

**SCIENTIFIC PRODUCTION ON THE CHALLENGES IN STUDENT TRAINING
AND TEACHING PRACTICES IN HEALTH: BIOMEDICINE IN THE COVID-19
PANDEMIC – A SYSTEMATIC LITERATURE REVIEW**

***PRODUÇÃO CIENTÍFICA SOBRE OS DESAFIOS NA FORMAÇÃO DISCENTE E
PRÁTICAS DOCENTES NA ÁREA DA SAÚDE: BIOMEDICINA NA PANDEMIA DA
COVID-19 – UMA REVISÃO SISTEMÁTICA DE LITERATURA***

***PRODUCCIÓN CIENTÍFICA SOBRE LOS DESAFÍOS EN LA FORMACIÓN
DISCENTE Y LAS PRÁCTICAS DOCENTES EN SALUD: BIOMEDICINA EN LA
PANDEMIA DE COVID-19 – UNA REVISIÓN SISTEMÁTICA DE LITERATURA***



Carla PISONI¹

e-mail: cpisoni@ucs.br



Elias da Rosa HOFFMANN²

e-mail: erhoffmann@ucs.br



Deise Renata BRINGMANN³

e-mail: deise.renata@ucs.br

How to reference this paper:

Pisoni, C., Hoffmann, E. R., & Bringmann, D. R. (2026). Scientific production on the challenges in student training and teaching practices in health: biomedicine in the COVID-19 pandemic – a systematic literature review. *Revista on line de Política e Gestão Educacional*, 30, e026092. <https://doi.org/10.22633/rpge.v30i00.21421>



| Submitted: 10/06/2026

| Revisions required: 08/07/2026

| Approved: 11/08/2026

| Published: 18/08/2026

Editor: Prof. Dr. Sebastião de Souza Lemes

Editor Adjunto Executivo: Prof. Dr. José Anderson Santos Cruz

¹ Unifete University Center (UNIFETC), Caxias do Sul – Rio Grande do Sul (RS) – Brazil. Professor at Unifete University Center, Main Campus.

² University of Caxias do Sul (UCS), Caxias do Sul – Rio Grande do Sul (RS) – Brazil. Professor at the University of Caxias do Sul, Main Campus.

³ University of Caxias do Sul (UCS), Caxias do Sul – Rio Grande do Sul (RS) – Brazil. PhD in Health Sciences (UCS).

ABSTRACT: The COVID-19 pandemic caused significant transformations in higher education, especially in health-related programs, whose training depends directly on practical, laboratory, and clinical activities. This study analyzed scientific production regarding the challenges of student training and teaching practices in Biomedical Sciences during the pandemic through a Systematic Literature Review (SLR/PRISMA 2020). Searches were conducted in PubMed, Scopus, Web of Science, and Google Scholar (2020–2025). Of 15,550 identified studies, 13 were included in the qualitative synthesis. Results revealed reductions in practical activities, difficulties adapting to remote teaching, teacher overload, emotional distress, digital inequalities, and structural limitations. Conversely, expanded use of digital technologies and hybrid teaching models was observed. It is concluded that the pandemic accelerated structural transformations in health education, demanding investments in technological infrastructure, teacher training, and balanced integration of face-to-face and digital teaching.

KEYWORDS: Biomedical Sciences. Health education. Covid-19. Remote teaching. Student training.

RESUMO: A pandemia de covid-19 provocou transformações significativas no ensino superior, especialmente nos cursos da área da saúde, cuja formação depende de atividades práticas, laboratoriais e clínicas. Este estudo analisou a produção científica sobre os desafios da formação discente e das práticas docentes em Biomedicina durante a pandemia, por meio de Revisão Sistemática da Literatura (RSL/PRISMA 2020). Buscas foram realizadas no PubMed, Scopus, Web of Science e Google Scholar (2020–2025). Dos 15.550 estudos identificados, 13 foram incluídos na síntese qualitativa. Os resultados evidenciaram redução das atividades práticas, dificuldades de adaptação ao ensino remoto, sobrecarga docente, sofrimento emocional, desigualdades digitais e limitações estruturais. Em contrapartida, observou-se ampliação do uso de tecnologias digitais e modelos híbridos. Conclui-se que a pandemia acelerou transformações na educação em saúde, demandando investimentos em infraestrutura tecnológica, capacitação docente e integração equilibrada entre ensino presencial e digital.

PALAVRAS-CHAVE: Biomedicina. Educação em saúde. Covid-19. Ensino remoto. Formação discente.

RESUMEN: La pandemia de covid-19 provocó transformaciones significativas en la educación superior, especialmente en los cursos del área de salud, cuya formación depende directamente de actividades prácticas, de laboratorio y clínicas. Este estudio analizó la producción científica sobre los desafíos en la formación discente y las prácticas docentes en Biomedicina durante la pandemia, mediante una Revisión Sistemática de Literatura (RSL/PRISMA 2020). Las búsquedas se realizaron en PubMed, Scopus, Web of Science y Google Scholar (2020–2025). De 15.550 estudios identificados, 13 fueron incluidos en la síntesis cualitativa. Los resultados evidenciaron reducción de las actividades prácticas, dificultades de adaptación a la enseñanza remota, sobrecarga docente, sufrimiento emocional, desigualdades digitales y limitaciones estructurales. Por otro lado, se observó ampliación del uso de tecnologías digitales y modelos híbridos. Se concluye que la pandemia aceleró transformaciones en la educación en salud, exigiendo inversiones en infraestructura tecnológica, capacitación docente e integración equilibrada entre la enseñanza presencial y digital.

PALABRAS CLAVE: Biomedicina. Educación en salud. Covid-19. Enseñanza remota. Formación discente.

INTRODUCTION

The COVID-19 pandemic has brought about profound changes in educational systems on a global scale, significantly affecting the organization of higher education. The health crisis caused by the SARS-CoV-2 virus led to the abrupt suspension of in-person activities at schools and universities around the world, forcing governments to take emergency measures across a wide range of societal sectors (Dias & Pinto, 2020; Vieira & Silva, 2020). In Brazil, in March 2020, the Ministry of Health authorized the replacement of in-person classes with activities mediated by digital technologies (Menezes & Santos, 2021), driving the emergency adoption of remote learning and, subsequently, the implementation of hybrid models. These changes required higher education institutions, faculty, and students to make rapid and profound adjustments to their academic routines and pedagogical interactions (Araujo et al., 2020; Vieira & Silva, 2020).

These impacts were particularly intense in health-related programs. The abrupt transition to remote learning exposed a structural tension that goes beyond a simple migration to new platforms: health education requires supervised hands-on training, which is grounded in laboratory and clinical settings, a dimension that no digital platform can fully replace (Gusso et al., 2020; Rondini et al., 2020).

In Biomedicine, this tension takes on even more specific forms. In addition to the pedagogical challenges common to all higher education, biomedical professionals were at the forefront of the response to the pandemic itself, working in laboratory diagnostics, scientific research, and the development of therapeutic and vaccine strategies (Pearse & Scott, 2023). They were, therefore, completing their education in the midst of a crisis they themselves had to combat, which lends the topic a sense of urgency that has been largely unexplored in the educational literature.

Scientific literature published since 2020 has highlighted different perspectives on this process (Menezes & Santos, 2021). Some studies emphasize the challenges related to practical learning, perceptions of professional competence, and the subjective impact of the changes experienced by students, including increased levels of anxiety, stress, and cognitive overload (Araujo et al., 2020). Other studies highlight the reorganization of teaching work, the need for technological adaptation, and the redefinition of pedagogical strategies in a context of urgency (Winters et al., 2023). A systematic review of this body of work allows for the identification of trends, gaps, and convergences in the field of health education (Vieira & Silva, 2020).

Given this context, this article aims to analyze the scientific literature on the challenges of student education and teaching practices in Biomedicine during the COVID-19 pandemic, through a Systematic Literature Review (SLR/PRISMA 2020). The goal is to systematize the state of the art on the topic, identify analytical and methodological trends, and highlight gaps that may inform new research in the field of education and health training.

HIGHER EDUCATION, HEALTH EDUCATION, AND BIOMEDICINE IN THE CONTEXT OF THE PANDEMIC

Understanding the effects of the COVID-19 pandemic on higher education in health requires going beyond the general assessment that in-person activities have been suspended. It involves recognizing that higher education was already experiencing internal tensions related to curricular rigidity, unequal access, and the limitations of traditional methodologies, and that the health crisis brought these issues to light in an abrupt and undeniable way (Gusso et al., 2020). In this context, Ministry of Education Ordinance No. 343/2020, while authorizing the replacement of in-person classes with digital activities, made a crucial exception: professional practices such as internships and laboratory work were excluded from this substitution (Brasil, 2020). This regulatory exception implicitly acknowledges that there are aspects of health education that cannot be conveyed on a screen, and whose absence leaves a lasting impact on students' educational journey. From the perspective of university administration, the Ordinance posed an unprecedented governance challenge: maintaining institutional continuity without compromising the integrity of education, a task that required rapid decisions in contexts of high uncertainty (Gusso et al., 2020).

In health-related programs, the literature published between 2020 and 2025 converges on a central point: the absence of supervised practical activities is not a peripheral shortcoming, but a rupture at the core of the educational process. Studies have documented a direct impairment in the development of clinical and laboratory skills essential to professional practice, with impacts that extend beyond the pandemic period (Melo et al., 2022; Santos et al., 2020). From the perspective of institutional policies, this implies that the resumption of in-person clinical practice cannot be treated as a simple return to normal; it requires active planning to address gaps in training.

Biomedicine fits directly into this context. It is a program whose curriculum is structured around specific competencies, such as clinical analysis, oncological cytology, hematology, molecular biology, and microbiology, among others, which rely fundamentally on laboratory

activities, equipment management, and the technical interpretation of results. Pearse and Scott (2023), in a review of the international literature on clinical laboratory training, documented that the pandemic directly affected training, assessment, and professional development in biomedical laboratory settings, creating training gaps that require specific recovery strategies. In this regard, the interruption or reduction of in-person laboratory activities affected not only the development of technical skills but also the formation of professional identity and the confidence needed for the future practice of the profession (Rondini et al., 2020).

Thus, examining the scientific literature on this topic involves understanding not only the immediate effects of emergency remote learning but also the ways in which the literature has interpreted the repercussions of this period on student education and teaching practices. In this context, the systematic literature review proposed in this article seeks to situate Biomedicine within a broader debate on higher education, university teaching, and health education, recognizing that the pandemic served as an event that brought to light the limitations, challenges, and possibilities of the educational process in times of crisis (Gusso et al., 2020; Melo et al., 2022).

METHODOLOGY

This study is a Systematic Literature Review (SLR/PRISMA 2020), conducted with the aim of analyzing the scientific literature on the challenges of student education and teaching practices in Biomedicine during the COVID-19 pandemic, considering scientific publications produced between 2020 and 2025. The guiding question seeks to understand how the scientific literature has addressed the pandemic's impacts on teaching and learning processes, pedagogical adaptations, emergency remote learning, and the transformations that have occurred in academic health education, particularly in the context of Biomedicine.

A systematic review is a rigorous, transparent, and reproducible scientific method aimed at identifying, selecting, critically evaluating, and synthesizing the available evidence on a specific research phenomenon (Akobeng, 2005; Kitchenham, 2004; Petticrew & Roberts, 2006). In the field of health, this method is widely used because it enables the integration and critical analysis of scientific studies on a specific topic, contributing to the production of reliable evidence and the consolidation of scientific knowledge (Galvão & Pereira, 2014; Sampaio & Mancini, 2007).

To conduct this review, we followed the methodological steps proposed by Kitchenham (2004), organized into three main phases: planning, conduct, and presentation of results. The study adheres to the PRISMA 2020 guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for structuring and reporting the results (Page et al., 2021). The planning phase involved defining the research question, the study objectives, and the inclusion and exclusion criteria. During the conduct phase, studies were identified in scientific databases, followed by selection, methodological evaluation using the CASP (Critical Appraisal Skills Program) tool, and extraction and synthesis of the information. Finally, the results presentation phase consisted of organizing, critically analyzing, and discussing the evidence found.

Research questions

With the aim of identifying research focused on the challenges of student education and teaching practices in biomedicine and health education during the COVID-19 pandemic, searches were conducted for full-text scientific articles published in Portuguese and English that were available in open-access, indexed scientific databases. The main research question [MRQ] of this study is to examine the landscape of scientific literature regarding the impacts of the COVID-19 pandemic on academic training, pedagogical practices, and teaching and learning processes in Biomedicine and health education.

The [MRQ] was broken down into three specific research questions [SRQ]: [SRQ1]: What research methodologies have been adopted in studies on health education and training in the context of the pandemic? [SRQ2]: What were the main challenges faced by faculty and students during the COVID-19 pandemic in the context of health education and Biomedicine? [SRQ3]: What pedagogical strategies, methodological adaptations, and educational practices were used to ensure the continuity of the teaching and learning process during the pandemic?

Databases and search strategies

The literature search was conducted in the scientific databases PubMed, Scopus, Web of Science, and Google Scholar, which were selected for their relevance and scope in the fields of health, education, and biomedical sciences. The search string was developed by combining the keywords using the Boolean operators “AND” and “OR”: (“Biomedicine” OR “health education” OR “health sciences education”) AND (“COVID-19” OR “pandemic” OR “coronavirus”) AND (“remote learning” OR “online teaching” OR “emergency remote

education” OR “hybrid teaching”) AND (“student training” OR “teaching practice” OR “higher education” OR “health education”). The publication period spanned the years 2020 through 2025.

Inclusion and exclusion criteria for the studies

The inclusion criteria (IC) adopted were: (IC1) articles whose subject matter was related to the challenges of student education, teaching practices, emergency remote learning, health education, or biomedical education during the COVID-19 pandemic; (IC2) full scientific articles published in peer-reviewed journals and available as open access; (IC3) studies conducted by national or international institutions; (IC4) articles published in Portuguese or English; (IC5) studies addressing the pandemic’s impacts on teaching and learning processes in health-related programs; (IC6) articles presenting analyses, experiences, or pedagogical strategies; and (IC7) studies published between 2020 and 2025.

The exclusion criteria were: (EC1) articles unrelated to the review’s objectives; (EC2) abstracts, editorials, letters to the editor, preprints, or studies with insufficient methodological depth; (EC3) duplicate articles; (EC4) studies for which the full text was unavailable; (EC5) articles in languages other than Portuguese and English; and (EC6) studies published outside the specified time frame.

Quality assessment of studies (CASP)

The included studies underwent quality assessment using the CASP (Critical Appraisal Skills Program) tool, adapted according to the methodological design of each article: the CASP Qualitative Checklist for qualitative studies (10 criteria), the CASP Cohort Study Checklist for cross-sectional and quantitative studies (11 criteria), and the CASP Systematic Review Checklist for systematic reviews (10 criteria). Each criterion was scored as “yes” (1 point), “no” (0), or “unclear” (0.5 points). Studies scoring less than 50% of the total possible points were excluded from the final qualitative synthesis. The 13 included studies scored between 65% and 95%, indicating moderate to high methodological quality. The assessment was conducted independently by the authors, with any disagreements resolved by consensus.

Ethical considerations

Since this is a Systematic Literature Review based exclusively on secondary data from previously published and publicly available studies, this study did not involve direct data collection from human subjects, which exempts it from submission to a Research Ethics Committee, in accordance with standard practice for this methodological design (Kitchenham, 2004; Page et al., 2021). Nevertheless, the authors upheld the principles of scientific integrity, transparency, and methodological rigor throughout all stages of the review.

Stages of the article selection process

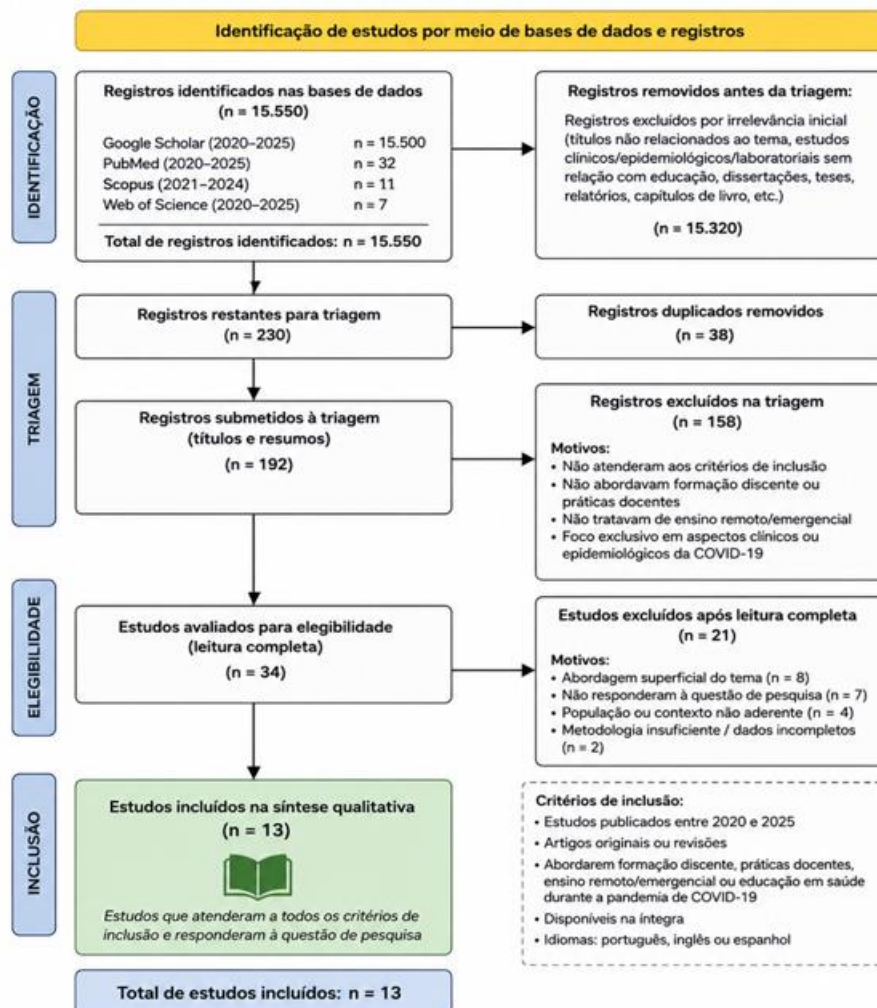
The selection process consisted of three main stages. In the first stage, after conducting the searches, potentially relevant studies were identified, and articles unrelated to the topic were excluded by reviewing titles and keywords. In the second stage, the abstracts, introductions, and conclusions were reviewed to verify the studies' adherence to the inclusion criteria. In the third stage, the selected articles were read in full, allowing for a critical evaluation of their content, methodology, and scientific relevance. Following this analysis, the eligible studies were included in the data extraction, organization, and analysis stage. For each included study, systematic information was extracted regarding authorship, year of publication, country, methodological design, population/sample, main findings, and contributions to the field, as summarized in Table 1. Data extraction followed a standardized protocol aligned with the PRISMA 2020 guidelines (Page et al., 2021) and the methodological frameworks of Kitchenham (2004) and Petticrew and Roberts (2006), which ensured theoretical and methodological consistency across the stages of search, selection, quality assessment, and synthesis of findings.

RESULTS

The search strategy developed using the PubMed, Scopus, Web of Science, and Google Scholar databases identified a total of 15,550 studies potentially relevant to the research topic. Of these, 15,320 studies were excluded in the initial stage because they did not align with the research topic, addressed exclusively clinical and epidemiological aspects of COVID-19, or did not include discussions related to student training, teaching practices, emergency remote learning, or health education. After this stage, 230 studies remained for preliminary analysis.

Next, 38 duplicate articles identified across the consulted databases were removed, resulting in 192 studies that underwent a review of titles, keywords, and abstracts. Following the screening stage, 158 articles were excluded for failing to meet the previously established inclusion criteria. Thus, 34 studies were deemed eligible for full-text review. After a complete analysis of the texts and the CASP quality assessment, 21 articles were excluded due to a superficial approach, lack of alignment with the review's objectives, or an insufficient score on the quality assessment tool. Consequently, 13 studies were included in the final qualitative synthesis of this Systematic Literature Review. Figure 1 presents the PRISMA flowchart.

Figure 1.
Flowchart of the study selection process (PRISMA 2020)



Note. Prepared by the authors in accordance with the PRISMA 2020 guidelines (Page et al., 2021).

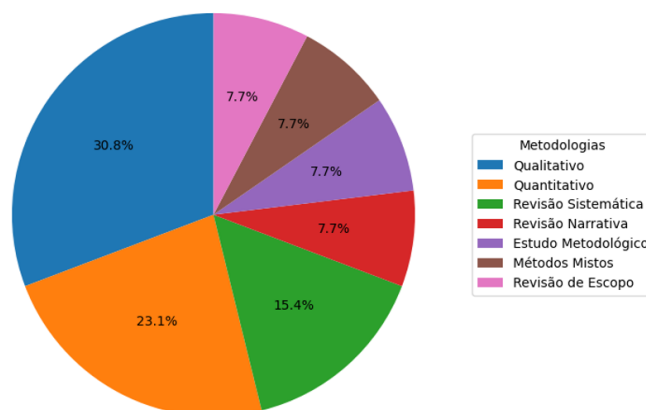
Research methodologies used [SRQ1]

The studies analyzed in this SLR reveal a methodological distribution that reflects the field's stage of development. The predominance of qualitative approaches—Garcia-Jr. et al. (2022), Winters et al. (2023), and Nyman et al. (2024)—indicates that the field is still in the phase of mapping perceptions and experiences, rather than measuring long-term learning outcomes. This characteristic is to be expected in contexts of abrupt disruption, in which empirical urgency takes precedence over the accumulation of longitudinal evidence. The quantitative and cross-sectional studies by Araujo et al. (2020) and Motta-Passos et al. (2023) focused on student satisfaction and access to technology, providing data on the profile of inequalities, but with limited capacity to capture lasting pedagogical impacts.

The systematic and scoping reviews by Naciri et al. (2021), Vieira and Silva (2020), and Santos et al. (2020) consolidated evidence from multiple contexts, broadening the analytical scope. Prosen et al. (2022) contributed by validating a tool for assessing the e-learning experience, and Sarkar et al. (2022) adopted mixed methods. Zhang et al. (2025) innovated by using text mining on social media to capture the emotional dimensions of the period. Taken together, this methodological distribution points to a gap: few studies employ longitudinal designs capable of assessing whether the educational gaps from the pandemic period were effectively overcome in the post-pandemic era. Figure 2 presents the type of research methodology used in each of the articles in this SLR.

Figure 2.

Type of research methodology used in the studies included in this SRL



Note. Prepared by the authors (2026).

Major challenges facing faculty and students [SRQ2]

The findings of the analyzed articles indicate that the main challenges faced by faculty and students during the pandemic were related to the rapid transition from in-person to emergency remote learning, limitations on practical and laboratory activities, inequalities in access to digital technologies, and the emotional impacts resulting from social isolation and academic overload.

From the students' perspective, Santos et al. (2020) noted that there was no consensus regarding students' participation in practical activities during the pandemic, in addition to highlighting limitations related to digital access. Garcia-Jr. et al. (2022) identified damage to the relationship between students and the community, reduced contact with patients, a lack of clinical practice, and psychological distress. Motta-Passos et al. (2023) found that health science students reported unstable internet connections, difficulty concentrating, and an inadequate home environment. Naciri et al. (2021) identified negative perceptions associated with difficulties in connecting and acquiring clinical skills. Zhang et al. (2025) analyzed the online emotions of college students during the pandemic, identifying a predominance of low-arousal negative emotions related to social isolation and restrictions imposed by public health measures.

With regard to faculty, Araujo et al. (2020) demonstrated that higher education faculty experienced increased stress during remote teaching, especially those with lower technological proficiency and faculty in health-related fields. Winters et al. (2023) emphasized that faculty had to create, recreate, and adapt their teaching practices to remote instruction, reporting a deterioration in mental health. In the specific context of biomedicine and clinical laboratories, Pearse and Scott (2023) highlighted that laboratory training was particularly affected in terms of practical training, competency assessment, and professional development in biomedical settings, indicating that the training gap in this area is more pronounced than in predominantly theoretical disciplines.

Pedagogical strategies used [SRQ3]

Studies indicate that, to ensure the continuity of the teaching and learning process during the pandemic, higher education institutions adopted various pedagogical strategies, notably emergency remote learning, the use of digital platforms, curricular reorganization, greater flexibility in academic activities, and, subsequently, the incorporation of hybrid models.

Santos et al. (2020) noted that these strategies focused on remote instruction, utilizing digital technologies and distance learning platforms. Sahu et al. (2022) emphasized that the effectiveness of online instruction depended on a combination of technological infrastructure, pedagogical planning, faculty training, and interactive methodologies. In this process, the need to develop new teaching competencies specific to the virtual environment became evident, including technology-mediated communication skills and instructional design (Appenzeller et al., 2020). Nyman et al. (2024) demonstrated that hybrid learning enabled greater flexibility and skill development, provided it was accompanied by pedagogical and organizational support. Garcia-Jr. et al. (2022) highlighted that, in medical education, the theory-practice relationship had dissolved, requiring a rethinking of curricular strategies. Sarkar et al. (2022) observed that students with lower adaptive capacity to remote learning required greater institutional support.

Table 1.
Summary of the studies included in the review (n = 13)

Author/Year	Country	Study type	Main public	Key finding	Contributions
Araujo et al. (2020)	Brazil	Descriptive quantitative	394 faculty members	Increased teacher stress, overload, and technological difficulties during remote teaching.	Highlights emotional impacts and the need for digital training for faculty.
Vieira & Silva (2020)	Brazil/Portugal	Systematic review	Education studies	Technological challenges, digital inequalities, and the transformation of teaching practices.	Shows the acceleration of digital transformation in higher education.
Gusso et al. (2020)	Brazil	Analytical essay	University administration	The need for institutional reorganization and pedagogical adaptation.	Reinforces the strategic role of university administration during the pandemic.
Santos et al. (2020)	Brazil	Scope review	Medical education	Remote teaching has become central, with limitations on clinical practices.	Points out weaknesses in practical health education in a remote setting.

Author/Year	Country	Study type	Main public	Key finding	Contributions
Naciri et al. (2021)	Morocco	Systematic review	111,622 students	Positive perceptions: flexibility; negative perceptions: practical difficulties and connection issues.	Shows partial acceptance of e-learning in health education.
Garcia-Jr. et al. (2022)	Brazil	Qualitative	46 medical students	Deterioration in the theory-practice relationship, psychological distress, and reduced contact with patients.	Demonstrates impacts on students' clinical and emotional development.
Motta-Passos et al. (2023)	Brazil	Cross-sectional quantitative	480 health sciences students	Internet instability and difficulty concentrating as the main problems.	Highlights structural inequalities and difficulties with remote learning.
Prosen et al. (2022)	Slovenia	Methodological study	Health sciences students	Validated a tool for assessing the e-learning experience.	Contributes to measuring the quality of the online educational experience.
Sahu et al. (2022)	International	Narrative review	Medical and health education	Best practices for online teaching and the need for technological infrastructure.	Highlights the need for permanent institutional policies for digital education.
Sarkar et al. (2022)	Australia	Mixed methods	Students and educators	Students with lower adaptability to remote learning.	Demonstrates the importance of adaptability and institutional support.
Winters et al. (2023)	Brazil	Qualitative	Health sciences faculty	Worsening mental health and the need to learn digital technologies.	Emphasizes the emotional and adaptive repercussions of teaching work.
Nyman et al. (2024)	Finland	Qualitative	Health sciences students	Hybrid learning promoted flexibility, interaction, and skill development.	Suggests the potential of the hybrid model in the post-pandemic era.

Author/Year	Country	Study type	Main public	Key finding	Contributions
Pearse & Scott (2023)	United Kingdom	Literature review	Clinical laboratory professionals and students	The pandemic directly affected training, assessment, and professional development in biomedical laboratory settings.	A key study for Biomedicine: it documents specific training gaps in the clinical laboratory.

Note. Prepared by the authors (2026).

DISCUSSION

An analysis of the selected studies revealed that the COVID-19 pandemic has brought about profound changes in higher education in health, particularly in student training processes and teaching practices in programs related to the Health Sciences and Biomedicine. The findings converge on three central analytical themes: (1) the structural limitations of practical training, (2) the emotional and institutional impacts on faculty and students, and (3) the opportunities and limitations of digital technologies.

With regard to the limitations of practical training, the studies reveal that the pandemic served to expose preexisting structural tensions in health curricula. Santos et al. (2020) and Garcia-Jr. et al. (2022) documented that the absence of in-person activities compromised the development of clinical and interpersonal skills, impacting the construction of students' professional identity. This phenomenon takes on a particularly serious dimension in biomedicine, as demonstrated by Pearse and Scott (2023): laboratory skills such as sample collection and processing, operation of diagnostic equipment, and morphological interpretation in microscopy cannot be fully replaced by video lectures or digital simulations. So-called “embodied competence,” developed through practical repetition in real laboratory settings, represents a formative dimension that digital platforms are not yet able to replicate faithfully. This implies that strategies to restore practical training in the post-pandemic period must be proactive and well-planned.

The emotional impacts on teachers and students constitute the second relevant analytical axis. Studies by Araujo et al. (2020), Winters et al. (2023), and Zhang et al. (2025) revealed that emergency remote learning took place under conditions of chronic stress for both groups. For teachers, the demand for immediate technological proficiency, coupled with the simultaneous reorganization of content and methodologies, resulted in both qualitative and quantitative work

overload. For students, difficulties with concentration, the lack of a suitable learning environment, and the instability of digital connections—as documented by Motta-Passos et al. (2023)—acted as barriers to learning. This scenario points to the need for permanent institutional psycho-pedagogical support, not only as a response to crises but as a structural component of educational policy.

The third area concerns the opportunities and limitations of digital technologies. Studies by Nyman et al. (2024), Sarkar et al. (2022), and Sahu et al. (2022) reveal that hybrid learning is not an automatic solution but a conditional possibility: its effectiveness depends on adequate technological infrastructure, ongoing pedagogical training for teachers, and deliberate institutional planning. Naciri et al. (2021), in a review covering more than 111,000 students, found that positive perceptions of e-learning centered on time flexibility and access to content, while negative perceptions focused on the lack of human interaction and the inability to develop practical skills.

Finally, it is worth noting that most of the studies included in this systematic review focus on the fields of medicine and nursing. The specific nature of biomedical training—with its specializations in clinical analysis, cytology, molecular biology, and laboratory diagnostics—remains underrepresented in the international literature, which points to a significant scientific gap and justifies the need for future research focused exclusively on this area. Although Pearse and Scott (2023) offer the contribution most directly focused on the clinical laboratory, most of the analyzed literature addresses the health field in aggregate, without distinguishing the specific competencies required by biomedicine from those of medicine and nursing. This lack of differentiation is relevant because the biomedical routine uniquely combines technical and analytical precision, the handling of diagnostic equipment, and responsibility for results that inform the clinical decisions of others—elements that have no exact equivalents in other health professions. It is therefore recommended that future studies specifically investigate the impacts of the pandemic on specific biomedical specializations, such as clinical analysis, oncological cytology, hematology, microbiology, and molecular biology, in order to inform more precise training policies for this professional category.

LIMITATIONS OF THE STUDY

This review has limitations that should be taken into account when interpreting the results. First, the searches were restricted to four databases (PubMed, Scopus, Web of Science,

and Google Scholar) and did not include regional databases such as LILACS and SciELO, which may have limited the identification of studies published in Latin American and Iberian contexts. Second, no systematic search was conducted in the gray literature (institutional reports, theses, and dissertations). Third, the quality assessment was performed by the study authors themselves, without independent review by a third-party evaluator, which may introduce confirmation bias. Fourth, the limited number of studies specifically focused on biomedicine imposes limitations on the generalizability of the conclusions to that specific area. The reviewers of this manuscript also suggested the inclusion of regional databases (LILACS and SciELO) and review by a third independent reviewer in the screening and quality assessment process. The authors acknowledge the relevance of these suggestions but chose not to repeat the searches and screening in this version of the article, since such a procedure would require completely repeating the already completed PRISMA process, which could compromise the traceability and reproducibility of the flowchart presented in Figure 1. These recommendations were incorporated as explicit guidelines for future research. These limitations do not invalidate the results but point to avenues for future research.

FINAL CONSIDERATIONS

This Systematic Literature Review (SLR/PRISMA 2020) synthesized the scientific literature on the challenges of student education and teaching practices in biomedicine during the COVID-19 pandemic. The 13 included studies, rated as having moderate to high methodological quality using the CASP instrument, offer a convergent overview whose implications extend beyond the emergency context: they highlight preexisting structural weaknesses in technological infrastructure, psycho-pedagogical support, and the management of laboratory practices—weaknesses that the pandemic has brought to light and that require medium- and long-term educational policy responses.

Emergency remote learning proved to be a necessary but partial solution; it ensured institutional continuity at the expense of significant gaps in education—particularly in practical and laboratory experiences—and at a significant emotional cost to students and faculty. These findings have direct implications for university administration, academic mental health policies, structured programs for the recovery of practical skills, and sustained investments in digital infrastructure—which should not be treated as emergency responses but as permanent components of institutional planning.

On the other hand, the pandemic has accelerated changes that expand the available pedagogical repertoire. The use of digital technologies, the adoption of active learning methodologies, and the consolidation of hybrid models represent gains that, if incorporated in a planned manner, can enhance health education in a lasting way. It is recommended that future research adopt longitudinal designs to measure the long-term effects on practical laboratory skills in biomedicine, expand coverage to regional databases such as LILACS and SciELO, and include gray literature, theses, dissertations, and institutional reports, in order to capture local experiences not yet represented in the international literature.

REFERENCES

- Akobeng, A. K. (2005). Understanding systematic reviews and meta-analysis. *Archives of Disease in Childhood*, 90(8), 845–848. <https://doi.org/10.1136/adc.2004.058230>
- Appenzeller, S., Menezes, F. H., Santos, G. G., Padilha, R. F., Graça, H. S., & Bragança, J. F. (2020). Novos tempos, novos desafios: Estratégias para equidade de acesso ao ensino remoto emergencial. *Revista Brasileira de Educação Médica*, 44(Supl. 1), e0155. <https://doi.org/10.1590/1981-5271v44.supl.1-20200420>
- Araújo, R. M., Amato, C. A. H., Martins, V. F., Eliseo, M. A., & Silveira, I. F. (2020). COVID-19, mudanças em práticas educacionais e a percepção de estresse por docentes do ensino superior no Brasil. *Revista Brasileira de Informática na Educação*, 28, 864–891. <https://doi.org/10.5753/rbie.2020.28.0.864>
- Brasil. (2020). *Portaria nº 343, de 17 de março de 2020: Dispõe sobre a substituição das aulas presenciais por aulas em meios digitais enquanto durar a situação de pandemia do Novo Coronavírus – COVID-19*. Diário Oficial da União. https://www.planalto.gov.br/ccivil_03/portaria/prt/portaria%20n%C2%BA%20343-20-mec.htm
- Dias, É., & Pinto, F. C. F. (2020). A educação e a Covid-19. *Ensaio*, 28(108), 545–554. <https://doi.org/10.1590/S0104-40362019002801080001>
- Galvão, T. F., & Pereira, M. G. (2014). Revisões sistemáticas da literatura: Passos para sua elaboração. *Epidemiologia e Serviços de Saúde*, 23(1), 183–184. <https://doi.org/10.5123/S1679-49742014000100018>
- Garcia, F. W., Kantoviski, A. L. L., Vettorazzi, M. L. T., Ogradowski, K. R. P., & Kantoviski, A. R. (2022). Percepção de docentes de cursos da área da saúde sobre adaptação ao ensino remoto. *Espaço Para a Saúde*, 23, e851. <https://doi.org/10.22421/1517-7130/es.2022v23.e851>
- Gusso, H. L., Archer, A. B., Luiz, F. B., Sahão, F. T., Luca, G. G. D., Henklain, M. H. O., Panosso, M. G., Kienen, N., Beltramello, O., & Gonçalves, V. M. (2020). Ensino superior em tempos de pandemia: Diretrizes à gestão universitária. *Educação & Sociedade*, 41, e238957. <https://doi.org/10.1590/ES.238957>
- Kitchenham, B. (2004). *Procedures for performing systematic reviews* (Technical Report No. TR/SE-0401). Keele University.
- Melo, S. D. G., Sousa, J. F. A., & Vale, A. A. (2022). A reorganização do trabalho docente na educação superior no contexto da pandemia de Covid-19. *Revista Brasileira de Política e Administração da Educação*, 38(1), e122790. <https://doi.org/10.21573/vol38n002022.122790>
- Menezes, S. K. O., & Santos, M. D. F. (2021). Tecnologias digitais da informação e comunicação e COVID-19 no contexto educacional: Revisão sistemática da literatura. *HOLOS*, (1), 1–18.

- Motta-Passos, I., Martinez, M. L. L., Andrade, S. C. S., Pinho, A. C. S., & Martins, M. A. (2023). Percepção do ensino remoto emergencial por discentes em uma escola de ensino superior de saúde. *Revista Brasileira de Educação Médica*, 47(1), e031. <https://doi.org/10.1590/1981-5271v47.1-20220261>
- Naciri, A., Radid, M., Kharbach, A., & Chemsí, G. (2021). E-learning in health professions education during the COVID-19 pandemic: A systematic review. *Journal of Educational Evaluation for Health Professions*, 18, 27. <https://doi.org/10.3352/jeehp.2021.18.27>
- Nyman, E., Pramila-Savukoski, S., Mikkonen, K., Törmänen, T., Juntunen, J., & Kuivila, H. M. (2024). The experiences of health sciences students with hybrid learning in health sciences education: A qualitative study. *Nurse Education Today*, 132, 106017. <https://doi.org/10.1016/j.nedt.2023.106017>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>
- Pearse, C., & Scott, S. (2023). A review of clinical laboratory education, training and progression: Historical challenges, the impact of COVID-19 and future considerations. *British Journal of Biomedical Science*, 80, 11266. <https://doi.org/10.3389/bjbs.2023.11266>
- Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide*. Blackwell Publishing.
- Prosen, M., Karnjuš, I., & Ličen, S. (2022). Evaluation of e-learning experience among health and allied health professions students during the COVID-19 pandemic in Slovenia: An instrument development and validation study. *International Journal of Environmental Research and Public Health*, 19(8), 4777. <https://doi.org/10.3390/ijerph19084777>
- Rondini, C. A., Pedro, K. M., & Duarte, C. S. (2020). Pandemia do COVID-19 e o ensino remoto emergencial: Mudanças na prática docente. *Interfaces Científicas – Educação*, 10(1), 41–57. <https://doi.org/10.17564/2316-3828.2020v10n1p41-57>
- Sahu, P. K., Dalcik, H., Dalcik, C., Gupta, M. M., Chattu, V. K., & Umakanthan, S. (2022). Best practices for effective implementation of online teaching and learning in medical and health professions education: During COVID-19 and beyond. *AIMS Public Health*, 9(2), 278–292. <https://doi.org/10.3934/publichealth.2022019>
- Sampaio, R. F., & Mancini, M. C. (2007). Estudos de revisão sistemática: Um guia para síntese criteriosa da evidência científica. *Revista Brasileira de Fisioterapia*, 11(1), 83–89. <https://doi.org/10.1590/S1413-35552007000100013>
- Santos, B. M., Cordeiro, M. E. C., Schneider, I. J. C., & Ceccon, R. F. (2020). Educação médica durante a pandemia da Covid-19: Uma revisão de escopo. *Revista Brasileira de Educação Médica*, 44(Suppl. 1), e0139. <https://doi.org/10.1590/1981-5271v44.supl.1-20200383>

- Sarkar, M., Liu, K., Kumar, A., Ilic, D., Morphet, J., Maloney, S., Davis, E., & Palermo, C. (2022). Student and educator perspectives of adapting to remote health professions education: A mixed-methods study. *Frontiers in Medicine*, 9, 834228. <https://doi.org/10.3389/fmed.2022.834228>
- Vieira, M. F., & Silva, C. M. S. (2020). A educação no contexto da pandemia de COVID-19: Uma revisão sistemática de literatura. *Revista Brasileira de Informática na Educação*, 28, 1013–1031. <https://doi.org/10.5753/rbie.2020.28.0.1013>
- Winters, J. R. D. F., Nogueira, D. R., Heidemann, I. T. S. B., Durand, M. K., Magagnin, A. B., & Arakawa-Belaunde, A. M. (2023). O ensino remoto durante a pandemia de COVID-19: Repercussões sob o olhar docente. *Revista Brasileira de Enfermagem*, 76(Suppl. 1), e20220172. <https://doi.org/10.1590/0034-7167-2022-0172pt>
- Zhang, Y., Duan, X., & Wang, B. (2025). Understanding Chinese college students' emotions and attributions during the COVID-19 epidemic: An analysis based on Sina Microblog. *BMC Public Health*, 25, 3411. <https://doi.org/10.1186/s12889-025-23863-1>

CRedit Author Statement

- ☐ **Acknowledgments:** Not applicable.
 - ☐ **Funding:** Not applicable.
 - ☐ **Conflicts of interesse:** Not applicable.
 - ☐ **Ethical approval:** Not applicable.
 - ☐ **Data and materials availability:** The data and materials are available in the references.
 - ☐ **Authors' contributions:** The authors contributed to the development, conceptualization, writing, and revision of the text.
-

Processing and editing: Editora Ibero-Americana de Educação
Proofreading, formatting, standardization and translation

