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**Uses of simulation during COVID-19 pandemic: a scoping review**

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**Key words:** COVID-19; healthcare simulation; virtual reality; medical education; technical and non-technical skills.

**Contributions:** GM, MP, conceived and designed the review, wrote the paper and revised it; IC, conceived and designed the review, analyzed the data, wrote the paper and revised it; AV, CP, GT, MG, MF, SP, analysed the data, revised the article; SS, PLI, wrote and revised the paper; PN, revised the paper. All authors read and approved the final manuscript.

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**Abstract**

Some experts have suggested how to use simulation during the pandemic, and simulation activities were carried out observing COVID-19 restrictions to improve technical and non-technical skills in health professionals. Several papers have been published on this. Through a retrospective review of the literature, we analyzed studies published during the pandemic to assess how simulation was used during this historical period. We conducted a retrospective review of the literature. The search generated 11,375 records. After removing duplicates, 5431 studies were screened. Of the 643 eligible full-texts, 221 were excluded. A total of 422 articles met the inclusion criteria. Half of the 422 included studies were carried out specifically for COVID-19 (211), while 152 (36%) were carried out during the pandemic but for other reasons. The analysis showed that simulation was used during the pandemic, with clear educational and research objectives. Most of the included studies dealt with COVID-19, focusing on high-acuity and critical scenarios but also including technical and non-technical skills. The experience gained from both “COVID-related” and “During

COVID" studies could be applied to other settings in the event of urgent training needed for disasters and to tailor simulation courses for retaining technical skills.

## Introduction

At the beginning of the COVID-19 pandemic in early 2020, the clinical characteristics of this new disease were poorly known, as well as procedures to treat patients and prevent contagions among healthcare personnel. Regardless of the income levels of the country, national health systems were diffusely unprepared to face this unprecedented challenge that rapidly depleted resources and resilience.[1] According to the principles of disaster medicine,[2] several strategies were implemented to reorganize the available personnel and equipment and repurpose structures in an attempt to mitigate the change in care levels from conventional to emergency and crisi.[3-5]

In particular, hospitals converted beds for non-urgent activities into COVID-19 wards; as a consequence, the personnel had to be specifically trained. Furthermore, traditional teaching directly at the patient's bedside has no longer been possible to prevent the spread of the disease. For these reasons, simulation became essential, despite simulation centers being closed to avoid spreading the spread of the disease.[6] Some experts have suggested how to use simulation during the pandemic,[7] and simulation activities were carried out under COVID-19 restrictions to improve technical and nontechnical skills in health professionals. Several papers have been published detailing the use of simulation during this period. This work aims to analyze such papers and assess how simulation was used in the COVID-19 pandemic.

## Materials and Methods

### *Study design*

A scoping review methodology was chosen to evaluate how simulation in healthcare was used during the COVID-19 pandemic, following the Joanna Briggs Institute Reviewers Manual 2020[8] and the Preferred Reported Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-Scr).[9]

After applying the mnemonic 'PCC' (Participants, Concept, Context) to develop the research question, the following inclusion criteria were defined: i) Types of participants: studies describing the use of simulation to train healthcare professionals, personnel involved in simulation training, and healthcare students; ii) Concept: to obtain and describe a perspective on the use of simulation in training healthcare professionals/students/sim trainers during the COVID-19 pandemic; iii) Context: papers detailing the use of simulation during the COVID-19 pandemic in all settings and locations, starting from January 2020 to June 2021; iv) Types of evidence sources: all types of studies reporting data (research studies/original studies) or extensively describing the experience of sim centers.

***Search strategy***

The search strategy was developed using a combination of subject headings and keywords related to two distinct groups: simulation in healthcare (a) and the COVID-19 pandemic (b). The final search string for MEDLINE can be found in Supplementary Materials, Section 1.

The search was carried out on 30 June 2021 in the following databases: MEDLINE, EMBASE, CINAHL, SCOPUS, Expanded Science Citation Index, Conference Proceedings Citation Index and Cochrane Database of Systematic Reviews (CDSR) (see Supplementary Materials, Section 1, Descriptive document showing the search strategy with results). The results were limited to articles published in English between December 2019 and June 30, 2021. The search was not updated before submitting the manuscript since the number of publications grew exponentially (see Supplementary Materials, Section 2).

After removing duplicates with Zotero 5.0.96.3 (CHNM, George Mason University, Fairfax, VA, USA), two authors (IC, SP) independently scanned the title and abstract of each record for eligibility. Studies that did not meet the criteria were excluded. In case of disagreement, a third opinion was sought (PLI). If available, the full texts of eligible manuscripts were evaluated and included if they met the inclusion criteria.

***Data extraction***

Six authors (AV, CP, GT, MG, MF, SP) worked in pairs to extract data from the included studies into standard templates. To ensure consistency in the process, all reviewers previously screened and extracted data from 20 selected publications and discussed the results together. Any disagreement was solved with a senior author (PLI, GM, MP).

All data obtained were coded onto a master sheet using a Microsoft Office Excel spreadsheet (Version 2016, Microsoft Corporation, Redmond, WA, USA) and classified into the following topics: i) study general characteristics: publication year, country, type of study, country level of income (according to the "World Bank Country and Lending Groups" classification;[10] ii) relationship with the COVID-19 pandemic: "COVID-related" studies (studies conducted specifically to test procedures or train personnel dealing with the COVID-19 pandemic), or "during COVID" studies (studies conducted during the pandemic but focused on other diseases or healthcare issues than COVID-19); iii) specific characteristics of the study, according to the conceptual framework proposed by Chiniara *et al.*[11] (namely: simulation zone; team composition; types of participants; setting, types of procedures and fidelity; simulation modality configuration; and purposes of the studies (train to clinical management of patients with COVID-19 (scenario), procedural training, test and prepare to face new protocols, test new equipment, latent threats, others); iv) notably, one study could contain one or more investigated features.[11]

Data were described by their distribution frequency.

## Results

### *Study selection*

The search generated 11,375 records. After removing duplicates (5944), 5431 studies were screened. 4788 articles were excluded because they did not meet the inclusion criteria at the first screening. Of the 643 eligible full-texts, 221 were excluded (specific reasons for exclusion are shown in Figure 1). A total of 422 articles met the inclusion criteria.

### *Study general characteristics*

During 2020, 205 (48.6%) records were published, while the remaining 217 (51.4%) were indexed in the first six months of 2021 (see Supplementary Materials, Section 3**)**

The characteristics of the included studies according to the year of the simulation are shown in Tables 1 and 2.

Some studies may be included in more than one category because they may have different data related to the same category. At the same time, some studies are not included in the table because they may have irrelevant or missing responses to the data analysed.

### *Relationship with the COVID-19 pandemic*

Half of the 422 included studies were carried out specifically for COVID-19 (211), while 152 (36%) were carried out during the pandemic but for other reasons than COVID-19; 59 records (14%) were not classified (opinion papers/editorials).

### *Specific study features*

Tables 1 and 2 also show the specific characteristics of the study in relation to the period of the COVID-19 pandemic. Figure 2 shows the distribution of simulation zones between COVID-related and during COVID studies.

The purposes of the "COVID-related" studies were: "Test a new protocol" (n=62), "Test new equipment" (n=61), "Train clinical management of COVID-19 patients (scenario)" (n=84), and "techniques and procedures" (n=48). The purpose of "During COVID" studies mostly focused on "Techniques and procedures" (n=52) and were marginally dedicated to "Test a new protocol" (n=12) or "Test new equipment "(n=3).

The distribution of the simulation modality between COVID-related studies and during COVID studies is shown in Figure 3 and Figure 4 represents the type of simulator.

**Discussion**

This scoping review included 422 simulation studies published in the first 18 months of the COVID-19 pandemic (01 January 2020 – 30 June 2021). Interestingly, an exponential increase in published simulation research was observed, probably related to the growing role of simulation science in healthcare as an effective tool to test and implement procedures and safely train personnel(12-13) along with the contingent and urgent need of training despite teaching constraints, as discussed below (see Supplementary Materials, Section 2).

Most of the articles are observational, simulation scenarios, or letters/editorials, with randomised trials comprising only 5.9%.

In this review, a dynamic and coherent use of the simulation emerged between the relationship with COVID-19 and the specific characteristics of the study. Being COVID-19 a high acuity and poorly known disease – with an unpredictable increase in prevalence across countries during 2020 – the "COVID-related" manuscripts consistently reported HALO and HAHO scenarios (Figure 2).[11] In the same vein, 'COVID-related' studies were mostly used to test new protocols and equipment and to securely train personnel to treat a poorly known disease, to increase patient and personnel safety.[14] This subset of studies primarily trained consultants and not students, probably with the intent to deliver content to those deployed on the frontline against the pandemic. Also, training of interdisciplinary teams in "COVID-related" studies seems to be prioritized; this can be explained

through existing studies in the literature suggesting the positive effects of interprofessional simulation on non-clinical outcomes,[15] such as improved teamwork skills[16] or reduction of healthcare personnel infections.[17] Again, simulations in “COVID-related” studies were reproduced in situ, favoring the fidelity of patients and environment to improve COVID-19 patient management in error-prone settings such as EDs, ICUs, and ORs, but also with potential effects on team development as suggested by Martin *et al.*[18]

In this review, among “COVID-related” records, the most adopted modality was procedural simulation, in which a simulator allows training specific psychomotor skills and their associated procedures.[11] Specifically, the simulations described in the “COVID-related” studies focused on the procedures related to airway management and ventilation, probably due to the peculiar characteristics of COVID-19. Another common simulation modality was the simulated patient; (Chiniara defines the simulated patient as a modality in which an actor, a patient, or a patient simulator plays the role of an actual patient, also called “standardized patient”). This is typically used for training in patient management, clinical diagnosis, and affective objectives,[11] with improvements previously registered in learning experience.[19]

On the other hand, the 152 studies conducted 'During-COVID' have different characteristics. First, it is possible that such a large amount of published simulated training has been due to restrictions imposed by governments to contain the spread of Sars-CoV-2, specifically by reducing the number of trainees allowed in wards or ambulatory care. Additionally, the “During-COVID” studies were more focused on LAHO, probably to maintain specific skills, as the prevalence of acute presentations in the ED and hospital admissions changed drastically during the first months of each pandemic peak.[20]

Consistent with the pandemic situation, limiting frontal training, and the need for healthcare professionals, this review found several studies 'During COVID' in which the purpose of the simulation was to train techniques and procedures other than COVID-19. The off-site and patient fidelity emerged as the most used in “COVID related” studies, probably because studies

concentrated more on developing clinical skills on simulated patients rather than the scenario. Furthermore, the use of computer simulation and virtual reality has emerged in 'COVID-related' studies, opening new ways of teaching, such as individual training and remote training; Such features could have helped healthcare personnel learn or retain technical skills during COVID-19 restrictions, which are enacted differently in all countries. Izard *et al.*, in their study, analyze how virtual reality can improve the methodologies used for medical training and discuss the implications as tools for teaching, learning, and training.[21]

## Conclusions

In conclusion, our analysis showed that simulation was significantly used during the pandemic, with clear educational and research objectives. Most of the included studies dealt with COVID-19, focusing on high-acuity and critical scenarios but also including technical and non-technical skills. The experience gained with both “COVID-related” and “During COVID” studies could be applied to other settings in case of urgent training needed for disasters and to tailor simulation courses for retaining technical skills.

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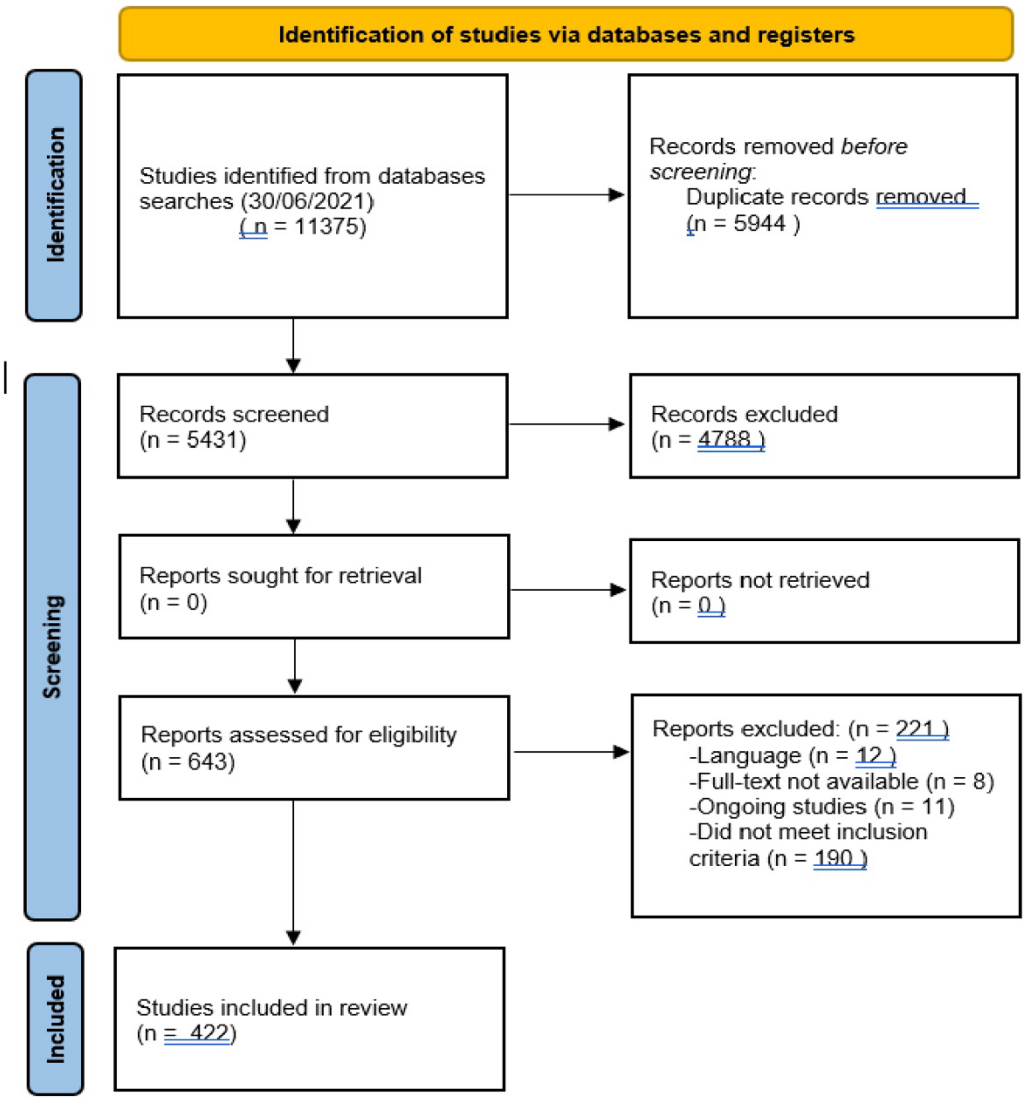


**Figure 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for study selection.

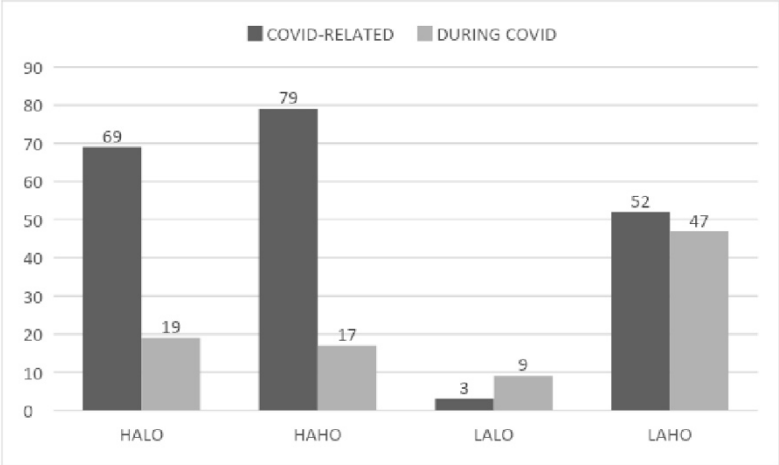


**Figure 2**. Distribution of simulation zones between COVID-related and during COVID studies. The most common simulation zone among COVID-related studies was HAHO (High Acuity High Opportunity) (37%); the most common simulation zone during COVID studies was LAHO (Low Acuity High Opportunity) (34%). HALO: High Acuity Low Opportunity; LALO: Low Acuity Low Opportunity. Some studies may be included in more than one category because they may have different data related to the same category. At the same time, some studies are not included because they may have irrelevant or missing responses to the analysed data.

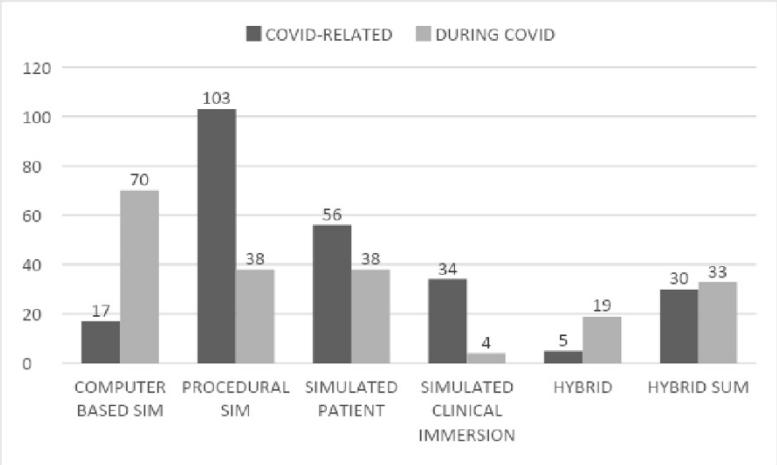


**Figure 3.** Distribution of the simulation modality between COVID-related studies and during COVID studies. The most common simulation modality among COVID-related studies was procedural simulation (49%) and simulated patient (26%). The most common simulation modality during COVID studies was computer-based simulation (46%), simulated patient (25%), and procedural simulation (25%). Hybrid sum: combined modalities of simulation in multiple sessions of a simulation program. Some studies may be included in more than one category because they may have different data related to the same category. At the same time, some studies are not included because they may have irrelevant or missing responses to the analysed data.

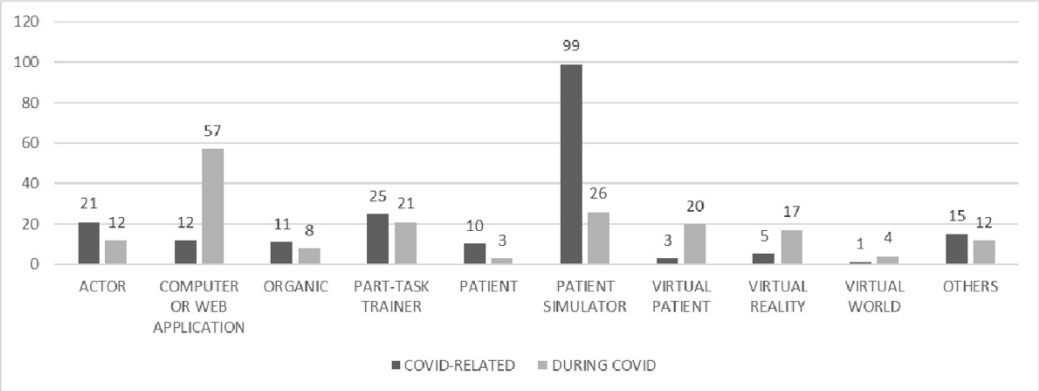


Figure 4. Presentation: simulator type. The most common simulator type among COVID-related studies was patient simulator (47%). The most common simulator type among COVID-studies was computer or web application (37%). Some studies may be included in more than one category because they may have different data referable to the same category. At the same time, some studies are not included because they may have irrelevant or missing responses to the data analyzed.

**Online Supplementary Materials**

**Section 1.** Descriptive document showing the search strategy with results.

**Section 2.** Bibliometric analysis. The figure shows the number of records identified exclusively with PubMed with the search strategy used for this review. The search period is from January 2020 to December 2021 with a monthly breakdown. As the figure shows, between January 2020 and June 2021, 3184 articles were identified, and between July 2021 and December 2021, 1804 articles were identified. Note that the growth in the number of publications makes it impossible to update the review before publication.

**Section 3.** Characteristic of the included studies according to the year of the simulation.

**Dataset**

**Table 1. Participants**.

| | | COVID-RELATED | DURING COVID | TOTAL |
|---|---|---|---|---|
| **Population: status of participants** | | | | |
| | *Physician (consultant)* | 127 (81,4%) | 29 (18,6%) | 156 |
| | *Resident* | 61 (53,5%) | 53 (46,5%) | 114 |
| | *Medical student* | 18 (27,3%) | 48 (72,7%) | 66 |
| | *Nurse student* | 12 (40%) | 18 (60%) | 30 |
| | *Nurse* | 80 (90,9%) | 8 (9,1%) | 88 |
| | *Simulation technician* | 6 (50%) | 6 (50%) | 12 |
| | *Psychologist* | 2 (66,6%) | 1(33,3%) | 3 |
| | *Engineer* | 4 (57,1%) | 3 (42,9%) | 7 |
| | *Pre-hospital Emergency Medicine Team* | 5 (83,3%) | 1 (16,7%) | 6 |
| | *Interprofessional* | 43 (87,8%) | 6 (12,2%) | 49 |
| | *Others* | 55 (70,5%) | 23 (29,5%) | 78 |
| **Presentation: team composition** | | | | |
| | *Single discipline* | 72 (51,1%) | 69 (48,9%) | 141 |
| | *Interdisciplinary / Interprofessional* | 78 (82,9%) | 16 (17,1%) | 94 |
| | *Actors* | 16 (76,2%) | 5 (23,8%) | 21 |
| | *Work unit* | 86 (78,2%) | 24 (21,8%) | 110 |
| | *Others* | 3 (42,9%) | 4 (57,1%) | 7 |

**Table 2. Setting of the included simulation studies.**

| | | COVID-RELATED | DURING COVID | TOTAL |
|---|---|---|---|---|
| **Location** | | | | |
| | *In situ* | 112 (92,6%) | 9 (7,4%) | 121 |
| | *Off-site* | 37 (36,3%) | 65 (63,7%) | 102 |
| | *Others* | 6 (27,3%) | 16 (72,7%) | 22 |
| **Setting** | | | | |
| | *Emergency Department* | 44 (95,7%) | 2 (4,3%) | 46 |
| | *Intensive Care Unit* | 38 (92,7%) | 3 (7,3%) | 41 |
| | *Operating room* | 30 (78,9%) | 8 (21,1%) | 38 |

| | | | |
|---|---|---|---|
| *Emergency Medical Service* | 4 (100%) | 0 (0%) | 4 |
| *Obstetrics & Gynecology* | 10 (76,9%) | 3 (23,1%) | 13 |
| *Others* | 41 (53,9%) | 35 (46,1%) | 76 |
| **Presentation: fidelity (realism)** | | | |
| *Patient (physical) fidelity* | 102 (72,9%) | 38 (27,1%) | 140 |
| *Environment fidelity* | 81 (85,3%) | 14 (14,7%) | 95 |
| *Temporal fidelity* | 22 (73,3%) | 8 (26,7%) | 30 |
| *Others* | 20 (40%) | 30 (60%) | 50 |