Revista Española
de Educación Médica

UNIVERSIDAD
DE MURCIA

Curricular insertion of clinical simulation in Medical Microbiology: design and implementation.

Curricular insertion of clinical simulation in Medical Microbiology: design and implementation.

Lourdes Lledó [1] *, Felipe Pérez-García [2] , Adriana Carolina Rojas [3] , Ramón Pérez-Tanoira [4] , Juan Cuadros-González [5]

Faculty of Medicine and Health Sciences, University of Alcalá, Spain

[1] lourdes.lledo@uah.es , https://orcid.org/ 0000-0001-5387-6792; [2] felipe.perez@uah.es , https://orcid.org/0000-0002-4885-4334; [3] adrianacarolina.roja@uah.es , https://orcid.org/0009-0007-7134-693X; [4] ramon.perezt@uah.es , https://orcid.org/0000-0002-9816-3208; [5] juan.cuadros@uah.es, https://orcid.org/0000-0003-4098-4377

* Correspondence: lourdes.lledo@uah.es

Received: 23/6/26; Accepted: 10/7/26; Published: 13/7/26

Summary.

Introduction Clinical simulation has become a key resource in medical education, but its systematic integration into basic subjects such as Medical Microbiology remains limited in the Spanish context. Such integration would facilitate students' connection of microbiological content with clinical reasoning and the reasoned request for microbiological tests. **Objective:** To analyze the academic results and perceived usefulness of clinical simulation exercises in this subject. **Method:** A descriptive observational study was conducted on the grades for the portion of the subject related to simulation exercises based on clinical interviews about infectious syndromes in third-year Medical Microbiology (academic years 2012-2013 to 2025-2026). The exercises were structured around simulated clinical interviews on common syndromes and were assessed using three successive formats (open-ended questions in the practical notebook, a take-home online test, and an in-person online test). Descriptive statistics and a repeated-measures ANOVA were used for data analysis. Additionally, open-ended student feedback on the educational value of the experience was reviewed. **Results:** Mean scores ranged from 7.54 to 9.67 out of 10, with high medians and low to moderate standard deviations. ANOVA showed significant differences between formats ($F = 466.92$; $p < 0.001$), with higher scores on the take-home online test and subsequent stability on the in-person online test. These findings suggest interpreting the academic results with caution, as some of the observed variation may be related to the assessment format and not solely to the teaching intervention. Students rated the practical sessions very positively, highlighting their usefulness in understanding the clinical relevance of Microbiology, organizing their studies around infectious syndromes, and preparing for OSCEs and clinical rotations. **Conclusions:** The simulation of clinical interviews in Medical Microbiology constitutes a sustainable teaching innovation, associated with high and consistent academic results, and a clearly perceived educational utility for students, which favors the basic-clinical integration in the Medicine degree and offers a transferable model to other faculties of different educational systems interested in incorporating simulation in basic subjects.

Keywords: Clinical simulation, Medical Microbiology, Simulated clinical interviews, Medical education, Clinical competencies, Medical degree.

Abstract.

Introduction: Clinical simulation has become a key resource in medical education, but its systematic integration into basic subjects such as Medical Microbiology remains limited in the Spanish context, which makes it difficult for students to connect microbiological content with clinical reasoning and the reasoned ordering of microbiological tests. **Aim:** Analyze the academic results and the perceived usefulness of the clinical simulation practices carried out in this subject. **Methods:** A descriptive observational study was carried out of the grades obtained in the part of the course linked to simulation-based practice sessions using clinical interviews on infectious syndromes in a third-year Medical Microbiology course (academic years 2012-2013 to 2025-2026). The practice sessions were structured around simulated clinical interviews on common infectious syndromes and were assessed using three successive formats (short-answer questions in a practical workbook, an at-home online test and an in-person online test), applying descriptive statistics and repeated-measures ANOVA. Open-ended student comments on the perceived educational value of the experience were also reviewed. **Results:** Mean scores ranged from 7.54 to 9.67 out of 10, with high medians and low to moderate standard deviations. The ANOVA showed significant differences between formats ($F = 466.92$; $p < 0.001$), with higher scores in the at-home online test and subsequent stability in the in-person online test. These findings suggest that academic results should be interpreted cautiously, since part of the observed variation may be explained by the assessment format rather than by the instructional intervention alone. Students rated the practice sessions very positively, highlighting their usefulness for understanding the clinical relevance of Microbiology, organizing their study around infectious syndromes and preparing for OSCEs and clinical rotations. **Conclusions:** The simulation of clinical interviews in Medical Microbiology is a sustainable teaching innovation, associated with high and consistent academic results, and a training utility clearly perceived by students, which promotes the basic-clinical integration in the degree in Medicine and offers a model that can be transferred to other faculties of different educational systems interested in incorporating simulation in basic subjects.

Keywords: Clinical simulation, Medical Microbiology, Simulated clinical interviews, Medical education, Clinical competences, Medical degree.

1. Introduction

Clinical simulation has become established as a fundamental pedagogical tool in healthcare education, with evidence of its impact on knowledge, technical and non-technical skills, and even certain healthcare outcomes (1, 2). The expansion of simulation centers in Spanish and European medical schools has boosted its use in emergency, critical care, communication skills, and OSCE (Objective Structured Clinical Examination) scenarios, within the framework of competency-based training programs (3–6). Its effectiveness depends primarily on planned curricular integration, aligned with explicit learning outcomes and coherent assessment systems, avoiding its use as an isolated experience or one exclusively associated with high-fidelity technologies.

However, the literature shows that simulation has been developed primarily in undergraduate clinical courses and in residency training, while its integration into basic subjects, such as Medical Microbiology, is much less frequent (7). In these subjects, teaching continues to focus on lectures and laboratory sessions, prioritizing the description of microorganisms and diagnostic techniques over reasoning applied to specific infectious syndromes, with limited use of methodologies that allow for working on complex clinical cases and simulating real-world healthcare settings.

This situation makes it difficult for students to connect microbiological content with the real clinical context, justify the indication for microbiological studies, and assess the impact of diagnostic decisions on patient safety and the rational use of resources. Simulated clinical interviews on infectious syndromes offer an opportunity to place students in the role of future physicians, integrating medical history, syndromic approach, etiological probability, and selection of microbiological tests. In Spain, simulation experiences have been described in Pediatrics, Emergency Medicine, and Intensive Care Medicine, as well as in OSCEs and competency-based training programs, but there are hardly any published models that integrate simulation longitudinally in Medical Microbiology (5, 8-10).

This paper describes a decade-long experience of simulating clinical interviews in Medical Microbiology and analyzes two distinct levels of outcomes: (a) the behavior of grades in different periods and assessment formats, and (b) the perceived usefulness of the simulations by students, as determined by open-ended questionnaires. This separation is explicitly introduced to avoid inappropriate causal inferences between academic performance and perception. This distinction is relevant because grades can be partially influenced by the assessment format, while student perception provides a complementary dimension regarding basic-clinical integration, applicability, and educational value. Although the experience was developed in Spain, the educational problem addressed—how to connect basic sciences and clinical reasoning early on—is shared by numerous international curricula.

2. Methods

2.1 Context and design of the intervention

Medical Microbiology is a compulsory third-year course in the Bachelor of Medicine program, taught in the second semester at a Spanish public medical school. Since the 2012–2013 academic year, clinical simulation exercises have been incorporated, based on simulated clinical interviews about common infectious syndromes (urinary tract, respiratory, gastrointestinal, skin and soft tissue infections, meningitis, sepsis, sexually transmitted infections, among others). Each session is conducted in small groups. Students prepare and perform a simulated clinical interview, assuming the roles of physician, standardized patient, or observer, and participate in a subsequent discussion focused on defining the infectious syndrome, formulating reasoned etiological hypotheses, selecting key microbiological samples and tests, and proposing empirical treatment and preventive measures. The PASEO framework (Patient, History, Syndrome, Etiology, Organization) is used as a structured guide for the interview and reasoning, but it is presented as a flexible support tool, easily transferable to different infectious syndromes, rather than as the central focus of the intervention. Throughout the course, practical exercises are structured around a map of infectious syndromes that serves as an integrating axis between theoretical instruction and activity in the simulation lab.

2.2 Supporting material

Since its inception, the teaching team has developed a Clinical Simulation Practice Guide, which is updated annually. This document is structured in four sections: objectives, methodology and timing, evaluation, and theoretical knowledge support. It explains the contribution of the practical sessions to the course syllabus and the competencies to be developed, describes the dynamics of the sessions, and details the use of the PASEO framework as a rationale. In addition, audiovisual material featuring simulated interviews conducted by the students themselves was designed.

2.3 Evaluation

The activity assessment includes mandatory attendance, active participation, and a self-assessment component. Formative assessment considers student involvement in the preparation and development of the simulations and in the subsequent discussion. The self-assessment format has varied over time: in the first period, a practice notebook with open-ended questions graded using a rubric was used; in the second, an online test completed at home; and in the third, an in-person online test. This approach combines formative and summative assessment and aligns with current recommendations for the curricular integration of simulation. An evaluation of the process is also conducted through open-ended student feedback surveys after the practical sessions have concluded. Grades for the simulation-related portion of the course were analyzed from 2012–2013 to 2025–2026. To assess the potential impact of the self-assessment test format, three periods were defined:

- First period (2012–2013 to 2015–2016): evaluation through a practice notebook with open questions, corrected with a rubric.
- Second period (2016–2017 to 2019–2020): online home test on virtual platform, with a deadline of 15 days.
- Third period (2020–2021 to 2025–2026): online test in person in computer room at the end of the internship.

Throughout all periods, the structure of the practical exercises, the syndrome map, and the marking criteria were maintained, with only the evidence collection format varying, in accordance with recommendations for curricular coherence and stability of learning outcomes regardless of the type of test (3,4,8,9). The distinction between periods is not solely due to logistical changes, but also to the need to adapt the assessment to different teaching conditions. Consequently, the three periods should not be interpreted as "three versions" of the simulation, but rather as three evidence collection formats within the same teaching model. Nevertheless, it was assumed from the analytical design stage that these variations could influence the observed grades, especially when comparing a take-home test with an in-person test. Therefore, the analysis of academic results was designed with a descriptive and interpretive purpose rather than a causal one.

2.4 Variables and instruments

The main variable was the numerical grade (0–10) for the portion of the course associated with simulation practice. For each period, the mean, median, mode, standard deviation, minimum and maximum values, and 95% confidence interval for the mean were calculated. Additionally, comments from open-ended questionnaires completed by students at the end of the practice sessions were reviewed. These questionnaires focused on the perceived usefulness of the simulations for learning the course and for future clinical practice. Validated instruments for self-efficacy, clinical competence, transfer, and observable performance were not used in this phase. This limits the inferential scope of the qualitative results and justifies presenting them as a perception of usefulness rather than an objective measure of competence acquisition. The combined use of quantitative and qualitative results aligns with current recommendations in educational research and the evaluation of simulation programs (1–4, 11, 12).

2.5 Statistical analysis

Descriptive statistics were used to explore differences between periods defined by the self-assessment format. Mean comparisons between periods were performed using a one-way repeated measures analysis of variance (ANOVA), with $p < 0.05$ considered the significance threshold. The study did not include a parallel control group or a comparable cohort without exposure to the simulation, which would have allowed for a robust estimation of the intervention's causal effect on academic performance. Consequently, the comparison between periods should be understood as an analysis of variation under assessment conditions within the same academic program, and not as an experimental comparison between students exposed and not exposed to the simulation.

3. Results

3.1 Academic performance

The scores associated with the simulation exercises remained high throughout the study period. Means ranged from 7.54 to 9.67 out of 10, with medians from 8.0 to 10.0 and standard deviations generally less than one point. In summary:

- First period (open questions): mean 7.54; median 8.00; minimum 5.00; maximum 8.00; 95% CI 7.44–7.63.
- Second period (online home test): mean 9.67; median 10.00; minimum 6.50; maximum 10.00; 95% CI 9.55–9.80.
- Third period (online face-to-face test): mean 8.63; median 8.8; minimum 2.00; maximum 10.00; 95% CI 8.57–8.69.

The repeated measures ANOVA showed significant differences among the three assessment formats ($F = 466.92$; $p < 0.001$), with higher means in the second period and a slight decrease when switching to the in-person test, within a generally high range and with moderate dispersion. The higher scores in the period with the at-home online test suggest that the assessment format may have contributed, at least in part, to the observed differences (e.g., testing conditions, availability of feedback, level of supervision). Consequently, these results should not be interpreted as a linear improvement attributable to the simulation itself, but rather as the combined expression of a stable teaching experience and changes in the self-assessment modality. This pattern is consistent with that described in other studies comparing at-home and in-person assessments in competency-based education contexts (3, 4, 8, 9).

3.2 Student perception and clinical learning

The analysis of the open-ended questionnaires reflects a very high level of student acceptance of the practical sessions. They repeatedly stated that the simulated interviews helped them to "give clinical meaning" to the microorganisms studied, facilitated their understanding of the indications for and interpretation of microbiological tests, and allowed them to practice clinical reasoning. Likewise, the infectious syndrome map associated with the practical sessions was perceived as a clear framework for organizing their studies and relating clinical manifestations, probable etiology, and priority microbiological tests. Unlike grades, these qualitative comments are not intended to measure academic performance, but rather to document the students' perceived usefulness of the experience. This analytical separation avoids simplistic causal inferences between satisfaction, perceived usefulness, and quantitative performance.

4. Discussion

This paper describes a well-established experience of integrating clinical simulation into the Medical Microbiology curriculum, aligned with the principles of competency-based medical education. Unlike other initiatives focused on isolated experiences or high-fidelity simulation, the model presented prioritizes curriculum planning, methodological coherence, and explicit links to learning outcomes and assessment systems.

The literature indicates that simulation is particularly effective when integrated longitudinally into the curriculum and structured around clinical problems relevant to the students' level of training (3, 13). The reviews and guidelines included in this manuscript further emphasize that its value depends on the alignment between objectives, activities, debriefing, and assessment, and not merely on the use of simulated scenarios (3, 4, 8, 9, 11, 12). This grounding is important for interpreting the present experience within an international framework of best practices and not just as a local innovation. In this sense, the use of infectious syndromes as a central theme allows for the contextualization of microbiological content and facilitates the transition between basic sciences and clinical practice, a challenge widely described in the teaching of Medical Microbiology.

The PASEO scheme acts as a cognitive scaffold that facilitates the structuring of clinical-microbiological reasoning, in line with studies that highlight the usefulness of structured frameworks to improve decision-making and the transfer of learning to new contexts (12, 13). Its repeated application in different clinical scenarios can contribute to the internalization of a systematic reasoning model, beyond the rote learning of etiological agents, allowing it to prioritize etiological hypotheses, select microbiological tests of greater value, and integrate the results into therapeutic and preventive decisions, in line with current recommendations for basic-clinical integration and competency-based assessment (4, 7–10).

This proposal can also be interpreted in light of specific theoretical simulation models that are particularly relevant in basic science subjects. On the one hand, the simulation is organized as an experiential learning experience in which students prepare for the interview, act in a plausible clinical scenario, reflect during the debriefing, and subsequently reorganize their knowledge for new cases, following a logic consistent with learning cycles applied in health education. On the other hand, the model approaches the alignment of task, fidelity level, learning objectives, and assessment, which is particularly relevant when the aim is not to reproduce complex procedures, but rather to promote conceptual integration, syndromic reasoning, and diagnostic decision-making in basic science subjects. This theoretical framework reinforces the idea that the usefulness of simulation in Medical Microbiology depends less on technological sophistication than on instructional design, debriefing, and the explicit connection between basic content and the clinical application of knowledge.

From an evaluative standpoint, academic results show high and stable performance over time. However, the absence of an adequate control group prevents us from causally attributing these grades to clinical simulation beyond inter-period comparisons. Furthermore, the applied analysis of variance focuses on comparing assessment formats—open-ended questions, take-home online tests, and in-person online tests—and not on isolating the specific effect of simulation as a teaching strategy. The differences observed between formats are consistent with what has been described in the literature regarding the impact of test type on grades, rather than with changes attributable solely to the teaching methodology (8, 9). Therefore, the data should be interpreted as an indicator of the feasibility, stability, and internal consistency of the model, rather than as a direct measure of causal efficacy.

Among the educational implications of this experience, the feasibility of incorporating moderately complex clinical simulations into basic-clinical subjects stands out, without requiring advanced technological infrastructure, in line with studies that emphasize that technological fidelity is not the main determinant of learning (3, 11). This characteristic facilitates its adaptation not only to other Spanish faculties, but also to health sciences programs in international contexts with heterogeneous resources. Furthermore, the model facilitates the development of transversal skills, such as communication and teamwork, which are typically underdeveloped in this type of subject.

4.1 Innovation and international transferability

In various international settings, the challenge of integrating basic sciences, clinical reasoning, and diagnostic decision-making into medical curricula at an early stage persists. Although the experience described here takes place in a Spanish medical school, its relevance is not limited to that context. In Spain, simulation has been implemented particularly in Intensive Care Medicine, Pediatrics, and Emergency Medicine, as well as in residency programs with extensive use of OSCE and competency-based activities (5, 9, 10, 14, 15). However, few experiences describe the longitudinal integration of simulation into basic subjects such as Medical Microbiology. This experience offers several innovative elements: mandatory and sustained integration of simulation for over a decade in a basic-clinical subject, use of simulated clinical interviews focused on infectious syndromes beyond purely procedural skills, and the availability of quantitative and qualitative data that support the consistency of academic performance and the high acceptability of the model. Therefore, the main contribution of the model is not only to document a sustained local innovation, but to show a pedagogical design that can be transferred to other basic subjects —such as Pathophysiology, Pharmacology, Immunology or General Pathology— and to different educational systems where there is a need to connect disciplinary content with plausible clinical situations.

The model's transferability relies on widely generalizable components: small group work, use of syndromic cases, rotating roles, structured discussion, debriefing, and assessment aligned with learning outcomes. These features make it a practical reference for other faculties wishing to strengthen clinical reasoning and basic-clinical integration through simulation, even with moderately fidelity resources.

4.2 Instructional design and debriefing

The design of the practical sessions combines preparatory work, interview simulation, structured discussion, and feedback, in line with recommendations on instructional design in simulation and the central role of debriefing in consolidating learning (2, 11, 12). The use of the PASEO framework as a support tool offers a clear yet flexible structure, facilitating the transfer of clinical microbiological reasoning to other curricular settings and future clinical rotations.

4.3 Strengths, limitations and areas for improvement

Key strengths of the model include its planned curricular integration, the coherence between objectives, methodology, and assessment, and the use of a structured reasoning framework applicable to multiple infectious syndromes. The ongoing implementation of the program reinforces its sustainability and its potential transfer to other educational contexts.

The main limitations of the study stem from its descriptive nature. First, a comparable control group was not available to allow for a more methodologically robust assessment of the causal impact of simulation on academic outcomes. Second, the statistical comparison was established between periods defined by different assessment formats, so some of the observed variation may depend on the type of test and not solely on the educational intervention. Third, the conclusion relies heavily on accumulated experience and student perceptions obtained through open-ended questionnaires, without incorporating validated instruments for measuring competencies, self-efficacy, transfer of learning, or observable clinical performance.

Finally, the experience is limited to a single medical school, which may restrict the generalizability of the findings.

Future studies should incorporate more robust comparative designs, ideally with control groups, as well as validated tools to measure clinical reasoning, basic science-clinical integration, and transfer to simulated or real-world care settings. It would also be worthwhile to analyze more specifically which components of the model—preparation, role-playing, structured discussion, or debriefing—contribute most significantly to learning.

5. Conclusions

- The simulation of clinical interviews on infectious syndromes in Medical Microbiology represents a significant teaching innovation in the Medicine degree program. After more than a decade of implementation, it is associated with consistently high grades and a very favorable perception among students.
- However, the academic results should be interpreted with caution, as the study does not include a control group, the variation between periods may be influenced by changes in the self-assessment format , and validated instruments have not been used to directly measure skills or transfer of learning.
- The model demonstrates that it is possible to integrate simulation into a basic-clinical subject using moderate fidelity resources and a careful curriculum design, offering a transferable reference for other faculties that wish to strengthen basic-clinical integration through simulation.

Funding This research has not received specific funding from any public, commercial, or non-profit agency.
Declaration of conflict of interest The authors declare that they have no conflict of interest.
Use of artificial intelligence. Generative artificial intelligence tools (Perplexity) were used in the preparation of this manuscript to assist in structuring and writing the text. The conceptual model, its theoretical architecture, its foundation, and the writing are the original work of the authors.
Authors' contributions Conceptualization: LLL, JCG, Formal analysis: LLL, FPG, ACR, RPT, JCG, Research: LLL, FPG, ACR, RPT, JCG, Methodology: LLL, FPG, ACR, RPT, JCG, Writing, review and editing: LLL, FPG, ACR, RPT, JCG.

6. References

1. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *JAMA.* **2011,** 306, 978-988. https://doi.org/ 10.1001/jama.2011.1234
2. Motola I, Devine LA, Chung HS, Sullivan JE, Issenberg SB. Simulation in healthcare education: best evidence practical guide. AMEE Guide No. 82. *Med Teach.* **2013,** 35, e1511-e1530. https://doi.org/ 10.3109/0142159X.2013.818632
3. Alonso-Peña M, Álvarez Álvarez C. Clinical simulation in health education: a systematic review. *Invest Educ Enferm.* **2023,** 41, e08. https://doi.org/ 10.17533/udea.iee.v41n2e08
4. Muñoz G, Sierra R. Clinical simulation in modern medical education: a review of reviews. *Rev Eugenio Espejo.* **2025, 19,** 102-115. https://doi.org/10.37135/ee.04.22.08
5. Abreu JM, Castelo-Branco M. Clinical simulation in intensive care training: evidence, European models and opportunities for Portugal. *Rev Esp Educ Med.* **2025,** 6, 657461. https://doi.org/ 10.6018.edumed.657461
6. Corvetto M, Bravo MP, Montaña R, et al. Simulation in medical education: a synopsis. *Rev Med Chil.* **2013;** 14170-79. https://doi.org/10.4067/S0034-98872013000100010

7. Rognoni G, Benet P, Castro A, et al. Clinical simulation in medical education. Advantages and disadvantages of bedside and simulated learning. *Med Clin Pract.* **2024,** 7, 100459. https://doi.org/10.1016/j.mcpsp.2024.100459
8. Norcini J, Burch V. Workplace-based assessment as an educational tool: AMEE Guide No. 31. *Med Teach.* **2007,** 29, 855-871. https://doi.org/ 10.1080/01421590701775453
9. Salam A, Alsharkawy A, Abdelhalim AT, et al. Use of Objective Structured Clinical Examinations (OSCE) as a Valid and Reliable Assessment Tool in Medical Education. *Int. J. Hum. Health Sci.* **2024,** 8, 3-8. https://doi.org/ 10.31344/ijhhs.v8i1.612
10. Saceda D, Fonda P, Moreno ÓM, et al. Objective structured clinical examination as an assessment tool of clinical competence in undergraduate dermatology. *Actas Dermosifiliogr.* **2017,** 108, 237-243. https://doi.org/ 10.1016/j.ad.2016.10.016
11. Cook DA, Hamstra SJ, Brydges R, et al. Comparative effectiveness of instructional design features in simulation-based education: systematic review and meta-analysis. *MedTeach.* **2013,** 35, e867-e898. https://doi.org/ 10.3109/0142159X.2012.714886
12. Cheng A, Eppich W, Grant V, et al. Debriefing for technology-enhanced simulation: a systematic review and meta-analysis. *Med Educ.* **2014,** 48, 657-666. https://doi.org/ 10.1111/medu.12432
13. Elendu C, Amaechi DC, Okatta AU, et al. The impact of simulation-based training in medical education: A review. *Medicine.* **2024,** 103, e38813. https://doi.org/ 10.1097/MD.0000000000038813
14. Castellanos L, Broch MJ, Palacios D, et al. Effect of a competence based medical education program on training quality in Intensive Care Medicine. *Intensive Med.* **2024,** 48, 260-268. https://doi.org/10.1016/j.medin.2024.502126
15. Butragueño L, Zanin A, López-Herce J, Mencía S. Use of simulation during the COVID-19 pandemic in Spanish PICUs. New challenges in medical education. *An Pediatr (Barc).* **2021.** 95, 373-375. https://doi.org/ 10.1016/j.anpedi.2021.06.007