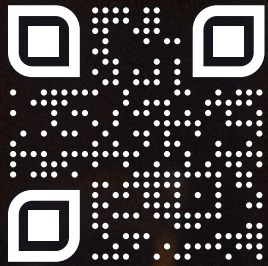
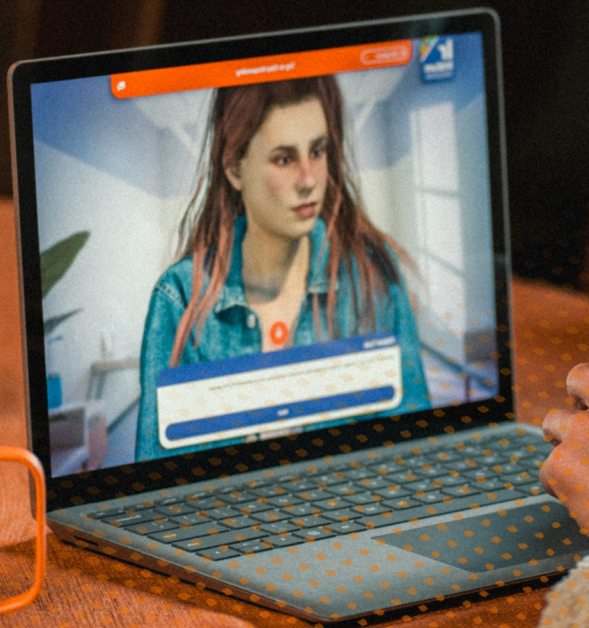


Virtual Patient AI Simulation Improves Uncomplicated UTI Antibiotic Stewardship



^ Scan to Learn More



RESPONSIBLE + REPEATABLE + OUTCOME-BASED

Virtual Patient AI Simulation Improves Uncomplicated UTI Antibiotic Stewardship

Why This Topic (and Why Now)

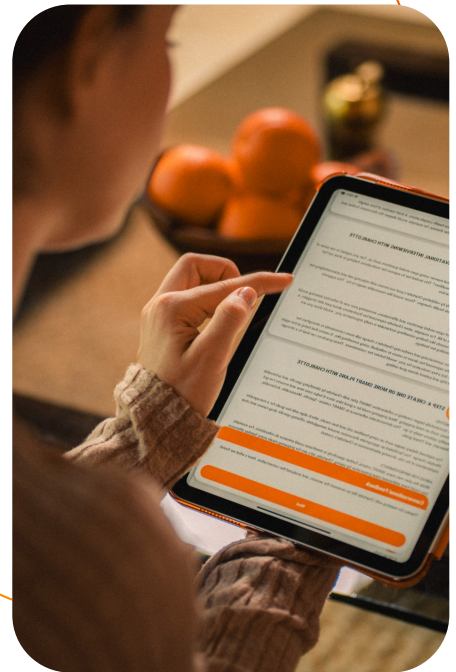
We're facing an antimicrobial resistance crisis that threatens decades of medical progress.^{1,2} Uncomplicated urinary tract infections sit at the center of this challenge, accounting for over 10 million outpatient antibiotic prescriptions annually in the United States.^{3,4} Despite clear clinical guidelines, inappropriate prescribing remains common, accelerating resistance patterns and compromising patient outcomes.^{5,6}

The problem extends beyond volume. Clinicians struggle with diagnostic ambiguity, often misinterpret urinalysis results, and frequently diverge from guideline-recommended therapies.⁷⁻⁹ Awareness of novel agents like pivmecillinam and gepotidacin remains low, while patient education about prevention and antimicrobial resistance is inconsistent. As resistance escalates, every prescription represents both a treatment opportunity and a stewardship decision with population-level consequences.²

The Educational Gap: Where Simulation Fits

Traditional CME hasn't solved the prescribing problem.¹⁰ Didactic lectures and knowledge-based approaches fail to address real-world challenges: managing diagnostic uncertainty, translating evidence into treatment decisions, and having effective patient conversations about prevention. Antimicrobial stewardship requires practice-based learning that develops clinical reasoning and communication skills simultaneously.

Simulation-based medical education demonstrates superior outcomes compared to traditional methods,¹¹⁻¹² but resource constraints limit widespread implementation. The question becomes: how do we give thousands of clinicians repeated opportunities to practice evidence-based UTI management in realistic scenarios?

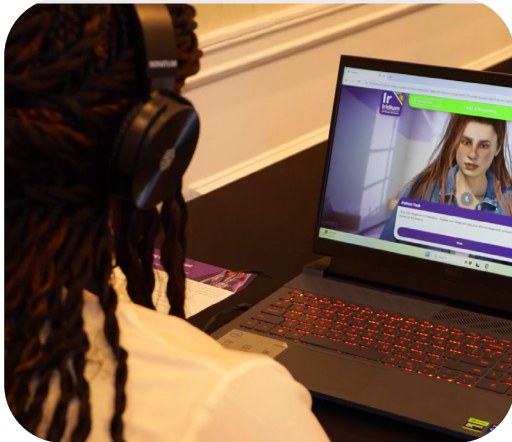


Uncomplicated urinary tract infections account for over **10 million outpatient antibiotic prescriptions annually** in the United States.

Antimicrobial stewardship requires **practice-based learning.**

Why AI Virtual Patients (Now)

AI-driven virtual patients deliver conversation-based practice on-demand with automated, rubric-aligned feedback. Recent evidence shows AI-simulated patients can improve clinical interview skills and are feasible for routine training.¹³⁻¹⁵ Unlike traditional simulation, AI platforms like Xuron provide 24/7 accessibility across devices, addressing geographic and scheduling barriers—particularly for rural and community-based providers who often face the greatest stewardship challenges.¹⁶⁻¹⁷



Live Deployment at The Roosevelt Hotel, New Orleans

What This Case Study Contributes

This ongoing study evaluated a blended CME program using AI virtual patient simulation for uncomplicated UTI management. Between March and July 2025, we reached two cohorts: a diverse online group and focused live workshops for experienced family medicine physicians.

Results revealed both progress and critical gaps. Knowledge improved 33% online and 10% in live workshops. Confidence surged dramatically: the proportion rating themselves “very/extremely confident” jumped from 22% to 71% online and 73% to 93% in live sessions.

But simulation performance exposed the stewardship challenge. Treatment discussion scored lowest (2.2/5), with only 47% of learners specifying any antibiotic therapy. Among those who prescribed, fewer than one in three selected guideline-concordant first-line agents. Novel agent awareness appeared in under 5% of responses. Patient education showed similar gaps: while 62% provided prevention counseling, only 23% addressed antimicrobial resistance.

These findings demonstrate that AI simulation produces measurable gains in knowledge and confidence through scalable, personalized learning. However, the persistent gap between improved knowledge and suboptimal treatment decisions highlights the complexity of translating education into practice change¹⁸⁻¹⁹—and the ongoing need for innovation in antimicrobial stewardship education.

How to Read the Rest of This Paper

1

Course Design & Methods

Quick scan for activity design and learner cohort, so you can benchmark against your own urinary tract infection programs.

2

Preliminary Results

KPI deltas and interpretation with visual summaries for knowledge, confidence, and simulation performance.

3

Discussion

Where these results sit within literature on AI-enabled training (communication, empathy, self-efficacy).

4

Conclusions

What we controlled for in this pilot and what we're evaluating next (larger cohorts, matched controls, and longitudinal follow-up).

Introduction

Uncomplicated urinary tract infections (uUTIs) account for over 10 million outpatient antibiotic prescriptions annually in the United States, making them a critical target for antimicrobial stewardship efforts.³ Despite clear clinical guidelines, inappropriate prescribing remains common, contributing to antimicrobial resistance and suboptimal patient outcomes.

Simulation-based medical education has emerged as a promising method to train these crucial clinical skills, demonstrating superior learning outcomes compared to traditional didactic methods.¹¹ However, traditional simulation faces scalability challenges and resource constraints that limit widespread implementation.

Artificial intelligence (AI)-driven simulations offer a potential solution by providing personalized, accessible, and scalable training experiences. AI simulation activities enable learners to interact with virtual patients using natural language and receive real-time feedback adapted to their individual responses. This approach addresses key limitations of traditional CME, while maintaining the experiential learning benefits of simulation.



Inappropriate prescribing remains common, contributing to antimicrobial resistance and suboptimal patient outcomes.

Study Rationale and Innovation

This study is the first large-scale evaluation of AI-driven simulation for antibiotic stewardship education. By comparing online self-paced learning with focused live workshops, we address a critical question about optimal delivery modalities for complex clinical training. The focus on uUTI management provides a well-defined clinical scenario with clear guideline recommendations, enabling precise assessment of learning outcomes and clinical competency development.

Study Rationale and Innovation

Prior needs assessment revealed that clinicians face several barriers to optimal uUTI management:

Educational Gaps		Learning Objectives 
	Diagnostic challenges Clinicians often struggle to distinguish uncomplicated from complicated UTIs and may misinterpret urinalysis results. Incomplete histories—omitting allergies, prior infections or medications—hinder accurate diagnoses.	Apply evidence-based guidelines to accurately interpret signs, symptoms, and laboratory test results for diagnosing uUTIs
	Treatment uncertainty Limited awareness of current guideline recommendations and emerging agents. Despite guidelines emphasising nitrofurantoin, trimethoprim-sulfamethoxazole, fosfomycin, pivmecillinam and first-generation cephalosporins as first-line therapy, many clinicians prescribe broad-spectrum antibiotics or inadequate durations.	Utilize evidence-based guidelines in selecting antimicrobial therapy for uncomplicated UTIs, thereby minimizing unnecessary antibiotic use
	Limited knowledge of risk factors Many healthcare providers underestimate factors contributing to recurrence and treatment failure.	Review the key factors contributing to treatment failure in patients with uncomplicated urinary tract infections
	Underappreciation of uUTI burden Clinicians may not fully recognize the economic and health impacts, including recurrent antibiotic exposure and the societal cost of antimicrobial resistance.	Evaluate the impact of uUTI and treatment failure on patient well-being
	Inadequate patient education Providers sometimes assume patients understand UTI management and therefore fail to educate them about prevention strategies such as hydration, post-coital urination and proper hygiene.	Integrate patient education and shared decision-making into their management of uUTIs

1 Course Design and Methods

Study Design and Setting

This pragmatic effectiveness study employed a multi-modal design comparing two distinct educational delivery approaches. The study was conducted between March 2025 and July 2025, with data collection ongoing until March 2026. There are two cohorts in this course: enduring (available to all) and a series of 5 live lectures/workshops throughout the US. Both cohorts completed identical virtual patient encounters, featuring a 23-year-old female presenting with dysuria and urinary frequency. The AI-driven simulation enabled natural language interaction, with dynamic responses based on learner inputs.

Each simulation activity included six sequential clinical tasks:

- 1

History taking
- 2

Quality of life assessment
- 3

Diagnostic evaluation
- 4

Treatment discussion
- 5

Patient education
- 6

Follow-up planning

Enduring (n=86)		Live (n=15)	
	Distributed over one year Learners accessed pre-simulation learning content within the enduring activity		Five-city road-show In each city, a live lecture reviewed uUTI epidemiology, diagnostic criteria, first-line treatments emerging agents
	AI-driven virtual patient simulation Each participant completed an AI-driven virtual-patient simulation with six tasks (below). Scores were recorded on a 1-5 Likert scale		Small-group workshops Some participants then moved to a small-group workshop featuring the same virtual-patient simulation used online
	Pre- and post-tests with AI feedback Pre- and post-tests measured confidence and knowledge. AI feedback after the simulation provided personalized, step-by-step guidance		Pre- and post-tests with AI feedback Pre- and post-tests measured confidence and knowledge. AI feedback after the simulation provided personalized, step-by-step guidance

Conversational Data Analysis

Learner simulation step scores, along with transcripts, were analyzed using AI large language models (ChatGPT o3, Claude Sonnet 4) to extract conversational insights for most simulation steps/LOs.

The top-line insight questions focused on:

- 1 Clinical decision-making process
- 2 Diagnostic and management challenges
- 3 Evaluation of uUTI and treatment failure on the patient's well-being

Learner Demographics

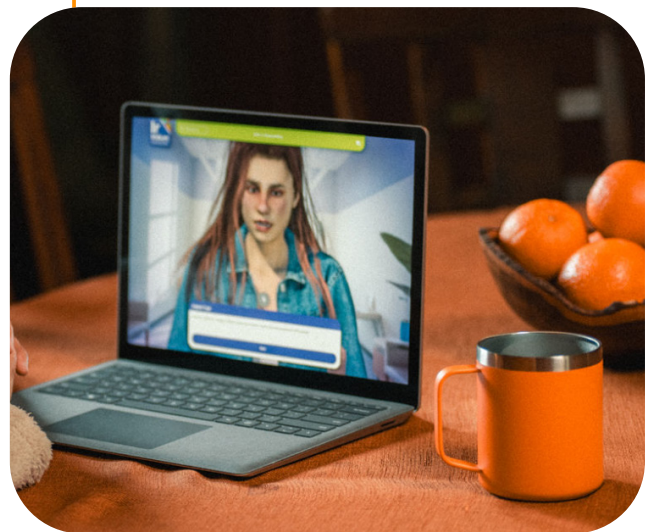
Enduring

The self-paced online cohort included a broad mix of professions and specialties, with only about one-third of learners having over 20 years in practice (n=36). Finally, a notable share of nurses (n=35) and advanced practitioners (n=34) made up the cohort.

Live

In contrast, the live workshop group consisted almost entirely of physicians. They were all from family medicine, and skewed slightly toward more seasoned clinicians, though still including some early-career providers.

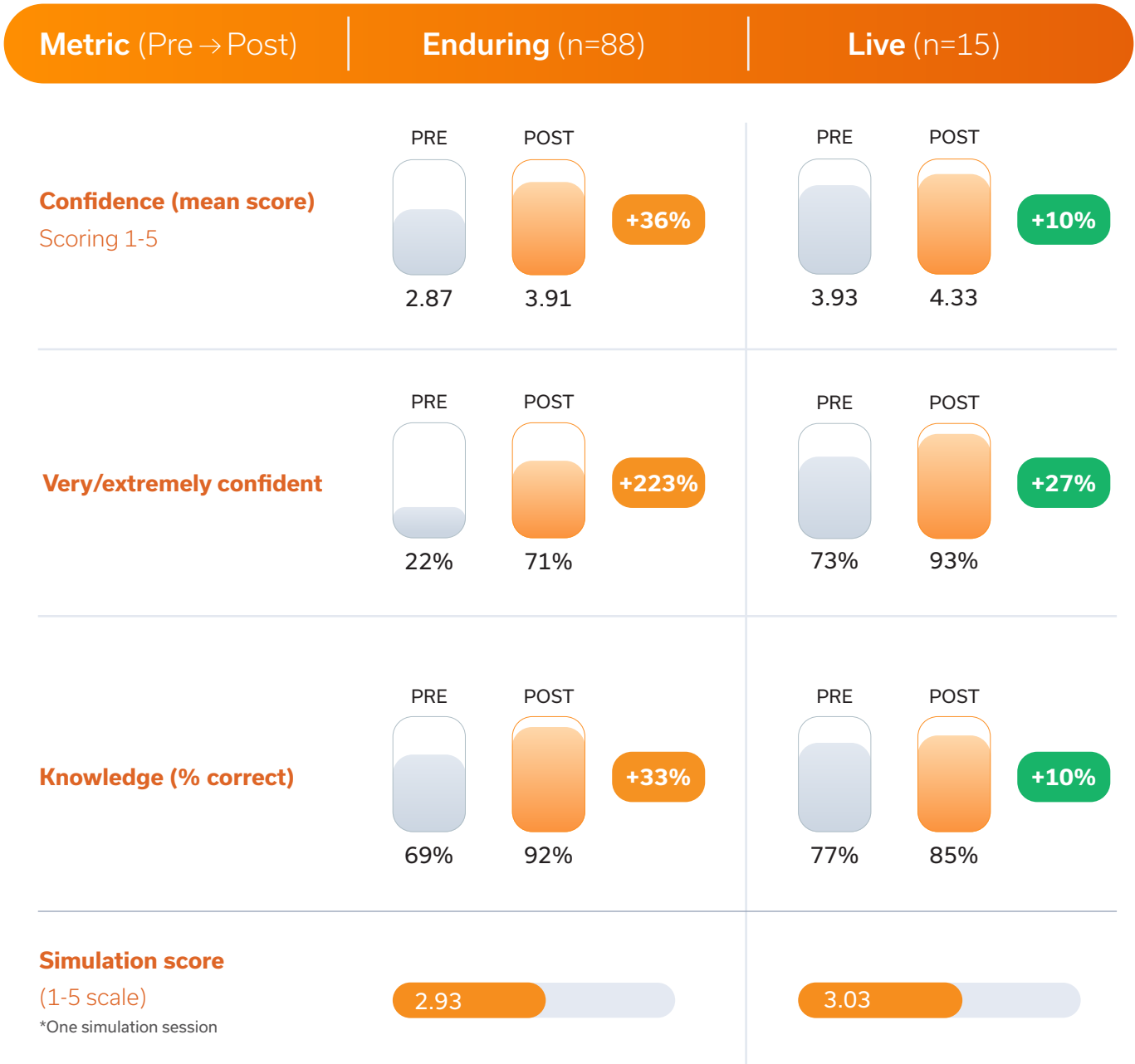
These differences suggest that the live session reached a narrower and more uniform audience compared with the online component.



2 Preliminary Results

Knowledge and Confidence Change

These top-line figures show that the **online module delivered substantial improvements** in knowledge and confidence across a broad learner population. The **live workshop produced smaller relative gains** (likely reflecting higher baseline expertise), but yielded the highest absolute confidence and performance scores.



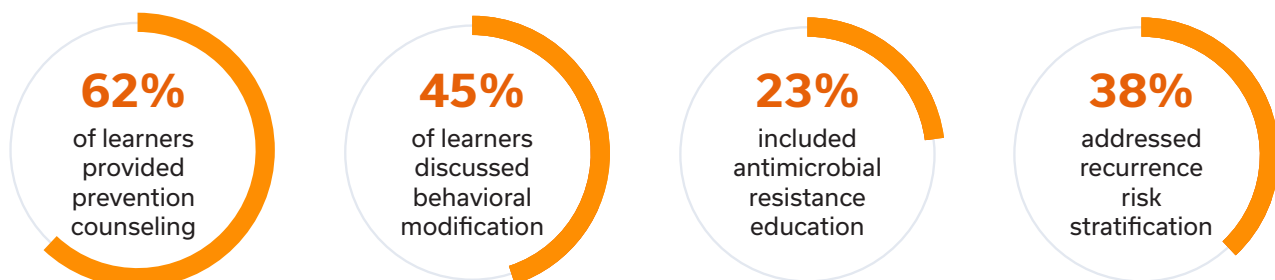
Simulation Step Performance

Simulation step	Enduring (n=88)	Live (n=15)
Step 1 - Obtain history Collect a comprehensive of the present illness	3.3	3.3
Step 2 - Quality of life assesment Evaluate how symptoms affect the patient's quality of life	3.4	3.3
Step 3 - Diagnosis & evaluation Explain the diagnosis and desired diagnostic evaluation based on the history	2.7	3.1
Step 4 - Treatment discussion Select the best management option and discuss novel and emerging treatments when appropriate	2.2	2.5
Step 5 - Patient education Explain recurrence, antibiotic resistance and prevention strategies	3.1	2.7
Step 6 - Follow-up Design a follow-up plan including monitoring and prophylaxis if UTIs persist	2.8	3.3
Overall average	2.92	3.05

Treatment Discussion represented the most significant competency gap across both cohorts. Detailed analysis revealed:

- Only 47% of learners specified any antibiotic therapy
- Of those prescribing antibiotics, only 31% selected guideline-concordant first-line agents
- Novel agent awareness (pivmecillinam, gepotidacin) was evident in <5% of responses.

Patient Education Competency:



3 Discussion

The program's outcomes highlight the effectiveness of blended learning for addressing uUTI educational gaps. The online format served as an effective "leveling" intervention, producing substantial knowledge and confidence gains across a diverse learner population. This finding aligns with Ruth Colvin Clark's multimedia learning principles, suggesting that self-paced, individualized instruction is particularly effective for addressing foundational knowledge gaps.²⁰

Conversely, the live workshop format, while producing smaller relative gains, achieved the highest absolute performance levels, indicating its value for skill refinement among more experienced practitioners.

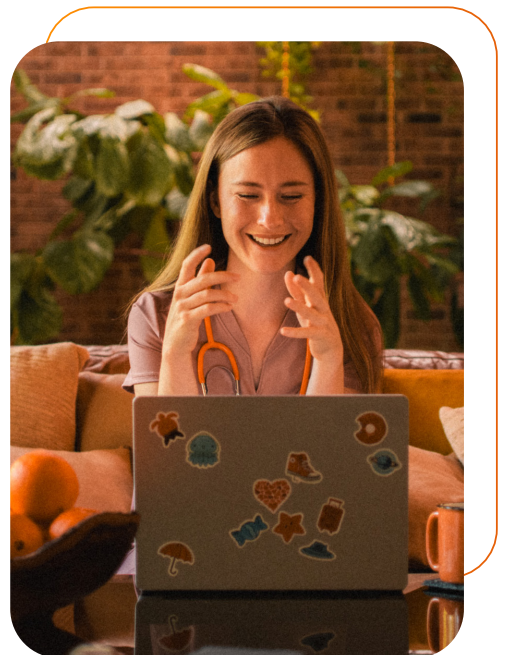
Persistent diagnostic ambiguity and suboptimal treatment choices in the simulation mirror real-world challenges. For example clinicians often misinterpret urinalysis and may diverge from guideline-recommended therapies. Limited patient education observed in the simulation reflects systemic gaps. Furthermore, awareness of novel agents such as pivmecillinam and gepotidacin was low. Addressing these weaknesses is vital as antimicrobial resistance escalates,³ and non-antibiotic preventive strategies are increasingly important.²¹

4 Conclusions

This ongoing study provides preliminary evidence that AI-driven simulation represents a significant advancement in continuing medical education, producing measurable improvements in clinical knowledge and confidence through scalable, personalized learning experiences. The differential effectiveness of online versus live delivery suggests that blended approaches optimize learning outcomes while addressing diverse learner needs.

Persistent gaps in evidence-based prescribing despite knowledge improvements highlight the complexity of translating education into practice change. For antimicrobial stewardship programs, detailed simulation analytics enable targeted interventions by identifying specific prescriber decision-making deficits.

As data collection continues through March 2026, future analysis will examine longitudinal outcomes and prescribing behavior changes. The platform's 24/7 accessibility across mobile, tablet, and desktop devices addresses critical barriers to continuing education, particularly for rural and community-based providers who traditionally face geographic and scheduling constraints. These preliminary findings suggest AI-driven simulation offers a promising pathway toward more effective and equitable professional development across diverse clinical domains.





Boris Rozendfeld, MD
Chief Learning Officer at Xuron

Boris has over 11 years of experience in medical education and currently serves as Chief Learning Officer at Xuron, specializing in AI-powered conversational simulations for teaching interpersonal, communication, and clinical reasoning skills.



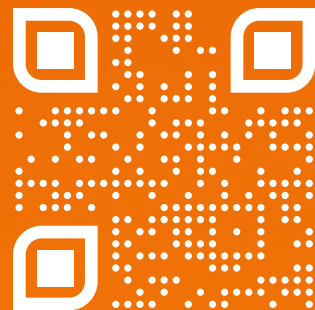
Ian Nott
CEO of Xuron

Ian has leveraged nearly a decade of experience in spatial computing and software development to lead innovations in AI-powered virtual human simulations for medical training.

References

1. Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*. 2022;399(10325):629-655. doi:10.1016/S0140-6736(21)02724-0
2. GBD 2021 Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. *The Lancet*. 2024;404(10459):1199-1226. doi:10.1016/S0140-6736(24)01867-1
3. Goebel MC, Trautner BW, Grigoryan L. The Five Ds of Outpatient Antibiotic Stewardship for Urinary Tract Infections. *Clin Microbiol Rev*. 2021;34(4):e00003-20. doi:10.1128/CMR.00003-20
4. Carlson K, Bender P. Appropriateness of Antibiotic Prescriptions for Urinary Tract Infections. *West J Emerg Med*. 2020;21(3):633-639. doi:10.5811/westjem.2020.2.45944
5. Durkin MJ, Keller M, Butler AM, et al. An Assessment of Inappropriate Antibiotic Use and Guideline Adherence for Uncomplicated Urinary Tract Infections. *Open Forum Infect Dis*. 2018;5(9):ofy198. doi:10.1093/ofid/ofy198
6. Bratsman A, Mathias K, Laubscher R, Grigoryan L, Rose S. Outpatient fluoroquinolone prescribing patterns before and after US FDA boxed warning. *Pharmacoepidemiol Drug Saf*. 2020;29(6):701-707. doi:10.1002/pds.5018
7. Kistler CE, Zimmerman S, Ward KT, et al. Performance of Urinalysis Parameters in Predicting Urinary Tract Infection: Does One Size Fit All? *Open Forum Infect Dis*. 2024;11(9):ofae434. doi:10.1093/ofid/ofae434
8. Midthun SJ, Paur RA, Lindseth GN, Lanier LR. Abnormal urinalysis results are common, regardless of specimen collection technique, in women without urinary tract infections. *J Emerg Med*. 2015;49(5):706-711. doi:10.1016/j.jemermed.2015.04.012
9. Bilsen MP, Jongerden IP, Vorst M, et al. Current Pyuria Cutoffs Promote Inappropriate Urinary Tract Infection Diagnosis in Older Women. *Clin Infect Dis*. 2023;77(1):69-76. doi:10.1093/cid/ciad116
10. Vaughan J, Lochlainn DM, Murphy R, Mulcahy H. Effectiveness of work-based educational interventions for antimicrobial stewardship: a systematic review. *JAC Antimicrob Resist*. 2024;6(6):dlae192. doi:10.1093/jacamr/dlae192
11. McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. *Acad Med*. 2011;86(6):706-711. doi:10.1097/ACM.0b013e318217e119

12. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *JAMA*. 2011;306(9):978-988. doi:10.1001/jama.2011.1234
13. Yamamoto A, Koda M, Ogawa H, et al. Enhancing Medical Interview Skills Through AI-Simulated Patient Interactions: Nonrandomized Controlled Trial. *JMIR Med Educ*. 2024;10:e58753. doi:10.2196/58753
14. Holderried F, Stegemann-Philipps C, Herrmann-Werner A, et al. A Language Model-Powered Simulated Patient With Automated Feedback for History Taking: Prospective Study. *JMIR Med Educ*. 2024;10:e59213. doi:10.2196/59213
15. Cook DA, Overgaard J, Pankratz VS, Del Fiol G, Aakre CA. Virtual Patients Using Large Language Models: Scalable, Contextualized Simulation of Clinician-Patient Dialogue With Feedback. *J Med Internet Res*. 2025;27:e68486. doi:10.2196/68486
16. O'Brien Pott M, Blanshan AS, Huneke KM, Baasch Thomas BL, Cook DA. Barriers to identifying and obtaining CME: a national survey of physicians, nurse practitioners and physician assistants. *BMC Med Educ*. 2021;21:168. doi:10.1186/s12909-021-02595-x
17. Curran VR, Fleet L, Kirby F. Factors influencing rural health care professionals' access to continuing professional education. *Aust J Rural Health*. 2010;18(6):259-264. doi:10.1111/j.1440-1584.2010.01167.x
18. Mahtta S, Fong R, Haston C, et al. Gaps and barriers in the implementation and functioning of antimicrobial stewardship programmes: results from an educational and behavioural mixed methods needs assessment in France, the United States, Mexico and India. *JAC Antimicrob Resist*. 2022;4(5):dlac096. doi:10.1093/jacamr/dlac096
19. Maagaard M, Rohde K, Trubka R, Thornley T, Winthrop Z, Davis C. A review of antimicrobial stewardship training in medical education. *Can Med Educ J*. 2017;8(4):e78-e87.
20. Clark RC, Mayer RE. *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*. 4th ed. Wiley; 2016.
21. Burrows LL. It's uncomplicated: Prevention of urinary tract infections in an era of increasing antibiotic resistance. *PLoS Pathog*. 2024;20(2):e1011930.
22. Watters C, Reedy G, Ross A, Morgan NJ, Handslip R, Jaye P. Does interprofessional simulation increase self-efficacy: a comparative study. *BMJ Open*. 2015;5(1):e005472.
23. Blackmore A, Kasfiki EV, Purva M. Simulation-based education to improve communication skills: a systematic review and identification of current best practice. *BMJ Simul Technol Enhanc Learn*. 2018;4(4):159-164.
24. Bono MJ, Leslie SW. Uncomplicated Urinary Tract Infections. In: *StatPearls [Internet]*. StatPearls Publishing; 2025.



xuron

© 2025 Xuron Inc.