times the population of high-income countries (HICs), experienced ~50% more in-hospital adverse events than HICs (25.9 million adverse events in LMICs as compared to 16.8 million events in HICs). Even with severe under-reporting, owing to inadequate medical records in the majority of LMICs,[3] this is still a very large number of events. When prospective mortality data following emergency abdominal surgery were collected across 58 HICs and LMICs in 2015, mortality at 30 days postoperation was found to be three times higher in LMICs than in HICs,[4] showing that mortality differs between LMICs and HICs and patient safety quality may play a role.

Das *et al*[5] found that 67% of patients with dysentery, unstable angina or asthma in urban Delhi and rural Madhya Pradesh, India were incorrectly diagnosed, while only 4% received correct treatment. Sylvia *et al*[6] report correct case management rates of 52–53% among village clinicians in rural China for chest pain and child diarrhoea, and Mohanan *et al*[7] report that rates of Oral Rehydration Salts were only 3.5% for child diarrhoea in Bihar. Similarly, low rates are also reported for other tracer conditions: for tuberculosis, correct case management rates were 21% for a sample of providers from Delhi, India.[8] Overall, there is significant potential for improvement of medical care across both the private and public sectors, and among major types of healthcare providers in LMICs, whether formally or informally educated due to poor logistics, funding and infrastructure, among the main factors.[9–11] A general lack of public trust in their country's public healthcare system and lack of control over the transmission of diseases may be leading patients to not seek care in a timely manner or failing to adhere to treatments.[1]

There have been numerous efforts to enhance the quality of care in LMICs by organisations such as the WHO, World Bank, US Agency for International Development (USAID), the Gates Foundation and Grand Challenges, by way of partnering up with researchers and institutions to implement projects. The WHO has partnered with and funded multiple organisations on projects aimed at improving healthcare quality around the world.[12] The USAID has funded multiple long-term projects since 1990 that regularly use several quality of care strategies in its missions. These include client-oriented, provider-efficient services developed by Engendered Health for the purposes of family planning and maternal and child

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healthcare, and the Standards-Based Management and Recognition strategy developed by Jhpiego.[1] USAID also recently funded a workshop aimed at strategising how to improve quality of care, when and where certain tools are most effective, and the best ways to measure the success and evaluate improvements.[1] The Gates Foundation partners with individual researchers and institutions on projects directed at improving the quality of healthcare services in maternal, newborn and child health in LMICs, currently focused in Ethiopia, northern Nigeria and the Indian states of Bihar and Uttar Pradesh.[13] Grand Challenges Canada funded OnTrackMedia, Indonesia's campaign to raise public and practitioner awareness about Alzheimer's disease in Indonesia with the aim of improving quality of care for these patients.[14]

The role of simulation

In HICs, simulation is increasingly used to improve quality of care and is regarded as the gold standard in healthcare professional education and assessment to enhance patient safety.[15] Simulation for both educational training and assessment is seen in many forms, including simulated patients, high-technology and low-technology manikins, procedural simulation methods such as animals, cadavers or virtual reality simulators, and also computer-based simulations such as virtual worlds, serious games and applications. Practising in immersive environments such as simulated operating rooms or in situ, where teaching and or assessment is performed in the actual clinical environment, are two other forms of simulation usage in HICs.[16]

Simulations realistically replicate medical scenarios that enable healthcare professionals in HICs to practise and improve their skills without harming patients.[17] For example, catheter-related blood-stream infection rates were significantly reduced by 84.5% after nephrology fellows in an urban teaching hospital in Chicago completed a simulation-based training in central venous catheter insertion.[18] Furthermore, a systematic review by Cook *et al*[15] of 609 studies summarised the effectiveness of technology-enhanced simulation training in comparison to no simulation intervention and found that in HICs, technology-enhanced simulation-based training in health professions showed consistently large effects in knowledge, skills and behaviour outcomes of medical trainees. A similar conclusion was drawn in another systematic review where the use of computer-based virtual patients as compared to no intervention showed large knowledge and skill improvements overall.[19] These improvements could translate into improved quality of care for patients, given the right incentive structures for healthcare providers. Overall, simulation-based training in HICs has increased significantly in the past two decades, aided by the development of new technologies and tools for professionals, widespread integration of simulation into medical education programmes and funding for academic medical simulation centres. It has also been shown to be effective in improving patient safety.[17]

In LMICs, however, simulation used to educate and assess healthcare trainees and professionals is limited and variable, with few permanently implemented simulation-based training programmes and centres for healthcare trainees and professionals to practise clinical skills. Furthermore, simulation use in health professional education is limited by the low funding for such education in LMICs.[20]

Currently, a few prominent examples exist to illustrate the beneficial use of medical simulation in LMICs and are presented as individual case study tables (box 1). One example is the Helping Babies Breathe programme implemented in Tanzania in 2014 (previously in Kenya and Pakistan), which is a simulation-based training programme to improve clinical neonatal resuscitation management. This showed that neonatal mortality reduction was statistically significant after training with static manikins.[21] Another simulation-based neonatal resuscitation training programme, PRONTO, included a team training component aimed at improving the clinical team's response to a neonatal emergency and was implemented in Guatemala after being tested in the UK.[22] These are two well-known HICs-funded programmes that show the positive benefits of context-specific simulation use—low technology manikins for low-resource settings, but with high impact. Other programmes have been developed by professional societies to teach specific skills or techniques. For example, the SAFE OB course was created by the Association of Anaesthetists of Great Britain and Ireland, and the Advanced Cardiac Life Support, or ACLS, course developed by the American Heart Association, have both been delivered in LMICs in the exact manner that they are provided in Britain or the USA.

Yet overall, there is a lack of knowledge about simulation use by individuals in LMICs in healthcare training and assessment and lack of work done in context-specific simulation use, targeted towards the budgets and needs of medical institutions and resources such as mortality rates. Thus, the use of simulation in LMICs is a potentially untapped area that, if increased and/or improved, could positively impact patient safety and the quality of care.

Simnovate Global Health Domain Group

The Simnovate international summit brought together experts in various fields of healthcare to shape the future of simulation, education and innovation across four domains: patient safety, pervasive learning, medical technologies and global health. This study represents the work of the Simnovate Global Health Domain Group, which consists of an international group of experts with backgrounds in global health, quality of care, maternal and child health, telesimulation, humanitarian crisis training, patient safety, health policy, health systems innovation and surgery. Together, the group exemplifies high-level track records of global health, innovation and simulation research through extensive publication and authority on the topic.

The aim of the Simnovate Global Health Domain Group was to provide a snapshot of the current use of simulation in LMICs and then present a framework, with actionable points, through which we can collaboratively begin to work towards the improvement of simulation use in LMICs. This study is a summary of a year's worth of collaborations. We hope that the information revealed through our studies and our overall suggestions may help to identify where and how the implementation of medical simulation can have the largest impact in LMICs.

METHODS

Teleconferences

Between September and December 2015, three teleconferences were convened by the members of the Simnovate Global Health Domain Group. The teleconferences sought to establish[1] the current state of simulation as pertains to global health,[2] potential maximum impact of simulation,[3] how this impact might be achieved and[4] the most effective interventions to achieve this. Teleconferences were recorded, detailed minutes were agreed on by all members and the findings were distilled into this white paper.

Box 1 Case studies of five global health simulation projects

1. *USAID Healthcare Improvement Project (HCI)*: The USAID HealthCare Improvement (HCI) Project sought to provide technical leadership and assistance to improve the healthcare delivery, health workforce capacity and performance across 38 USAID-assisted LMICs from 2007 to 2014. It focused on four major areas—quality improvement, health systems strengthening, health communications and behaviour of providers, and research and evaluation of the projects it funded—across nine topics—HIV and AIDS, tuberculosis, health workforce development, reproductive health and family planning, food and nutrition, community health, non-communicable diseases, vulnerable children and families, and maternal, newborn and child health. Over 8 years, it funded projects related to antiretroviral therapy delivery, prevention of mother-to-child transmission of HIV, the Helping Babies Breathe and Kangaroo Care programmes, developing and testing the Safe Childbirth Checklist, and improving vulnerable childcare services, among others. The full results and lessons learnt from HCI can be found in "Improving Health Care: the Results and Legacy of the USAID Health Care Improvement Project *Final Report*".[42] The ASSIST Project, running from 2012 to 2017, is USAID's next quality of care improvement initiative, which builds directly on HCI's lessons on how to design and implement improvement strategies. Its focus is to further address system-level factors that will improve the quality of care in these countries.
2. *Case Study of PREVEN*: The PREVEN Network is an integrated network of physicians, midwives and pharmacy workers trained in sexually transmitted disease (STD) management in Peru by 'prevention salespersons' who regularly visited pharmacies, boticas and clinicians to provide an educational intervention and collect numbers of STD cases managed. This study was a randomised control trial, split between 10 intervention and 10 control cities, which evaluated the impact of the educational intervention. Simulated clients visited pharmacy workers at one, three and 6 months after the training was complete in order to assess how the STD syndrome management, counselling and recommendations for condom use, and counselling for the treatment of partners progressed. At the end of the study, the PREVEN Network included 792 pharmacies and 597 clinicians. The simulated client study showed a significant improvement in the management of STDs at pharmacies that were given educational training.[32]
3. *Case Study of PRONTO*: PRONTO is a low-tech simulation-based training programme aimed to improve obstetric and neonatal emergency responses through the use of a PartoPants, a model that simulates the birthing canal, and by focusing on team training for healthcare providers. This programme was first developed in the UK, but has since been implemented in several countries, including Mexico and Guatemala. In this study, the researchers assessed the training programme's use in 24 hospitals in Mexico through a pair-matched hospital implementation control trial. A total of 450 healthcare providers in interprofessional teams were trained in 12 intervention hospitals and assessed both pretrial and post-trial. Knowledge and self-efficacy scores significantly improved for both physicians and nurses, and 60% of the goals determined by the teams to improve clinical team functioning and care were achieved. Thus, PRONTO is a possible training programme that can be used to optimise emergency responses and improve teamwork in emergency settings, specifically in neonatal and maternal mortality cases.[22]
4. *Case Study of the Helping Babies Breathe Programme*: The Helping Babies Breathe (HBB) Programme is a simulation-based education programme (previously implemented in Kenya and Pakistan) that trains providers in basic neonatal care and resuscitation with the aim of reducing perinatal mortality. In a previous study, local staff at a rural hospital in Northern Tanzania were trained for 1-day in the HBB Programme using a manikin, but researchers concluded that the improvements in neonatal mortalities and stillbirth rates seen in simulated settings did not translate into long-term clinical practice.[43] A second study was conducted to assess whether multiple brief and frequent (3–5 min per week) on-site simulated trainings would positively impact clinical neonatal management. Over a period of 3 months, trained midwives held weekly 3–5 min trainings, 40 min monthly trainings and one full day training for healthcare workers at the same rural hospital in Northern Tanzania. Data were collected by research assistants who attended all of the births for 1 year before and 1 year after full implementation of the programme. More babies were resuscitated and neonatal mortality decreased from 11.1/1000 births to 7.2/1000 births post the brief and frequent simulation training programme. Trainees also improved significantly in knowledge. Thus, a decline in mortality was observed and overall improvements in clinical practice may be associated with the frequent, brief trainings instead of a 1-day training programme.[21]
5. *Case Study of the Use of Telesimulation*: Telesimulation is a novel teaching method where the instructor can teach new techniques to a trainee located in a different place using basic videoconferencing software and simulators that are connected through the internet. The objective of this study was to see whether Toronto paediatricians could use telesimulation effectively to teach physicians of multiple disciplines in Botswana, Africa mechanical intraosseous (IO) needle insertion skills for vascular access in children. Twenty-two doctors in Botswana participated in the training to use EZ-IO, completing pretraining and post-training self-assessment questionnaires and written multiple-choice tests. They also completed a skills assessment after the training. The mean score on the written test (out of 12) increased by 5 points, showing an improvement in knowledge. Botswanan physicians reported an increased comfort in managing paediatric resuscitation, with their IO insertion skills and the EZ-IO system, and their management of paediatric resuscitation. Telesimulation was concluded to be worthwhile, with several advantages such as affordability, flexibility and convenience.[44]

Literature review

Since our initial step was to understand the current scope of simulation use in LMICs, we conducted two studies: first, a scoping review on the use of simulation in LMICs that focused on published research studies with measured outcomes. This was to inform us specifically about the research projects conducted in LMICs using simulation methodologies in the past 25 years (1990–2016). The scoping review included research studies using simulation as defined previously, were published in English (in PubMed and EMBASE) and focused on human participants. The search strategy included mesh terms (patient simulation, distance education), 'simulation-based', variants of 'standardised patients', and a search strategy developed by Cochrane that included key low-income and middle-income terms and the countries classified in 2012 as LMICs by the World Bank (latest available version).[23] During the study review,

all studies were screened to include the 2015 World Bank classified LMICs.

Survey

A detailed survey was developed and sent to a systematically comprised list of contacts in order to understand the real-time use of simulation within a healthcare setting. The aim of this survey was to understand the current status of simulation use across medical institutions in LMICs that would not be captured by scanning published literature. We developed our survey in English using dedicated professional online survey software (SurveyMonkey.com, LLC, Palo Alto, California, USA) for ease of use online. A list of emails was compiled of LMIC medical schools from the World Directory of Medical Schools[24] and of LMIC-based simulation centres and laboratories listed within the National League of Nursing Clinical Simulation Centers database,[25] the Society for Simulation in Healthcare database,[26] the MedSim Magazine Medical Simulation Center Directory,[27] the Society in Europe for Simulation Applied to Medicine database,[28] the National Center for Collaboration in Medical Modelling and Simulation database[29] and the Bristol Medical Simulation Center database.[30] In addition, contacts from the scoping review who were based in LMICs were added. We had 849 emails on the final list, after counting the failed mail deliveries (258).

RESULTS

Teleconference discussions

The Simnovate Global Health Domain Group members collectively shared knowledge of known uses of simulation that have positively impacted or revealed deficiencies in the healthcare services in LMICs. Three ideas were discussed: first, the general lack of simulation in medical education and training in LMIC; second, the emerging use of simulated patients in LMICs as a measure of quality of care; and third, the use of simulation in strengthening a healthcare system or country's ability to react to unforeseen medical events/threats/emergencies and outbreaks/disasters. Overall, it was concluded that there were multiple gaps in our understanding, with no established study systematically summarising the literature to build on, or database that could inform us on current simulation-based activities. Thus, a collective decision was made to conduct both a scoping review of published literature and a survey of current medical schools and simulation centres in LMICs.

Scoping review: publications on simulation in LMIC

Of 2073 articles that were identified in the initial search, 203 were included in the final full-text review (see online supplementary appendix 1). A majority of the excluded studies were not medical simulation-based research studies with defined and measured outcomes. Of the 203 articles, 80% of the studies were conducted in middle-income countries, as categorised by the World Bank.[31] Studies were split approximately equally between the World Bank defined geographical regions of East Asia and the Pacific, Latin American and the Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa (15–26%), with the per cent of studies from Sub-Saharan Africa at a slight majority (26%), as seen in figure 1. Less than 1% of studies were conducted in Europe and Central Asia. Furthermore, 68% of simulation publications were from urban settings, with 14% using simulation in rural and urban settings. Simulation publications were mainly set in academic institutions for medical training (31%) and in pharmacies (28%), where simulated patients were used to assess the quality of care provided by pharmacy employees. Only 2% of the studies indicated using a simulation centre or simulation laboratory.

Topics covered by the studies ranged across 23 medical areas, though the majority of studies used simulation to train and/or assess infectious disease management (22%), reproductive health services (19%), cardiopulmonary resuscitation skills

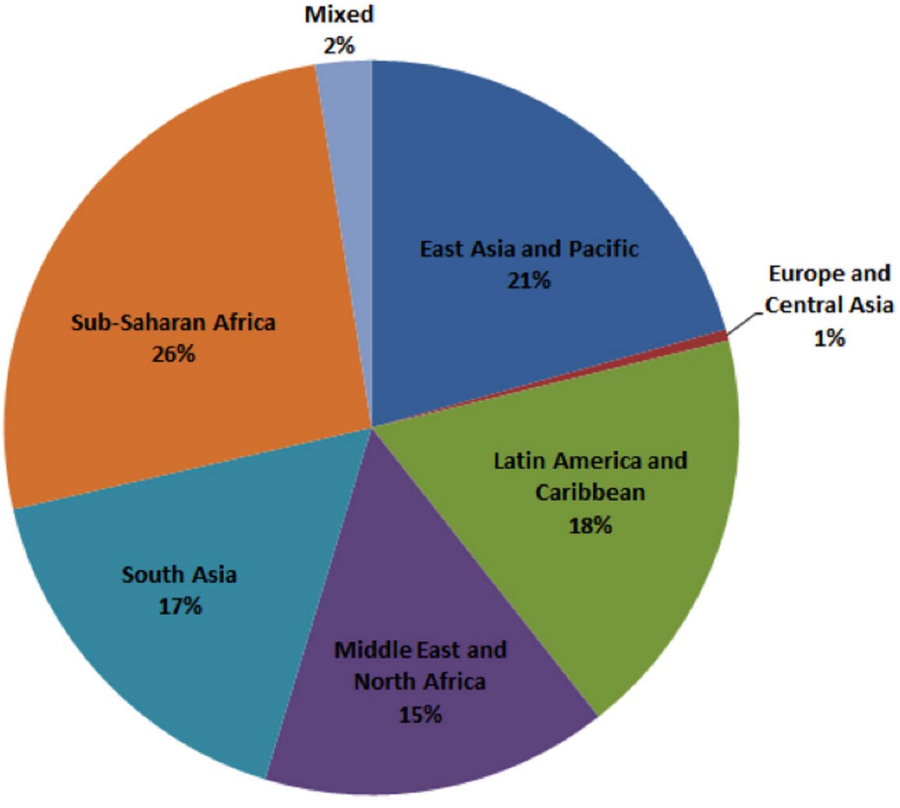

Figure 1 Geographical regions corresponding to the scoping review studies (N=203).

(12%) and the obstetric skills required to prevent maternal and neonatal mortality and morbidity (11%). Learners ranged between professional medical practitioners, medical trainees, nurses, formally and informally educated pharmacy workers, pharmacy students, midwives, midwifery students, paramedics, dentists and dental students. Fifty per cent of the studies focused on groups that included both formally and non-formally educated learners, as it was hard to credibly determine the educational background of the learner within the study. This is unsurprising due to the existence of an informal private sector in many LMICs, where both kinds of professionals can practise side by side.[9]

The use of simulation was divided into two broad categories: 42% of studies focused on medical education training and evaluation using various simulation methods, while 58% of studies used standardised patients to assess the quality of care provided by healthcare practitioners. The total spread of simulation technologies used can be seen in figure 2.

The medical education studies mainly consisted of short-duration single group, pre–post trials and randomised control trial designs that used either standardised patients or low-tech manikins and low-cost models for training and/or assessment. A few studies used virtual patients, using specific computer software developed by the researchers and modelled as common cases seen in the respective research settings. Studies mainly focused on measuring the improvement in knowledge of the learners through either multiple choice and/or skills tests.

The quality of care studies were of cross-sectional or randomised control trial designs that used standardised patients to assess the quality of care provided by the specific group of learners, either as a surveying method to understand the baseline quality of care, or as part of an educational intervention trial. The practitioners included physicians, pharmacists, nurses and midwives, with a mix of formal and non-formal education backgrounds. About 78% of the quality of care studies focused on understanding the baseline quality of clinical practice delivered to the patient. Only 19% were educational intervention trials that aimed to improve the learner's knowledge in order to improve quality of care. A majority of these studies measured the quality of care based on the level of adherence to established guidelines for diagnosis and treatment of a condition and if the patient was counselled adequately or not. Consistently, these studies also determined that the quality of care provided was low, across a variety of medical conditions, settings and healthcare providers.

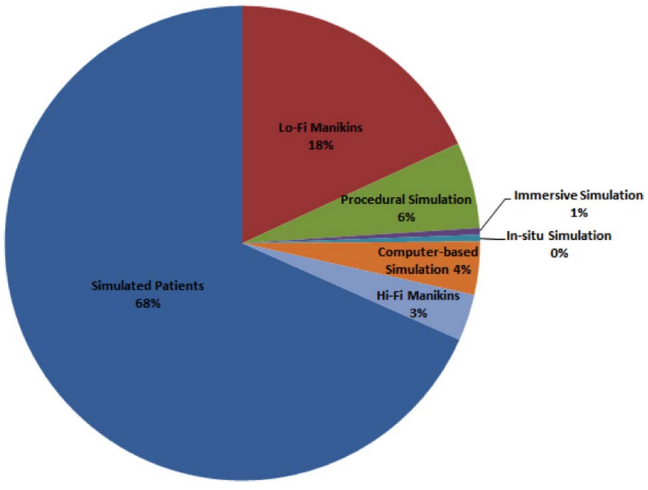

Figure 2 Simulation technologies used across all scoping review studies (N=221, 18 studies used two technologies).

Survey results—current use of simulation in LMICs

Results from the survey include 46 (5.4% response rate, from a total of 849 delivered emails) completed responses, with respondents from 21 countries across the six World Bank defined geographical regions—Europe and Central Asia (15%), Middle East and North Africa (7%), South Asia (32%), Sub-Saharan Africa (17%), Latin America and the Caribbean (24%), and East Asia and the Pacific (4%).

Eighty per cent of respondents were based in urban settings, with 89% based in academic institutions. Respondents identified themselves as healthcare professionals across all types of specialties, and several times indicated more than one specialty. About 89% used simulation in their settings for either training and/or assessment and represented a total of 28 established simulation centres. A majority of the instructors in charge of teaching simulation were medical professionals, though a wide range of professionals taught simulation at at least one institution. Those who taught simulation included midwives, paramedics and nurses in addition to physicians.

A majority of instructors in simulation received half a day to multiple days of formal training, though mainly it was <1 week of training. Thirty per cent of instructors were not formally trained in simulation. The majority of learners at these institutions were medical trainees, medical professionals, nursing students and nursing professionals, though respondents indicated that all healthcare professions were trained at at least one of the institutions. This included professionals such as midwives, paramedics, community health workers and pharmacists, among others.

Of the six simulation categories, low-tech manikins were used at most institutions (74%), while simulated patients and synthetic models for procedural simulation were used at 60% of the institutions. About 48% of the respondents used high-tech manikins. Several institutions also used virtual reality simulators (24%), simulated wards (22%), simulated operating rooms (20%) and computer-based virtual patients (15%). In situ simulation was used the least across the institutions. These simulation technologies were used mainly for training purposes and for mainly teaching medical expertise and communication skills, though both simulated patients and manikins were also almost equally used for assessment as well.

Knowledge acquisition was the main outcome measured at institutions with simulation-based training (83%), followed by learner behaviour in a clinical setting (59%) and then the effect on patient care (50%). Finally, 24 of the 46 respondents indicated that their institutions conducted educational research related to simulation, producing an average of three abstracts, five presentations and two manuscripts per year.

DISCUSSION

This study presents the findings of the Simnovate Global Health Domain Group whose goals were to understand and discuss the current and future states of simulation use in LMICs, and ultimately to positively impact the quality of care. With no previous study summarising simulation use in LMICs, the scoping review and survey were undertaken to provide an overall snapshot of the current use of simulation in the literature and in real time, with respect to existing simulation centres or environments and the faculty and learners involved.

The results of the scoping review reaffirm the statement made previously that simulation use is both variable and limited in

LMICs. It highlights that though simulation has been used for training and or/assessment, as in HICs, it has been carried out in a sporadic way, with a focus on single-time, short duration studies. A majority of the studies evaluated the baseline adherence to guidelines for diagnosis, treatment and counselling using standardised patients, with repetitive results of low adherence and recommendations for the need to improve medical knowledge in the field and in medical education. Relatively few of these quality of care studies aimed to actually improve medical knowledge through educational intervention programmes. Furthermore, very few simulation-based educational programmes targeted informal providers or healthcare professionals such as midwives or pharmacists, even though there is a large informal sector that diagnoses and treats patients.[9] A smaller subset of medical education interventional studies used low-resource methods such as low-technology manikins, procedural models and standardised patients in formal academic institutions. These studies were also mainly single-time, short duration studies. It is unknown whether these studies led to the implementation of permanent simulation-based components of medical curricula at the institutions; nor is it known whether these studies impacted long-term retention rates for trainees or clinical outcomes. If they did not, it is a missed opportunity for improving medical education within these institutions using the low cost, context-specific solutions many of the researchers came up with because wherever simulation was used, it showed improvement.

Previous studies have shown that simulation-based activities have a positive impact on the knowledge and quality of care delivered, especially in HICs where they have clearly been seen to improve the quality of care of healthcare workers. Numerous studies have also been published; Cook *et al*[15] identified 609 papers for their systematic review of technology-enhanced simulation use in HICs, even after excluding studies using simulated patients and any study that was not focused on medical education. In comparison, our much broader scoping review including both additional categories captured only 203 articles. The small number of studies from LMICs underscores the low penetration of applied simulation methods within these countries. In addition, 80% of these studies were in middle-income countries, highlighting the significant inequity in simulation use and availability in low-income countries.

Studies in HICs provide us with a baseline understanding that simulation is a validated and valuable tool to measure and improve the quality of care, while the lack of studies in LMICs and the inequity of their distribution highlight the tremendous potential for simulation to be used globally (tables 1 and 2). It is important to point out that though HICs focus on high technology simulation methods, context-specific and low-cost simulation methods can also be implemented with high impact, as seen from the LMICs case studies in box 1. A focus on improving and increasing simulation use could positively impact the quality of health services provided to patients in LMICs by removing the patient from the healthcare practitioner's learning curve and improving patient safety.

In addition, the responses from the survey are encouraging in that, though there was a low response rate of only 46 from 849 emails sent, professionals highlighted their interest in simulation and identified established simulation centres within several institutions. Results of the simulation technologies used and the use of simulation within a medical setting reflect what are seen in the scoping review results as focused mainly on manikins and simulated patients. Based on the responses, engagement with these institutions through a collaborative relationship could serve as our baseline attempt to help improve simulation use through medical education and effectively impact the quality of training provided.

Table 1 Comparison of simulation technologies used between HICs and LMICs (findings based on literature review and survey data)

HICs	LMICs
▶ Simulated patients ▶ High-technology and low-technology manikins ▶ Procedural simulation methods such as animals, cadavers or VR simulators ▶ Computer-based simulations such as virtual worlds, serious games and applications. ▶ Immersive environments such as simulated wards or operating rooms ▶ In situ, where teaching and/or assessment is performed in the actual clinical environment	▶ Simulated patients ▶ Low-technology manikins, few high-technology manikins ▶ Procedural simulation (animal, synthetic) ▶ Computer-based virtual patients

HICs. High-income countries; LMICs, low income and middle income countries; VR, virtual reality.

Table 2 Comparison of uses of the simulation technologies between HICs and LMICs (findings based on literature review and survey data)

HICs	LMICs
▶ Medical education studies —using all 6 technologies ▶ Quality of care studies	▶ Quality of care studies: used standardised patients to assess the care provided by established healthcare providers ▶ Quality of care intervention studies: developed an educational programme taught to healthcare providers, who were then assessed using standardised patients at the end, or at certain periods during the educational intervention period ▶ Medical education studies: both training and assessment of health trainees of various professions using simulation

HICs. High-income countries; LMICs, low income and middle income countries.

Several ideas present themselves in how we can further impact the medical quality of care through simulation. A majority of the research studies captured by the scoping review concluded that the quality of care of healthcare providers assessed was harmfully low, while only a few studies actually tested interventions that targeted these healthcare providers. In addition, the smaller subset of medical education studies were mostly one-time interventions that did not assess further implications, such as the effect on patient care or longitudinal knowledge and skill retention. It would thus be beneficial to extend the duration of an educational intervention using simulation in order to strengthen a healthcare system. Successful examples include the PRONTO programme and PREVEN network.[22 32] These programmes target both formally and informally educated practitioners, and focus on patient outcomes and the development of a network of trained healthcare workers who could potentially pass on the knowledge. Mobilising financial resources towards low-income countries could also help offset the inequity identified in the use of simulation in low-income countries.

Simulation could also be used to address the global burden of disease in these countries. The most frequently reported topic

area in the scoping review was infectious disease management, but a hugely lacking topic was trauma and injury management, which is a high cause of morbidity and mortality in LMICs.[33] A few studies already address this: two studies in Brazil focused on teaching life support and first aid skills (including cardiopulmonary resuscitation) to the general public using both television time and by training middle school teachers who, in turn, taught their students in a mass training event.[34 35] These were studies conducted in response to the increase in road traffic accidents seen in Brazil and the importance of treating cardiac arrest immediately. Encouraging the adoption and implementation of these ideas in other LMICs would be beneficial to the health system as the global burden of road traffic accidents is concentrated in LMICs, and there is a growing morbidity and mortality trend due to cardiovascular diseases in LMICs.[36 37] Similarly, these simulation-based initiatives can improve a country's ability to react to unforeseen threats or medical emergencies in order to deliver healthcare safely and handle outbreaks, especially after the recent Ebola crisis. There is also potential in adapting those programmes used in HICs to low-resource areas to target various areas of high mortality and morbidity such as maternal and childcare, trauma and resuscitation.

There is currently minimal cost-effectiveness research on the use of simulation in healthcare. Existing evidence from HICs suggests that investments into simulation for teaching and assessments are likely to be cost-effective,[38 39] but there are very few studies actually reporting the cost of using simulation methods.[40] In LMICs, however, it might not be feasible to implement simulation methods common in HICs (eg, high-technology simulators can be expensive), and this must be considered within the context of our suggestions. A preliminary cost comparison was conducted within a randomised control trial based in India that compared neonatal resuscitation training of medical trainees on low-fidelity or high-fidelity simulators. Researchers found that there was no significant difference in improvement between groups with respect to the knowledge and skills acquired both immediately after and 3 months post-training. Thus, the investment in high-technology manikins may have been an unnecessary cost burden in this low-resource setting.[41] Low-fidelity simulation has huge potential to significantly impact training and patient safety in LMICs, also shown by the context-specific and low-cost examples for simulation use in LMICs in boxes 1–5.

Since we have described that simulation in LMICs is, understandably, limited to basic technologies such as manikins, procedural models and standardised patients, one direction of focus to improve quality of care could be the widespread implementation of these low-resource methods into more medical programmes to teach the next generation of medical practitioners. This would be less of a cost burden to the already overloaded health systems and institutions. It would also allow for the development of training programmes within the local context and possibly shorten the trainees' learning curve in the real environment, leading to increased productivity and potential decreases in medical errors.[17] A focus on the economic impact of simulation use may also help convince institutions to invest and implement these methods into their medical education curriculums. Finally, introducing simulation into medical education would shift simulation use from the individual to the institution and have a larger impact.

Finally, as discussed above and in relation to encouraging the integration of simulation into medical education in LMICs, there should be a focus on developing a collaborative network of experts between HICs and LMICs and, more importantly, within LMICs. This would facilitate the development and implementation of simulation into medical programmes through mentorship and could establish more programmes to improve and/or evaluate LMICs' health systems (eg, PRONTO and PREVEN). Mentors would become a resource for interested professionals from LMICs to guide the development of a medical education programme and also function as observers of how simulation can successfully be implemented in low-resource settings. It is important to note that there is much to learn from the use and implementation of simulation in low-resource settings that can reversely impact medical education development in HICs, possibly impacting cost reduction, for example, and this mentorship would act as a two-way street. Furthermore, this collaborative network could expand into the development of a simulation project database as an information resource of those using simulation in global health.

Both studies have several limitations. The scoping review was based on only English language published work, which excluded a large number of studies in other languages. Furthermore, there is a general lack of research and publications from low-income settings captured in traditional literature databases catering to high-income settings. The studies that do exist from these regions might be in smaller region-specific or subject-specific databases. Both facts point to a potential bias in the higher number of studies from middle-income settings and the use of low-technology simulation methods. If we had searched the grey literature, we would have found descriptions of simulation-based programmes offered at different institutions not reported as formal papers as well as unpublished studies. Currently, we have focused on only simulation use in high-quality academic research. We offset this publication bias by conducting the survey to capture non-published information straight from simulation users. The survey we developed, though, was written and distributed in English, which could have limited the response rate. Nevertheless, both studies offer a general snapshot of the current use of simulation and the need to increase and improve its use in order to positively impact patient safety.

Conclusions

This study presents an overview of the current status and recommends future directions to improve the quality of care in LMICs through the increased use of medical simulation. Overall, on the basis of our preliminary work, we have identified a significant inequity between LMICs related to the use of simulation, with multiple areas where simulation use can be innovatively modified for medical education and health systems evaluation in these settings. Though simulation-based training and assessment studies have been conducted in LMICs, they have been sporadically carried out. Thus, a broad implementation of simulation is lacking in LMICs, and the full potential of simulation-based interventions for improved quality of care has yet to be tapped into. With the suggestions and discussions outlined in this paper, we can work towards and implement collaborative and systematic efforts that can enable us to positively impact the quality of care in LMICs.

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