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Abstract

Objective: This study was proposed to identify the use Information and Communication Technologies of tools based on Information and Communication Technologies as simulators, applications, or simulated environments in the teaching-learning processes in human and animal health sciences in different levels of academic studies. ***Materials and methods:*** In this research, a twelve-question survey was administered to staff of simulation laboratories/centers, and undergraduate and graduate academic programs in the field of human and animal health sciences in Colombia. The survey focused on identifying simulation spaces, hardware, and software tools available. Data analysis was performed using a 95% confidence level and a minimum sample size of 15 from a population of 86 higher education institutions. ***Results and Discussion:*** A clear trend to use health-care simulation in undergraduate programs was found, followed by graduate and finally specialty programs. The most commonly used simulators are task trainers and manikins for developing motor skills. However, the number of available simulators is still insufficient, in contrast to the increased demand for the growing number of students in the health field. ***Conclusions:*** The development of new tools is a high-priority need, especially in fields such as gynecology and obstetrics, surgery, and cardiology, which require specific skills and capabilities.

Keywords: health sciences; higher education; information technology; software applications; medical informatics applications; immersive virtual reality; mannequins; standardized patients; task trainers; health programs.

Retos en el Desarrollo de Simuladores y Software para la Enseñanza en el Campo de las Ciencias de la Salud: Instituciones de Educación Superior Colombianas

Resumen

Objetivo: Este estudio busca identificar el uso de herramientas basadas en tecnologías de la información y la comunicación como simuladores, aplicaciones o entornos simulados en procesos de enseñanza-aprendizaje en las ciencias de la salud humana y animal para diferentes niveles de estudios académicos. ***Materiales y métodos:*** En esta investigación, se aplicó una encuesta de doce preguntas a líderes de laboratorios/centros de simulación, y programas académicos de pregrado y posgrado en el campo de las ciencias de la salud humana y animal en Colombia. La encuesta se centró en identificar espacios de simulación, hardware y herramientas de software. El análisis de datos se realizó, estableciendo un nivel de confianza del 95% y un tamaño de muestra mínimo de 15 instituciones. ***Resultados y Discusión:*** Se encontró una clara tendencia a utilizar la simulación en programas de nivel profesional, posgrados, técnico profesional y tecnología. Siendo los simuladores más utilizados, los entrenadores de tareas y maniquíes, los cuales se centran en la adquisición de habilidades motoras. Sin embargo, el número de simuladores disponibles sigue siendo insuficiente, en contraste con la creciente demanda por parte de los estudiantes. Conclusiones: El desarrollo de nuevas herramientas es una necesidad con alta prioridad, particularmente en áreas como ginecología y obstetricia, cirugía y cardiología, que requieren habilidades y destrezas específicas que los simuladores disponibles aún no abordan.

Palabras claves: Ciencias de la salud; educación superior; tecnología de la información; software; aplicaciones de la informática médica; realidad virtual; maniquíes; simulador paciente; simulador de tareas; programas del área de la salud.

1. Introduction

Recently, Information and Communication Technologies (ICTs) have experienced an unprecedented advance in history, which has not been unknown to Higher Education Institutions (HEIs) around the world. These institutions have been focused on handling large amounts of information, not only for administrative management but also to improve the teaching-learning processes, including evaluation methods as a complement to the traditional strategies (López de la Madrid, 2007). The above requires the development and implementation of software and applications to services related to instant messaging tools, video games, telecommuting, virtual learning platforms, resources to organize work, academic, or social activities. These tools should allow access to different work environments and the sharing of files regardless of their source format (Portillo *et al.*, 2017).

The wide availability of tools has created new challenges for teaching methods used in the education of professionals from all fields, especially in the health sciences (Bustos Jorge, 2012). One uses clinical simulation and problem-based learning methodologies that seek to create an environment with characteristics similar to those of a real clinical situation (Utili Ramírez, 2007). For example, learning the skills and abilities to perform medical-surgical procedures is a challenge for the training of any professional, since these are skills that can only be acquired through continuous practical experience (Davis and Summers, no date; Offiah *et al.*, 2019), under the supervision of a teacher or trained personnel.

Since 2011, it has been estimated that there are about 1,430 clinical simulation centers in the world, mainly concentrated in the United States of America and Canada (1000 centers), with the countries of South America and Africa being the least users of this technology (no more than 23) (Mancilla Carriel and Ramírez Amat, 2012). Nevertheless, in recent years, universities in Latin American countries have made efforts to incorporate in their professional training programs a more significant number of tools. The objective is to integrate the evaluation of knowledge, skills, and attitudes developed in different situations and clinical environments that allow the assessment and feedback for students and teachers (Guerrero-Aragón, Chaparro-Serrano and García-Perdomo, 2017). Thus, ICTs have been characterized as a potentially powerful tool to expand educational opportunities, in particular to allow students to learn in scenarios as close to reality as possible, to encourage critical thinking, to reduce exposure to risks for patients and animals, and to reduce the occurrence of adverse events due to ignorance or lack of training during the learning phase (Utili Ramírez, 2007).

In recent years, Colombia has presented an increase in academic demand, mainly in programs in the field of health sciences such as medicine, nursing, physiotherapy, respiratory and cardiorespiratory therapy, surgical instrumentation, among others (Ministerio de Educación de Colombia, 2019). According to current information of the Colombian National Information System of Higher Education (SNIES, Sistema Nacional de Información de Educación Superior), there are approximately one hundred and ninety-two health science programs, of which one hundred and thirty-seven are undergraduate programs, and fifty-five graduate programs, including master's and doctoral degrees. An average of 65,492 students are enrolled in private institutions, while 25,162 are in the free public education system (Ministerio de Educación de Colombia, 2019). This volume of students requires spaces for training in simulated environments, especially when the current legislation, according to Law 1917 of 2018. limits the participation of undergraduate and graduate students in the care of patients within hospital entities. This law also limits the number of weekly hours of clinical activity they should have (Congreso de Colombia, 2018), thus reducing the possibilities of training for future professional life.

The main advantage of medical simulation is its development in controlled environments, which guarantees the safety of the patient and the trainer, in addition to the possibility of changing variables and observing the effect in real time, as many times as the student needs (Lamé and Dixon-Woods, 2018). Generally, clinical simulation is based on the use of high-fidelity physical simulators, which require physical space for the proper use and imply high costs for educational institutions (Padilha, Machado, Ribeiro and Ramos, 2018). Fees that can range from $ 159 to $ 100,000 depending on the type of simulator and the fidelity of the simulation (Medical X, 2017; Laerdal Medical Corporation, 2018).

In addition to the high investment costs mentioned above, there is also the need to update simulation laboratories/centers, which in countries such as Colombia is compounded by requirements such as the geographical characteristics of the country, which require

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lightweight equipment to be transported to remote regions of difficult access. Additionally, commercial brands do not produce simulation systems for training in the diagnosis of tropical and uncommon diseases such as dengue, leishmaniasis, or chagas, among others.

Therefore, the need to create new training spaces according to the current training needs in higher education in Colombia is imperative. Still, there are no reports on the use of ICT in the academic sector, linked to its capacity to develop new solutions to its own needs (Salinas, 2004). In this context, this study was proposed to identify the use of ICT-based tools as simulators, applications, or simulated environments in the teaching-learning processes in human and animal health sciences at different levels of training in undergraduate and graduate academic programs. From these findings, this study also summarizes the challenges for simulation tools considering the type of simulation, the environment of use, and software and hardware features, as a basis or guide in the future development of simulators and applications for the healthcare education.

2. Materials and methods

2.1. Survey Development

After a review of the literature on simulators in the field of health and technological surveillance for the last five years, we developed questions that focused on the use and intended goals of simulation in training laboratories/centers, undergraduate and graduate academic programs in the field of human and animal health sciences in Colombia, type of simulations used, and clinical skills taught.

Simulation labs/centers consist of realistic-looking clinical and interactive spaces that include training labs, analysis workshops, and feedback rooms. They reproduce in a real environment and have technical equipment for simulated patient care. They differ from a simulation laboratory, which is an academic space dedicated to the development of teaching-learning activities through simulation. The clinical simulation addressed in simulation centers includes three main areas related to the stages of the learning process

(Dudding and Nottingham, 2018): (i) prebriefing, where learners are provided with information about a patient situation, (ii) simulation scenarios, where a case study is addressed using physical or software simulators, or even actors, (iii) debriefing, where learners review and reflect on their actions during the scenario, identifying the good and bad practices as well as the opportunities to improve the technique or communication. For this study, it is very important to identify whether the institutions that focus on offering simulation tools at the undergraduate level have simulation centers, since this implies a higher level of complexity in terms of technology, adequate spaces and available personnel.

2.2. Survey Instrument

The survey consists of twelve questions of various types: open-ended, closed-ended dichotomous, and multi-choice with single or multiple responses, which are described by section below.

The first five questions in the survey asked about general information, including the name, location, type of institution (university, corporation, foundation, or simulation center), the academic level of the health sciences programs they offer, and the type of accreditation according to SNIES. Some of the academic programs were grouped into general medicine, nursing, veterinary medicine, respiratory and cardiorespiratory therapy, anesthesiology specialty, ophthalmology, pneumology specialty, surgery specialty, bioengineering, critical care medicine, and intensive care medicine specialty. Next, we asked about simulation facilities, including available space and equipment. These five questions were multiple choice. If they used simulation, participants were asked what simulation tools they used (web and mobile applications, simulators, and applications). We asked which simulators are used in the classroom. The choices included simulators classified into five broad groups (see Table 1): Standardized patients, task trainers, mannequins, computer-based, and immersive virtual reality, and "other" option.

In the next section of the survey, we asked multiple-choice questions about whether the goals of simulations were to enhance

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knowledge, acquire skills, research activities, provide summative evaluation, and "other" goals. We also asked about the health care specialties being trained in the simulation rooms, such as general medicine, gynecology, obstetrics, cardiology, general surgery, laparoscopic surgery, physical therapy, and other fourteen other options. Finally, we asked an open-ended question that allowed the participants to comment on aspects that they considered relevant.

2.3. Survey Administration

The survey was conducted between May and August 2019, with the approval of the Ethics Committee of the Institute of Medical Research - Faculty of Medicine - Universidad de Antioquia in Medellin, Colombia (F-017-00, Acta No. 011). The survey was used as an instrument of non-invasive information collection: institutional and non-personal information. In total, 86 entities were contacted via email, between simulation laboratories/centers, undergraduate and graduate academic programs in the area of human and animal health sciences in Colombia. The contact information of the institutions was obtained from the SNIES. The survey was sent to participants via e-mail and provided a link that directed responders to a Web site where the survey could be completed.

2.4. Survey Analysis

This study is descriptive and observational, whose variables of interest are qualitative with a nominal measurement scale, where all responses are analyzed statistically independently. Since the total number of HEIs is known (N = 86), a simple random probability sample was used with a 95% confidence level, it was determined that the significant sample for the study, considering a finite population (Saraí Aguilar-Barojas, 2005), was 15 institutions .

The objective of the analysis was to identify the areas with the least use of simulators and simulation tools for clinical training and skills acquisition of trainees, as well to determine the areas of human and animal health sciences that have the greatest use of ICT tools.

3. Results

The response rate of HEIs was a total amount of 69 surveys completed, as follows: 36.23% (25/69) undergraduate programs, 27.53% (19/69) graduate programs, including master's and doctoral studies, 11.60% (8/69) technical and vocational programs, and 24.64% (17/69) non-formal training. It is important to highlight that nowadays, there are approximately 64 technical and technological active programs in Colombia, 313 undergraduate and 1016 graduate programs. Therefore, the sample size concerning the size of the population in technical and technological programs is 12.5%, whereas in undergraduate is 8.0% and 1.8% in graduate programs.

Table 1. *The simulators classification according to levels fidelity was taken from (Lopreiato, 2016; Dudding and Nottingham, 2018).*

Type of Simulators	Definition	Example
Computer-based	A simulation of a model of a given system that is presented on a computer and handled through a program.	A virtual representation of real bodies, obtained from clinical images that include 3D volumes, for a deeper understanding of human anatomy and physiology. Commercial Simulator: Sectra Table; Anatomage; CardioLab; RespiLab (*Mesa de Disección Virtual SECTRA*, no date; Hernandez *et al.*, 2009).
Immersive virtual reality	A three-dimensional environment generated by computer technology, which creates in the user the feeling of being immersed in it.	Laparoscopic training simulators that use innovative learning tools, with platforms compatible with all simulation modules to complete procedure training (*LAP Mentor III*, no date). Commercial Simulator: LapSim; EndoTrainer; Lap Mentor III (van Dongen *et al.*, 2007).

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Type of Simulators	Definition	Example
Mannequins	An articulated model of the human body, with physiological parameters similar to those of a human being and that, are handled through software.	A male patient simulator designed to practice skills and provide medical assistance in case of emergency is a fully functional wireless computer that allows making adjustments in the course of training. Commercial Simulator: Adam X; Resusci Anne QCPR; Newborn Hal, SAM II; SimMan 3G (*ADAM-X, Human Patient Simulator*, 2017; Laerdal Medical Corporation, 2019).
Standardized patients	A simulation of a patient under controlled conditions that emulate medical care situations according to academic needs.	A neonatal and pediatric patient designed to meet the specific learning objectives focusing on initial assessment and treatment for the smallest patients. Commercial Simulator: Megacode; SimMan; Nursing Anne Simulator, Ovace Simulator (Kyle and Bosseau Murray, 2008).
Task trainers	A synthetic device for training specific tasks.	A gynecological simulator to allow the practice of different pelvic exams, the recognition of pathologies, and insertion of contraceptive devices. Commercial Simulator: SimMom; RCP mannequin, Zoe; Airway Larry (*Simulador ginecológico ZOE*, no date).

Source: Authors own creation

Ninety-six percent of HEIs use simulation spaces for training activities in Colombia, either through simulation laboratories/centers, or methodologies that include tools with virtual simulators and software applications. The classification of these is fundamental to analyze their distribution according to the levels of professional and technical training in the country. This work was based on what was proposed by Lopreiato (Lopreiato, 2016) and Dudding et al. (Dudding and Nottingham, 2018), who classified the simulators into five groups based on the level of fidelity of the tool concerning its actual implementation in clinical practice: (a) standardized patients, (b) task trainers, (c) mannequins, (d) computer-based, and (e) immersive virtual reality.

Table 1 summarizes each simulators definition, includes an example and trade names of the grouped simulators identified in the study sample. It can be seen that the existence of simulators in all fields of training and with different levels of fidelity. According to this classification, computer-based simulators focus on providing visual, conceptual, and in some cases, interactive experiences, but do not include an active strategy. These might be the least expensive, while immersive virtual reality simulators, standardized patients, and mannequins require more time and financial resources to build because they involve generating complex visualization systems, haptic feedback, and robust robotic systems. Finally, the task- specific trainers may be less expensive, and since they solve a smaller problem, this could be the appropriate choice in the case of universities or simulation centers interested in developing tools adapted to the needs.

Figure 1 shows the percentage distribution of the use of simulators according to the classification described in Table 1. According to this figure, there is a clear trend to use health care simulation in Bachelor undergraduate programs, followed by graduates and finally by two or three years (2-3 yr) undergraduate programs. This result is particularly interesting because one would expect the use of simulators to correlate with the complexity of the skills to be developed. Although in the case of undergraduate programs, non-formal training and 2-3 yr programs this trend is evident (greater complexity it implies greater use of simulators), the same does not happen in the case of graduate programs, which could be related to the high cost of these simulators.

Following the classification previously depicted, we found there are: 29.17% task trainers, 25.52% mannequins, 19.27% standard patients, 19.63% Computer-based simulators, and 10.42% belong to the immersive virtual reality group. This very low result in terms of immersive virtual reality systems can be related to the penetration times of new technologies, such as serious games, and the low level of development of customized solutions. The low use of simulators in undergraduate academic programs of 2-3 yr is a paradox because, in these academic levels the training demand is focused on the development of important motor skills and soft skills, aspects in which simulation tools have proven to be very useful.

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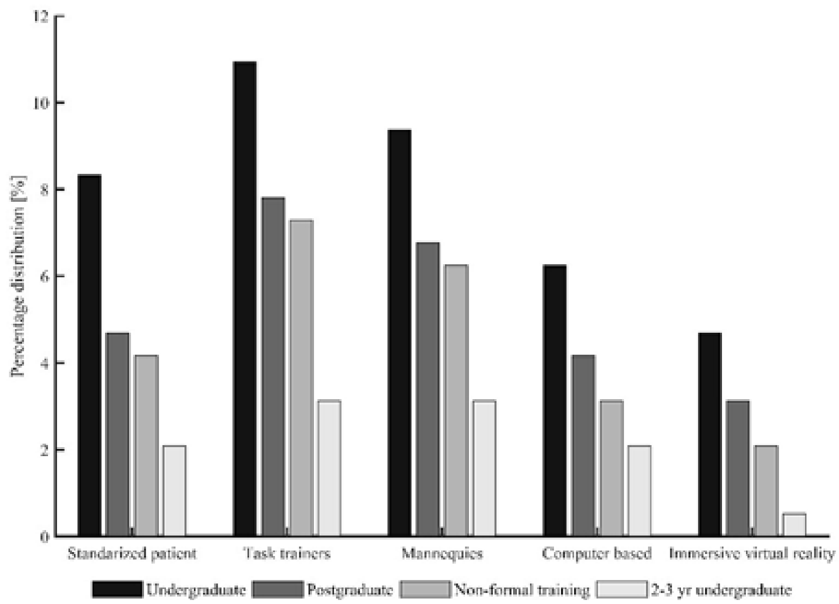
Figure 1. *Percentage distribution of different kinds of simulators from the total guided academic work. The simulators were grouped according to the fidelity levels (Table 1).*



Source: Authors own creation

Seems like the most common use of simulators are SimMom, RCP mannequin, Zoe, and Airway Larry; and something similar happens with mannequins simulators, had more emphasis on articulated models of the human body, which are multipurpose simulators and are used both in undergraduate and graduate programs.

In the case of Immersive virtual reality simulators, the use is focused on a three-dimensional environment generated by computer technology, like LapSim, EndoTrainer, and Lap Mentor III (*LAP Mentor III*, no date). While in the case of computer-based simulators, its use has been focused on a simulation of a model of a given system but in mobile/web applications like Sectra Table, Anatomage, CardioLab, and RespiLab (*Mesa de Disección Virtual SECTRA*, no date; Hernandez *et al.*, 2009).

The use of clinical simulation spaces and simulation tools of HEIs and simulation centers in the country, according to the results presented in Table 2, were distributed between strengthen knowledge, acquire skills, research activities, and performance of academic evaluations. The primary purpose was the acquisition of skills for all institutions, followed by the performance of academic evaluations, strengthen knowledge and research activities. Acquiring skills in 2-3 yr undergraduate programs is the most important use of simulators, which confirms the paradox because just in those programs, there are fewer simulators, according to Figure 1.

Table 2. *Current use of the simulation spaces. N corresponds to the number of higher education institutions.*

Use	Simulators in different levels of Higher Education [%]			
	Undergraduate N = 25	Graduate N = 19	2-3 yr undergraduate programs N = 8	Non-formal training in Labs and Sim-Centers N = 17
Strengthen knowledge	24.05	27.27	24.00	28.57
Acquire skills	31.65	28.79	32.00	30.36
Research activities	15.19	16.67	12.00	12.50
Performance of academic evaluations	29.11	27.27	32.00	28.57

Source: Authors own creation.

In order of importance in terms of acquiring skills, the most value use is in 2-3 yr undergraduate programs (32.00%), followed by undergraduate programs (31.65%), Non-formal training in Labs, and Sim-Centers (30.36%) and finally by graduate programs (28.79%). These results can be comparable with the use for performance of academic evaluations, where the higher use is in 2-3 yr undergraduate programs (32.00%) and the lower in graduate programs (27.27%). Regarding research activities, it is confirmed that institutions have simulation tools in health mainly for training processes, and their use in research is significantly dismissed. Research activities are concentrated and comparable in postgraduate and undergraduate programs, with values of 16.67% and 15.19%, respectively.

Although the above meets the objective that students can use the spaces to consolidate knowledge and be evaluated, it is

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also remarkable that in none level of education, the design and development of simulators are a priority for research activities, at least for 14.49% (10/69) of the HEIs and simulation centers of this study (sample).

Likewise, as shown in Table 3, training and acquisition of skills through spaces and simulation tools are mainly focused on the fields of general medicine (25.81%), respiratory system (14.87%), gynecology and obstetrics (12.31%), nursing (10.77%), and surgery (10.26%). However, it highlights low percentages in the acquisition of simulation tools stand out in areas of professional training that currently present an increase in the demand for students, such as bioengineering (2.05%), nutrition (2.05%), and veterinary-zootechnics (1.03%).

Table 3. *Percentage of use of different kinds of simulators and simulation tools from the total areas of training in health sciences in the HEIs along the country.*

Health area	%	Health area	%	Health area	%
General medicine	24.62	Nutrition	2.05	Pediatrics	8.72
Surgery	10.26	Obstetrics and Gynecology	12.31	Veterinary and zootechnics	1.03
Nursing	10.77	Ophthalmology and optometry	4.10	Respiratory system	14.87
Physiotherapy	4.62	Cardiology	4.62	Bioengineering	2.05

Source: Authors own creation.

4. Discussion

In general, simulators, software applications, and spaces for clinical simulation could significantly improve the traditional pedagogical methodology, and it is possible by the implementation of "real situations" with greater precision and care towards patients. Thus, the results shown in Figure 1, allow inferring that most of the simulators that are acquired by HEIs in Colombia belong mainly to two of the five subgroups mentioned in Table 1: mannequins and task trainer. This could be because these offer models like the anatomy of the human body and can be used in controlled scenarios, which are generally modified or configured through computer programs. According to the information collected, there is no evidence in any of the HEIs the existence of tools that facilitate the implementation of the prebriefing and debriefing stages during the learning process, nor the existence of software and databases that allow assessing the impact of the training processes.

In general terms, the number of these simulators available in the country is still insufficient (see Figure 1), considering the increase in the number of students admitted to health programs in recent years. Further, according to published by the SNIES, of the 377 programs offered at the undergraduate level in health sciences, there are more than 60,000 active students throughout the Colombian territory (Ministerio de Educación de Colombia, 2019). This population of students requires versatile tools to improve the necessary abilities to perform simple or complex clinical procedures, especially when the law in Colombia strictly regulates the number of hours of clinical practice in hospital environments (Ministerio de Salud y Proteccion Social, 2009). The above not only reduces training spaces but also strengthens the need for technology acquisition and development because these tools significantly increase the number of students who can receive individual training, improving their skills and considerably reducing training costs per student (Padilha, Machado, Ribeiro and Ramos, 2018). It is important to note that the purpose is not to replace the training with patients but to reduce both times in the performance of multiple procedures, as well as the risks derived from the inexperienced professional, also promoting teamwork and leadership skills in trainees (Baeza A et al., 2011). Concerning the simulation services offered by specialized laboratories and centers, the numbers evidence an immature sector where professionals use the non-formal retraining services timidly in contrast with industrialized countries where this kind of centers, even provide continuous evaluation services (DeMaria, Levine and Bryson, 2010) including research activities to optimize procedures, protocols and improve the treatment in some cases.

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Likewise, this weakness in the availability of resources also extends to research activities, whose destination does not exceed 17% at all levels of training. The primary purpose of these training spaces at the level of undergraduate is the acquisition of skills and knowledge assessment (see Table 2). The above percentage is contradictory because many studies have shown that the use of simulators and their implementation facilitate the training of professionals and researchers to acquire skills for generating new knowledge, with the capacity for analysis, synthesis and critical thinking (Banerjee, 2019; Clay and Gold, 2019).

Development of new tools is a need, even more evident given the low percentage of use, mainly because the lack of simulators (see Table 3) in relevant areas in health sciences training as gynecology and obstetrics (12.31%), surgery (10.26%) and cardiology (4.62%), which require specific skills. The lack of spaces and devices for training in these areas can directly impact the occurrence of adverse events, for example, the development of infections in the patient related to the mode of transmission of infectious agents and the kind of care. Activities that the Ministry of Health in Colombia seeks to minimize under the application of strict protocols, for the first semester of 2019, it generated the notification of 2071 adverse events only due to infections associated with medical devices, 18.7% more than the previous year. Catheter-associated bloodstream infection was the most frequent type of infection (47.5%), followed by pneumonia associated with a mechanical ventilator (26.8%) and symptomatic infection of the catheter-associated urinary tract (25.5%) (Rivera Vargas, 2019). In addition, there is a lack of simulation spaces, devices, or software in areas with very high rates of adverse events, such as neurosurgery, medicine administration (infusion pumps), anesthesiology, and urgency services, among others. Therefore, more professional training is required, which can be through multiple simulators and medical software applications. These tools must be designed, in a general or specific way, according to the needs or interests of each specialty in the health sciences, employing simulation scenarios that allow implementing improvements in the performance of these events, for example, with training in face-to-face or semi-face-to-face courses.

4. Conclusion

Despite the different studies and experiences that have demonstrated the usefulness of including simulation in the training processes in the areas of health, great immaturity is evident in Colombia in terms of the conception of the utility of simulation, in general, the HEIs and simulation centers do not have research processes articulated with simulation-based health training processes. There is neither evidence of interest in the development and implementation of simulators that enable the development of new diagnostic and therapeutic techniques, which limits the possibilities of training and generation of new knowledge, particularly in those areas that companies who develop simulators consider uninteresting.

The most commonly used simulators were mannequins and standardized patients, had more emphasis on articulated models of the human body. The weakness of the country in the availability of simulators in areas like neurosurgery, gynecobstetrics, urgency services, physiotherapy, nutrition, ophthalmology, cardiology, and veterinary represent an interesting opportunity for research and development teams in universities and companies. Some of these areas could be widely covered by software applications, which characterize these opportunities by requiring little investment.

The vision of the usefulness of simulation in healthcare is still precarious in Colombia because it is not evident that it is used in the framework of a structured process in which the activities prior to and after the simulation are a fundamental part of the training. Therefore, not only should efforts be concentrated on acquiring or developing simulation tools, training processes for the use of simulators are also necessary. This would reduce costs and facilitate the development of research activities aimed at improving clinical practice, reducing adverse events, and developing tools adapted to the needs.

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5. References

ADAM-X, Human Patient Simulator (2017) *MEDICAL-X*. Available at: https://www.medical-x.com/products/adam_x/.

Baeza A, M. A., Mella B, J., Soldati O, A., Escuelero Z, E., Tapia S, A. and Arraztoa V, J. A. (2011) 'Aplicabilidad de Simuladores de Mediana Complejidad en el Proceso de Formación de Residentes de Ginecología y Obstetricia', *Revista chilena de obstetricia y ginecología*. [Online] https:// doi.org/10.4067/s0717-75262010000600002.

Banerjee, I. (2019) 'Integration of ICT in pedagogy of teacher education: Influence of constructive thinking in global socierty', *International Journal of Scientific Research and Review*, 07(06), pp. 130–136.

Bustos Jorge (2012) 'Aprendizaje basado en problemas y simulación clínica: aprendiendo por competencias en la educación en salud', 1(1), pp. 52–61. [Online] https:// doi.org/10.1590/1518-8345.0979.2734.

Clay, A. S. and Gold, J. A. (2019) 'Teaching with Simulation', in *Medical Education in Pulmonary, Critical Care, and Sleep Medicine*. Humana, Cham, pp. 213–233. [Online] https:// doi.org/10.1007/978-3-030-10680-5_12.

Congreso de Colombia (2018) *Ley 1917 de 2018*.

Davis, B. and Summers, M. (no date) *Applying Dale's Cone of Experience to increase learning and retention: A study of student learning in a foundational leadership course*. [Online] https:// doi.org/10.5339/qproc.2015.elc2014.6.

DeMaria, S., Levine, A. I. and Bryson, E. O. (2010) 'The use of multi-modality simulation in the retraining of the physician for medical licensure', *Journal of Clinical Anesthesia*. Elsevier Inc., 22(4), pp. 294–299. [Online] https:// doi.org/10.1016/j.jclinane.2008.12.031.

van Dongen, K. W., Tournoij, E., van der Zee, D. C., Schijven, M. P. and Broeders, I. A. M. J. (2007) 'Construct validity of the LapSim: Can the LapSim virtual reality simulator distinguish between novices and experts?', *Surg Endosc*, 21(8), pp. 1413–1417.

Dudding, C. C. and Nottingham, E. E. (2018) 'A national survey of simulation use in university programs in communication sciences and disorders', *American Journal of Speech-Language Pathology*, 27(1), pp. 71–81. [Online] https:// doi.org/10.1044/2017_AJSLP-17-0015.

Guerrero-Aragón, S. C., Chaparro-Serrano, M. F. and García-Perdomo, Á. A. (2017) 'Evaluación por competencias en salud: revisión de literatura', *Educación y Educadores*, 20(2), pp. 211–225. [Online] https:// doi.org/10.5294/edu.2017.20.2.3.

Hernandez, A. M., Herrera, G. P., Ma, M. A., Ciber-bbn, B. N. and Costa-castell, R. (2009) 'Cardiolab : A Virtual Laboratory for the analysis of Human Circulatory', in *2009 IEEE Conference on Emerging Technologies & Factory Automation*. [Online] https:// doi.org/10.1109/ETFA.2009.5347145.

Kyle, R. R. and Bosseau Murray, W. (2008) *Clinical Simulation*, *Clinical Simulation*. Academic Press. [Online] https:// doi.org/10.1016/B978-012372531-8.50137-0.

Laerdal Medical Corporation (2018) *Laerdal Medical*. Available at: https://www.laerdal.com/ (Accessed: 12 April 2019).

Laerdal Medical Corporation (2019) *SimMan 3G: Ayudando a mejorar los resultados en los pacientes*. Available at: https://www.laerdal.com/la/products/simulation-training/emergency-care--trauma/simman-3g/ (Accessed: 26 February 2020).

Lamé, G. and Dixon-Woods, M. (2018) 'Using clinical simulation to study how to improve quality and safety in healthcare', *BMJ Simulation and Technology Enhanced Learning*, p. bmjstel-2018-000370. [Online] https:// doi.org/10.1136/bmjstel-2018-000370.

López de la Madrid, M. C. (2007) *Uso de las TIC en la educación superior de México. Un estudio de caso*.

Lopreiato, J. O. (2016) *Healthcare simulation Dictionary*. Edited by J. O. Lopreiato. Society for Simulation in Healthcare Associate. [Online] https:// doi.org/10.1145/324898.325330.

Mancilla Carriel, J. A. and Ramírez Amat, G. (2012) 'Prácticas de simulación en medicina: ventajas, limitantes, recuento histórico y perspectiva ecuatoriana', *Medicina*, 17(4), pp. 285–291.

Medical X (2017) *LAP-X, Laparoscopic surgical simulator*. Available at: https://www.medical-x.com/products/lap_x/ (Accessed: 9 April 2019).

Mesa de Disección Virtual SECTRA (no date) *Simulat: Simulación médica*.

Ministerio de Educación de Colombia (2019) *SNIES - Sistema Nacional de Información de la Educación Superior*. Available at: https://www.mineducacion.gov.co/sistemasinfo/snies/ (Accessed: 9 October 2019).

Ministerio de Salud y Proteccion Social (2009) *Decreto 2376*, *Diario Oficial No. 47.392*.

Offiah, G., Ekpotu, L. P., Murphy, S., Kane, D., Gordon, A., O'Sullivan, M., Sharifuddin, S. F., Hill, A. D. K. and Condron, C. M. (2019) 'Evaluation of medical student retention of clinical skills following simulation training', *BMC Medical Education*. BioMed Central, 19(1), p. 263. [Online] https:// doi.org/10.1186/s12909-019-1663-2.

Padilha, J. M., Machado, P. P., Ribeiro, A. L. and Ramos, J. L. (2018) 'Clinical Virtual Simulation in Nursing Education', *Clinical Simulation in Nursing*. Elsevier, 15, pp. 13–18. [Online] https:// doi.org/10.1016/J.ECNS.2017.09.005.

Portillo, A., Rosalba, N., Escobar, E., Maidel, J. and Jiménez, J. E. (2017) *Las nuevas tecnologias de informacion y comunicacion social (TIC's) inciden en la enseñanza aprendizaje de las competencias academicas de la informatica en los estudiantes de primer año*. Universidad de El Salvador.

Rivera Vargas, S. M. (2019) *Informe de infecciones asociadas a dispositivos, Colombia, I semestre 2019*. Bogotá, Colombia.

Salinas, J. (2004) 'Innovación docente y uso de las TIC en la enseñanza universitaria', *Revista de Universidad y Sociedad del conocimiento*, pp. 1–16. [Online] https:// doi.org/10.7238/rusc.v1i1.228.

Saraí Aguilar-Barojas (2005) 'Fórmulas para el cálculo de la muestra en investigaciones de salud', *Salud en Tabasco*, 11, pp. 333–338.

Simulador ginecológico ZOE (no date) *3B Scientific*.

Utili Ramírez, F. (2007) 'Simulación en el aprendizaje, práctica y certificación de las competencias en medicina', *ARS MEDICA Revista de Ciencias Médicas*, 36(2), p. 152. [Online] https:// doi.org/10.11565/arsmed.v36i2.154.