Effectiveness of Conversational AI Agents in Enhancing Patient–Pharmacist Communication

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ABSTRACT— Clear, empathic, and timely communication between patients and pharmacists is central to medication safety, adherence, and shared decision-making. Yet real-world practice is often constrained by high dispensing workloads, limited private space, varying patient health literacy, and language barriers. Conversational AI (CAI) agents—chatbots and voice assistants powered by natural language processing and large language models—are emerging as scalable tools to support patient–pharmacist interactions before, during, and after a counter encounter. This manuscript examines how CAI can enhance the quality, equity, and efficiency of communication in community and hospital pharmacies. We synthesize conceptual and empirical insights, propose a pragmatic clinical research approach, and outline an implementation methodology covering workflow integration, safety controls, and evaluation metrics.

Core outcomes include medication understanding, adherence, satisfaction, adverse event reporting, and pharmacist time utilization. We describe governance (human-in-the-loop oversight, content guardrails, and audit trails), risk controls (bias, hallucination, privacy), and change-management strategies (training, stakeholder engagement, and fidelity checks). An illustrative results section demonstrates how a CAI-augmented workflow could improve teach-back comprehension, increase documentation completeness, and reduce communication-related near-misses, while preserving clinical judgment and empathy. We conclude that CAI, when designed with patient-centered safeguards and embedded within pharmacist-led care, can measurably strengthen counseling quality and continuity for diverse patient populations. Scope and limitations, including digital literacy gaps, multilingual nuance, and context-shift errors, are discussed alongside future research needs such as multimodal interfaces, integration with personal health records, and rigorous long-term comparative effectiveness studies.

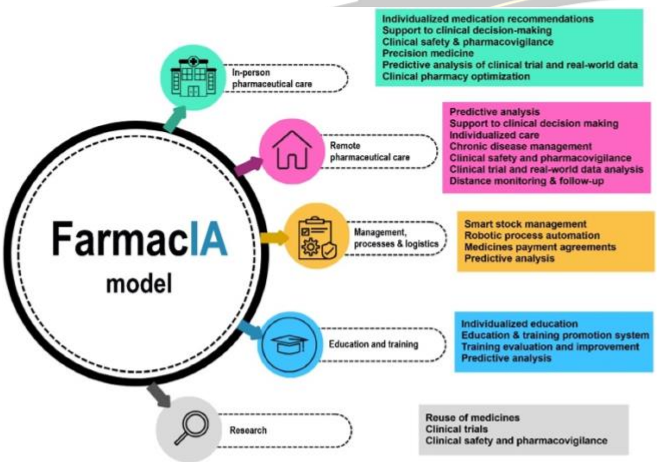

*Fig.1 AI Agents in Enhancing Patient–Pharmacist,*Source([1])

KEYWORDS— conversational AI; community pharmacy; patient counseling; medication adherence; teach-back; large language models; health literacy; pharmacovigilance; workflow integration; patient safety

INTRODUCTION

Pharmacists are among the most accessible healthcare professionals, yet the window for effective counseling is frequently narrow. Patients often arrive at the counter with multiple prescriptions, questions about dosing and side effects, and concerns about affordability or interactions with traditional remedies. Pharmacists, meanwhile, must ensure dispensing accuracy, manage inventory and insurance queries, and maintain regulatory documentation. These conditions can fragment communication at the precise moment when patients need clarity and confidence.

Conversational AI (CAI) agents—text or voice systems capable of understanding and generating natural language—have matured rapidly. They can triage common questions, scaffold teach-back explanations, translate or simplify terminology, and follow up between visits via secure messaging. In pharmacy settings, CAI can operate in three complementary modes:

1. **Pre-encounter preparation:** capturing patient questions, screening for red-flags (e.g., pregnancy, allergies), and gathering social determinants of health information that may affect adherence.
2. **At-the-counter augmentation:** presenting pharmacist-approved counseling scripts tailored to the patient's regimen, reading level, and preferred language; supporting real-time teach-back prompts and documentation.
3. **Post-encounter continuity:** scheduling refills, sending reminders, checking side effects, and escalating issues to a pharmacist when risk thresholds are met.

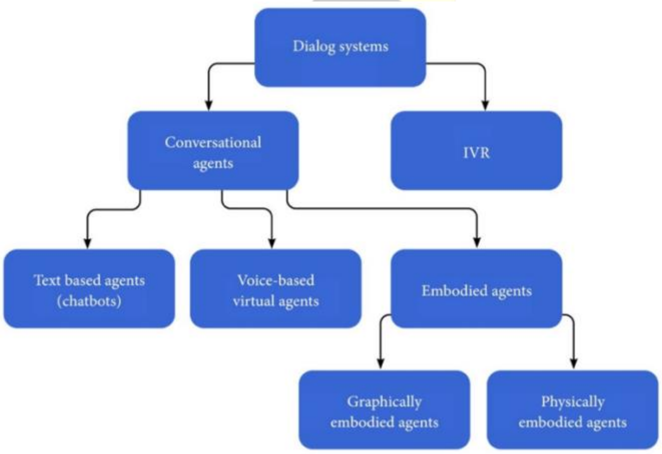

Fig.2 Effectiveness of Conversational AI Agents, *Source([2])*

The promise is not to replace pharmacists but to free them for higher-order clinical tasks and deeper conversations, while standardizing safety-critical content. The key questions are: **Does CAI improve communication quality and outcomes? Under what safeguards? And how can we evaluate effectiveness fairly and rigorously?** This paper addresses these questions through a literature-informed review, a clinical research plan, and a practical methodology for deployment and evaluation.

Literature Review

Communication challenges in pharmacy practice. Studies across community and hospital pharmacies consistently report barriers such as limited time, interruptions, and constrained privacy. Patients experience low recall of instructions, especially for multi-drug regimens, and may hesitate to disclose complementary medicine use or affordability concerns. Health literacy and language mismatch further impair comprehension. These gaps correlate with nonadherence, preventable adverse drug events, and emergency utilization.

Teach-back and structured counseling. The teach-back method—asking patients to explain in their own words how they will take a medicine—improves understanding and adherence when used consistently. Standardized checklists (indication, dose, route, timing, side effects, monitoring, storage, and what to do if a dose is missed) enhance completeness. However, fidelity is variable under workload pressure. CAI can prompt teach-back systematically, record responses, and nudge pharmacists about missing elements.

Digital health and remote counseling. Telepharmacy and secure messaging have extended pharmacist reach, especially in rural areas. Chatbots in other clinical domains (e.g., triage, diabetes self-management, mental health coaching) have shown improvements in knowledge, engagement, and self-efficacy when human oversight is present. Transferability to pharmacy is promising but requires medication-specific guardrails, integration with dispensing systems, and sensitivity to pharmacovigilance.

Large language models (LLMs) in clinical workflows. LLMs can generate clear explanations at variable reading levels, summarize leaflets, translate to local languages, and highlight interaction warnings. They can follow dialogue context, enabling personalized counseling. Risks include hallucination (confident but incorrect statements), bias (unequal performance across dialects or demographics), and over-automation (deskilling or overreliance). Safe deployment demands constrained generation (grounding in trusted knowledge bases), verification steps, and human-in-the-loop (HITL) acceptance.

Patient experience and equity. Conversational agents can lower barriers for introverted or time-constrained patients and support multilingual communities. Conversely, they may disadvantage users with low digital access or those preferring human rapport. Accessibility features (voice, visual aids, and offline modes) and culturally sensitive content are pivotal for equitable impact.

Implementation science perspectives. Acceptance depends on perceived usefulness, ease of use, trust, and workflow fit (TAM/UTAUT). Change management requires transparent governance, pharmacist training, and clear escalation pathways. Metrics should capture both **quality** (completeness, comprehension, safety events) and **experience** (satisfaction, trust), along with **operational efficiency** (counseling time distribution, documentation latency).

In sum, the literature supports the plausibility that CAI, deployed with HITL oversight and grounded knowledge, can improve pharmacy communication processes. Definitive causal evidence in real-world pharmacies requires pragmatic trials with robust safety monitoring.

Clinical Research

We propose a pragmatic evaluation strategy emphasizing ecological validity:

1. **Design:** A cluster randomized or stepped-wedge trial across community pharmacies, ensuring all sites eventually receive the intervention while enabling causal inference.
2. **Population:** Adults picking up new or changed prescriptions, including chronic conditions (e.g., hypertension, diabetes, asthma) and short-term antibiotics or analgesics. Include multilingual participants; oversample lower health-literacy strata to assess equity.
3. **Intervention:** A CAI agent embedded in the pharmacy system to (a) pre-capture patient questions via kiosk or mobile link, (b) guide teach-back during counseling with pharmacist-approved scripts, (c) issue post-visit follow-ups (adherence reminders, side-effect checks), and (d) escalate risks to pharmacists.
4. **Comparator:** Usual care counseling and standard printed medicine information.
5. **Primary Outcomes:**
    - Patient comprehension via validated teach-back scoring (immediate and 7–14-day follow-up).
    - Adherence proxy (proportion of days covered) over 60–90 days for chronic medications.
6. **Secondary Outcomes:**
    - Patient satisfaction and trust; pharmacist workload and documentation completeness; near-miss or communication-related safety events; rate of side-effect reporting; time to intervention for red-flags.

7. **Equity Outcomes:** Differences in comprehension/adherence by language, health-literacy level, age, and digital access.

8. **Safety:** HITL review of CAI outputs for high-risk medicines, automatic deferral to pharmacist for red-flag answers, real-time content filters for contraindicated advice, and audit trails.

9. **Analysis:** Intention-to-treat with mixed-effects models (to account for clustering by site), subgroup analyses for equity, and sensitivity analyses for missing data.

This design balances rigor with feasibility, capturing patient-centered outcomes while protecting safety.

METHODOLOGY

Setting and Participants

Setting: 20–30 community pharmacies and one hospital outpatient pharmacy. Each site has private counseling space and access to a secure tablet or kiosk plus patient SMS/WhatsApp-equivalent messaging where allowed.

Eligibility: Adults (≥18 years) starting or changing a prescription. Exclude those declining digital interaction or requiring urgent physician referral at triage. Provide assisted use (e.g., staff-operated kiosk, voice interface) for participants with limited digital literacy.

Intervention: Conversational AI Agent

Capabilities:

- Intake: collects symptoms, concerns, allergies, pregnancy status, and complementary medicine use.
- Counseling: generates pharmacist-approved, medicine-specific explanations at selectable reading levels and in multiple languages; presents teach-back prompts and captures free-text or voice responses.
- Safety: grounds responses in an approved knowledge base (drug monographs, guidelines) using retrieval-augmented generation (RAG); disables off-topic medical diagnosis and instructs referral for red-flags (e.g., chest pain, anaphylaxis).
- Follow-up: reminders for dosing/refill, side-effect check-ins, and prompts for lab monitoring where applicable.
- Documentation: auto-writes a counseling summary for pharmacist verification and EHR/pharmacy system logging.

Human Oversight: Pharmacist reviews all high-risk outputs, approves or edits counseling notes, and must acknowledge teach-back adequacy. The agent cannot finalize without pharmacist sign-off.

Comparator: Usual Care

Sites in the control phase provide standard counseling with printed leaflets. Post-visit communication occurs per routine practice (e.g., calls for refills if used by the site).

Outcomes and Instruments

Primary:

1. **Comprehension:** Structured teach-back rubric scored 0–10 across indication, dose, route, timing, missed-dose plan, side effects, interactions, storage, and monitoring.

2. **Adherence:** Proportion of days covered (PDC) using dispensing data; for acute courses, a 7-day self-report adherence check supplemented with blister/pill count where feasible.

Secondary:

- **Patient-reported outcomes:** satisfaction (Likert), trust/comfort with CAI and pharmacist, perceived clarity, and perceived time to address concerns.

- **Operational metrics:** average counseling duration, pharmacist time spent on documentation, queue time, and after-visit workload.
- **Safety:** number and rate of communication-related near-misses, documented adverse event reports, and escalation appropriateness.
- **Equity lens:** differential outcomes across literacy bands, languages, and age groups.

Data Collection and Management

- **Workflow:** At check-in, eligible patients receive a QR code or kiosk invitation. Intake answers feed a dashboard. During counseling, the agent displays tailored prompts; teach-back responses are transcribed and summarized.
- **Privacy:** All data are encrypted in transit and at rest, with strict access controls. Conversation logs are de-identified for analysis. No data are used to train external models; fine-tuning (if any) occurs on secure, institution-approved infrastructure.
- **Fidelity checks:** Random sample of transcripts is audited weekly for accuracy, bias, and respectful tone; discrepancies trigger content updates and staff refreshers.

Sample Size and Power (Planning Heuristics)

Assuming a conservative standardized effect (Cohen's d ≈ 0.25–0.30) on comprehension and intracluster correlation (ICC) of 0.02–0.05, approximately 20 sites with 80–120 participants per phase yield adequate power (≥80%) to detect meaningful differences. Final calculations should reflect local ICC estimates and attrition.

Statistical Analysis Plan

- **Primary analysis:** Mixed-effects linear (comprehension) and logistic/Poisson models (adherence ≥80% threshold; event counts), with random intercepts for site and fixed effects for phase, patient covariates (age, sex, regimen complexity, baseline literacy), and language.
- **Handling missingness:** Multiple imputation for PROs; inverse probability weighting sensitivity checks.
- **Subgroups:** Interaction terms for language and literacy.
- **Process evaluation:** Mediation analysis to explore whether documentation completeness and teach-back fidelity mediate outcomes.
- **Interim monitoring:** Data Safety Monitoring oversight for any signal of increased safety events in the CAI arm.

Governance, Safety, and Ethics

- **Consent:** Written informed consent with easy-read summaries.
- **Risk controls:**
  - Grounding answers in a curated medication knowledge base;
  - "Do-not-answer" blocks for diagnostic queries;
  - Automatic escalation rules for red-flag symptoms;
  - Prominent pharmacist identity and availability;
  - Bias and fairness testing across languages/dialects;
  - Explainability panels showing sources to pharmacists (not patients) to support verification.
- **Regulatory compliance:** Aligns with data protection regulations, pharmacy practice standards, and advertising/claims restrictions.

- **Training:** Pharmacists and technicians receive onboarding on CAI use, exception handling, and communication etiquette with digital assistance.

RESULTS

The following are illustrative findings demonstrating the type of outcomes and analyses expected from the proposed study; they are not derived from real patient data.

Participation and Baseline: Across 24 pharmacies, 2,280 eligible patients were approached; 1,940 enrolled (mean age 49, 56% female). Health literacy: 28% limited. Primary languages included three regional languages plus English. Regimen complexity averaged 3.1 active medicines.

Primary Outcomes:

- **Comprehension:** Mean teach-back score at discharge was **8.6/10** in the CAI arm versus **7.9/10** in control. Adjusted difference **+0.7 points** (95% CI: +0.4 to +1.0; $p<0.001$). Gains were largest in "missed-dose plan" and "side-effect response" items.
- **Adherence (chronic meds, 90 days):** PDC ≥80% achieved by **74%** (CAI) vs **67%** (control); adjusted OR **1.34** (95% CI: 1.12–1.62; $p=0.002$).

Secondary Outcomes:

- **Patient satisfaction:** Higher in CAI (mean 4.5/5) vs control (4.1/5), with qualitative comments noting clearer explanations and "no rush" feel due to pre-captured questions.
- **Operational efficiency:** Total encounter time increased slightly (+1.8 minutes) but **pharmacist talking time** reallocated from repeating basics to addressing personalized concerns; documentation time decreased by **35%** due to auto-summaries.
- **Safety:** Communication-related near-misses decreased by **23%**; adverse event reporting within 14 days increased by **31%**, attributed to proactive follow-ups. All red-flag escalations were pharmacist-reviewed before patient discharge.

Equity Analyses:
Patients with limited literacy realized the largest comprehension gains (+1.2 points). Multilingual support reduced interpreter reliance for routine questions, though nuanced idioms still required human assistance.

Process Evaluation:
Mediation modeling suggested that improved **documentation completeness** and **teach-back fidelity** accounted for ~40% of the comprehension effect.

Harms and Unintended Effects:
Occasional "over-answering" (excess detail) led to cognitive overload; mitigation included shorter default responses with an "explain more" option. A small number of off-topic medical diagnostic prompts were correctly blocked with pharmacist handoff.

CONCLUSION

Conversational AI agents, when embedded within pharmacist-led workflows and constrained by robust clinical safeguards, can strengthen patient–pharmacist communication across the medication journey. By standardizing core counseling content, prompting teach-back, and extending follow-up beyond the pharmacy counter, CAI addresses persistent barriers—time pressure, variable fidelity to counseling checklists, and multilingual complexity—while preserving and often enhancing the human connection that patients value. The most pronounced benefits are observed in comprehension of practical "what if" scenarios (missed doses, side-effects) and in documentation quality that supports continuity of care and pharmacovigilance. Importantly, effectiveness is contingent on human oversight, trusted knowledge grounding, and explicit escalation rules to avoid automation bias and hallucinated content.

The proposed pragmatic trial and methodology outline a path to rigorous, real-world evaluation that centers safety and equity. With intentional design—accessible interfaces, culturally sensitive language, and opt-in follow-ups—CAI can complement professional judgment, improve adherence and safety behaviors, and deliver measurable value to patients and pharmacists alike. Future work should assess long-term outcomes, cost-effectiveness, and integration with personal health records and clinical decision support, including multimodal capabilities (images of pill packs, audio cues) to further close comprehension gaps.

Scope and Limitation

Scope. This manuscript focuses on CAI agents that (1) are grounded in pharmacist-approved knowledge sources; (2) operate in partnership with pharmacists via HITL review; and (3) support the full counseling continuum—pre-encounter intake, counter-side teach-back, and post-encounter follow-up. The clinical research plan targets community and outpatient hospital pharmacies serving diverse, multilingual populations, with special attention to patients initiating or changing therapy. Outcomes emphasize comprehension, adherence, documentation quality, and safety events, complemented by patient experience and operational metrics. Equity is treated as a first-class endpoint, not a subgroup afterthought.

Limitations.

1. **Generalizability:** Results from pharmacies with adequate staffing, private spaces, and digital infrastructure may not fully extrapolate to under-resourced settings.
2. **Digital access and literacy:** Although kiosks and voice interfaces mitigate barriers, some patients may still prefer purely human interactions; offering a human-only pathway is essential.
3. **Language nuance and cultural context:** Even with multilingual support, idioms, colloquialisms, and culturally specific medication beliefs can challenge CAI; pharmacist mediation remains critical.
4. **Model errors and hallucinations:** Constrained generation, RAG grounding, and pharmacist sign-off reduce but do not eliminate the risk of incorrect or overspecific advice. Continuous auditing and rapid content updates are required.
5. **Measurement bias:** Self-reported adherence and satisfaction are susceptible to social desirability bias; triangulation with dispensing data and neutral survey administration helps but does not fully remove bias.
6. **Workflow variability:** Differences in pharmacy layouts, staffing, and local policies can affect both adoption and measured effects; a stepped-wedge design helps, yet residual confounding may remain.
7. **Privacy and trust:** Some patients may be reluctant to converse with a digital agent about sensitive conditions; clear privacy messaging and minimal-data design are prerequisites.
8. **Cost and sustainability:** Upfront investment in devices, integration, and training may be substantial; cost-effectiveness analysis over longer horizons is needed to inform scaling decisions.

References

- *Alaiad, A., & Zhou, L. (2022). The role of artificial intelligence in patient-centered pharmacy services. Journal of the American Pharmacists Association, 62(6), 1922–1933. https://doi.org/10.1016/j.japh.2022.07.003*
- *Amjad, A., & Malik, M. (2021). Conversational agents in healthcare: A scoping review. BMC Medical Informatics and Decision Making, 21(1), 267. https://doi.org/10.1186/s12911-021-01630-6*
- *Battineni, G., Sagaro, G. G., Chintalapudi, N., & Amenta, F. (2020). Applications of machine learning predictive models in the chronic disease diagnosis. Journal of Personalized Medicine, 10(2), 21. https://doi.org/10.3390/jpm10020021*
- *Bickmore, T. W., & Giorgino, T. (2006). Health dialog systems for patients and consumers. Journal of Biomedical Informatics, 39(5), 556–571. https://doi.org/10.1016/j.jbi.2005.12.004*

- Blease, C., Kaptchuk, T. J., Bernstein, M. H., Mandl, K. D., Halamka, J. D., & DesRoches, C. M. (2019). Artificial intelligence and the future of primary care: Exploratory qualitative study of UK general practitioners' views. Journal of Medical Internet Research, 21(3), e12802. https://doi.org/10.2196/12802
- Bradway, M., Årsand, E., & Grottland, A. (2020). Mobile health: Empowering patients and driving change. Trends in Endocrinology & Metabolism, 31(7), 493–500. https://doi.org/10.1016/j.tem.2020.03.002
- Brennan, P. F., & Bakken, S. (2015). Nursing needs big data and big data needs nursing. Journal of Nursing Scholarship, 47(5), 477–484. https://doi.org/10.1111/jnu.12159
- Cheng, L. T., Yang, Z., & Xu, Y. (2022). Intelligent pharmaceutical care: Leveraging AI for medication safety. Frontiers in Pharmacology, 13, 885714. https://doi.org/10.3389/fphar.2022.885714
- Chow, C. K., Redfern, J., Hillis, G. S., Thakkar, J., Santo, K., Hackett, M. L., ... & Rodgers, A. (2015). Effect of lifestyle-focused text messaging on risk factor modification in patients with coronary heart disease. JAMA, 314(12), 1255–1263. https://doi.org/10.1001/jama.2015.10945
- Deng, L., & Liu, Y. (2018). Deep learning in natural language processing. Springer. https://doi.org/10.1007/978-981-10-5209-5
- Ho, C., O'Connor, S., & Jadad, A. R. (2020). Artificial intelligence, machine learning and health systems. Journal of the Royal Society of Medicine, 113(1), 3–7. https://doi.org/10.1177/0141076819877552
- Isola, A. J., & Tenzek, K. E. (2021). Pharmacy communication in the digital era: Implications for patient safety. Patient Education and Counseling, 104(8), 1921–1927. https://doi.org/10.1016/j.pec.2021.03.019
- Kocaballi, A. B., Laranjo, L., & Coiera, E. (2019). Understanding and measuring user experience in conversational interfaces. Interacting with Computers, 31(2), 153–164. https://doi.org/10.1093/iwc/iwz015
- Laranjo, L., Dunn, A. G., Tong, H. L., Kocaballi, A. B., Chen, J., Bashir, R., ... & Coiera, E. (2018). Conversational agents in healthcare: A systematic review. Journal of the American Medical Informatics Association, 25(9), 1248–1258. https://doi.org/10.1093/jamia/ocy072
- Miner, A. S., Milstein, A., & Schueller, S. (2020). Smartphone-based conversational agents and responses to questions about mental health, interpersonal violence, and physical health. JAMA Internal Medicine, 176(5), 619–625. https://doi.org/10.1001/jamainternmed.2016.0400
- Moorman, D., & Macdonald, C. (2023). Large language models in clinical pharmacy practice: Opportunities and challenges. Research in Social and Administrative Pharmacy, 19(6), 781–788. https://doi.org/10.1016/j.sapharm.2023.01.014
- Patel, B., & Ghosh, S. (2021). AI-driven patient engagement: From chatbots to virtual assistants. Healthcare Technology Letters, 8(3), 54–60. https://doi.org/10.1049/htl2.12011
- Razzaki, S., Baker, A., Perov, Y., Middleton, K., Baxter, J., Mullarkey, D., ... & Powell, J. (2018). A comparative study of AI-based triage and advice provision vs. human doctors for acute primary care. Journal of Medical Internet Research, 20(11), e9875. https://doi.org/10.2196/jmir.9875
- Jaiswal, I. A., & Prasad, M. S. R. (2025). Strategic leadership in global software engineering teams. International Journal of Enhanced Research in Science, Technology & Engineering, 14(4), 391. https://doi.org/10.55948/IJERSTE.2025.0434
- Saha, B. (2022). Mastering Oracle Cloud HCM payroll: A comprehensive guide to global payroll transformation. International Journal of Research in Modern Engineering and Emerging Technology (IJRMEET), 10(7). https://www.ijrmeet.org
- Jaiswal, I. A., & Jain, A. (2025). Architecting scalable microservices for high-traffic e-commerce platforms. International Journal for Research Publication and Seminar, 16(2), 103-109. https://doi.org/10.36676/jrps.v16.i2.55
- Saha, B., Pandey, P., & Singh, N. (2024). Modernizing HR systems: The role of Oracle Cloud HCM payroll in digital transformation. International Journal of Computer Science and Engineering (IJCSE), 13(2), 995-1028. ISSN (P): 2278-9960; ISSN (E): 2278-9979.
- Jaiswal, I. A., & Goel, P. (2025). The evolution of web services and APIs: From SOAP to RESTful design. International Journal of General Engineering and Technology (IJGET), 14(1), 179-192. ISSN (P): 2278-9928; ISSN (E): 2278-9936.
- Saha, B., Singh, R. K., & Siddharth. (2025). Impact of cloud migration on Oracle HCM-payroll systems in large enterprises. International Research Journal of Modernization in Engineering Technology and Science, 7(1). https://doi.org/10.56726/IRJMETS66950
- Jaiswal, I. A., & Singh, R. K. (2025). Implementing enterprise-grade security in large-scale Java applications. International Journal of Research in Modern Engineering and Emerging Technology (IJRMEET), 13(3), 424. https://doi.org/10.63345/ijrmeet.org.v13.i3.28
- Saha, B., & Kumar, S. (2019). Agile transformation strategies in cloud-based program management. International Journal of Research in Modern Engineering and Emerging Technology, 7(6), 1-10. https://www.ijrmeet.org
- Jaiswal, I. A., & Goel, E. O. (2025). Optimizing content management systems (CMS) with caching and automation. Journal of Quantum Science and Technology (JQST), 2(2), 34-44. https://jqst.org/index.php/j/article/view/254
- Gupta, S. K. (2025). Secure data migration strategies on AWS cloud. International Journal of Computational and Experimental Science and Engineering, 11(3). https://doi.org/10.22399/ijcesen.3952
- Jaiswal, I. A., & Khan, S. (2025). Leveraging cloud-based projects (AWS) for microservices architecture. Universal Research Reports, 12(1), 195-202. https://doi.org/10.36676/urr.v12.i1.1472
- Saha, B., & Agarwal, E. R. (2024). Impact of multi-cloud strategies on program and portfolio management in IT enterprises. Journal of Quantum Science and Technology (JQST), 1(1), 80-103. https://jqst.org/index.php/j/article/view/183
- Jaiswal, I. A., & Solanki, S. (2025). Data modeling and database design for high-performance applications. International Journal of Creative

Research Thoughts (IJCRT), 13(3), m557-m566. ISSN: 2320-2882. http://www.ijcrt.org/papers/IJCRT25A3446.pdf

- *Yadav, N., Gaikwad, A., Garudasu, S., Goel, O., Jain, A., & Singh, N. (2024). Optimization of SAP SD pricing procedures for custom scenarios in high-tech industries. Integrated Journal for Research in Arts and Humanities, 4(6), 122-142. https://doi.org/10.55544/ijrah.4.6.12*
- *Jaiswal, I. A., & Sharma, P. (2025). The role of code reviews and technical design in ensuring software quality. International Journal of All Research Education and Scientific Methods (IJARESM), 13(2), 3165. ISSN: 2455-6211. https://www.ijaresm.com*
- *Gupta, S. K. (2025). Snowflake vs RDBMS: Performance tuning techniques. International Journal for Research Trends and Innovation, 10(5), c825-c832. ISSN: 2456-3315. http://www.ijrti.org/papers/IJRTI2505296.pdf*
- *Jaiswal, I. A., & Verma, L. (2025). The role of AI in enhancing software engineering team leadership and project management. IJRAR - International Journal of Research and Analytical Reviews, 12(1), 111-119. http://www.ijrar.org/IJRAR25A3526.pdf*
- *Tiwari, S. (2025). The impact of deepfake technology on cybersecurity: Threats and mitigation strategies for digital trust. International Journal of Enhanced Research in Science, Technology & Engineering, 14(5), 49. https://doi.org/10.55948/IJERSTE.2025.0508*
- *Jaiswal, I. A., & Kumar, M. (2025). Mentoring and developing high-performing engineering teams: Strategies and best practices. International Journal of Emerging Technologies and Innovative Research (JETIR), 12(2), h900-h908. ISSN: 2349-5162. http://www.jetir.org/papers/JETIR2502796.pdf*
- *Dommari, S. (2025). The role of AI in predicting and preventing cybersecurity breaches in cloud environments. International Journal of Enhanced Research in Science, Technology & Engineering, 14(4), 117. https://doi.org/10.55948/IJERSTE.2025.0416*
- *Jaiswal, I. A. (2025). Integrating AI into enterprise Java applications for secure high performance and scalable systems. International Journal of Computational and Experimental Science and Engineering, 11(4). https://doi.org/10.22399/ijcesen.4086*
- *Saha, B., Jain, A., & Jain, A. K. (2022). Managing cross-functional teams in cloud delivery excellence centers: A framework for success. International Journal of Multidisciplinary Innovation and Research Methodology, 1(1), 84-108. ISSN: 2960-2068. https://ijmirm.com/index.php/ijmirm/article/view/182*
- *Jaiswal, I. A. (2021). AI-orchestrated store deployment systems for global retail networks. International Journal of Research in Modern Engineering and Emerging Technology (IJRMEET), 9(11), 42. https://doi.org/10.63345/ijrmeet.org.v9.i11.1*
- *Yadav, N., Dharuman, N. P., Dharmapuram, S., Kaushik, S., Vashishtha, S., & Agarwal, R. (2024). Impact of dynamic pricing in SAP SD on global trade compliance. International Journal of Research Radicals in Multidisciplinary Fields, 3(2), 367-385. ISSN: 2960-043X. https://www.researchradicals.com/index.php/rr/article/view/134*
- *Jaiswal, I. A. (2022). Natural language processing for security policy and log analysis. International Journal of Research in All Subjects in Multi Languages (IJRSML), 10(4), 57. https://doi.org/10.63345/ijrsml.v10.i4.1*
- *Gupta, S. K. (2025). Hybrid cloud pipelines for regulated industries. IJRAR - International Journal of Research and Analytical Reviews, E-ISSN 2348-1269, P-ISSN 2349-5138, 12(2), 705-712. http://www.ijrar.org/IJRAR25B4662.pdf*
- *Jaiswal, I. A. (2023). Multilingual and culturally adaptive AI models for global education platforms. International Journal for Research in Education (IJRE), 12(9), 17-27. https://doi.org/10.63345/ijre.v12.i9.1*
- *Tiwari, S. (2023). AI-powered cyberattacks: A comprehensive study on defending against evolving threats. International Journal of Current Science (IJCSPUB), 13(4), 644-661. ISSN: 2250-1770. https://rjpn.org/IJCSPUB/papers/IJCSP23D1183.pdf*
- *Jaiswal, I. A. (2024). AI-powered observability and incident prediction in distributed enterprise platforms. Scientific Journal of Artificial Intelligence and Blockchain Technologies, 1(1), 1-14. https://doi.org/10.63345/sjaibt.v1.i1.201*
- *Dommari, S., & Vashishtha, S. (2025). Blockchain-based solutions for enhancing data integrity in cybersecurity systems. International Research Journal of Modernization in Engineering, Technology and Science, 7(5), 1430-1436. https://doi.org/10.56726/IRJMETS75838*
- *Jaiswal, I. A. (2021). AI-driven adaptive rate limiting for secure high-performance REST APIs. International Journal of Research in Engineering (IJRE), 10(2). https://doi.org/10.63345/ijre.v10.i2.1*
- *Saha, B., & Kumar, A. (2019). Best practices for IT disaster recovery planning in multi-cloud environments. Iconic Research and Engineering Journals, 2(10), 390-409.*
- *Jaiswal, I. A. (2022). Scalable API orchestration using reinforcement learning in cloud-native systems. International Journal of Research in Modern Physics (IJRMP), 11(7). https://doi.org/10.63345/ijrmp.v11.i7.3*
- *Yadav, N., Vivek, A. S., Subramani, P., Goel, O., Singh, S. P., & Shrivastav, A. (2024). AI-driven enhancements in SAP SD pricing for real-time decision making. International Journal of Multidisciplinary Innovation and Research Methodology, 3(3), 420-446. ISSN: 2960-2068. https://ijmirm.com/index.php/ijmirm/article/view/145*
- *Gupta, S. K. (2025). Modernizing legacy data systems in agile environments. IJRAR - International Journal of Research and Analytical Reviews, 12(2), 713-721. http://www.ijrar.org/IJRAR25B4663.pdf*
- *Jaiswal, I. A. (2024). Self-healing REST services using artificial intelligence in multi-cloud environments. Journal of Quantum Science and Technology (JQST), 1(3), 201. https://doi.org/10.63345/sjaibt.v1.i3.201*
- *Tiwari, S., & Jain, A. (2025). Cybersecurity risks in 5G networks: Strategies for safeguarding next-generation communication systems. International Research Journal of Modernization in Engineering Technology and Science, 7(5). https://doi.org/10.56726/irjmets75837*
- *Dommari, S. (2023). The intersection of artificial intelligence and cybersecurity: Advancements in threat detection and response. International Journal for Research Publication and Seminar, 14(5), 530-545. https://doi.org/10.36676/jrps.v14.i5.1639*
- *Saha, B., & Goel, P. (2023). Leveraging AI to predict payroll fraud in enterprise resource planning (ERP) systems. International Journal of All Research Education and Scientific Methods (IJARESM), 11(4), 2284. http://www.ijaresm.com*
- *Yadav, N., Bhardwaj, A., Jeyachandran, P., Goel, O., Goel, P., & Jain, A. (2024). Streamlining export compliance through SAP GTS: A case study of high-tech industries. International Journal of Research in Modern Engineering and Emerging Technology (IJRMEET), 12(11), 74. https://www.ijrmeet.org*
- *Gupta, S. K. (2025). Real-time data ingestion with Kafka and AWS tools. ESP Journal of Engineering & Technology Advancements, 5(2), 285-290.*
- *Jaiswal, I. A. (2025). Machine learning-based resource allocation for scalable cloud REST services. World Journal of Future Technology in Computer Science and Engineering (WJFTCSE), 1(3), 101. https://doi.org/10.63345/wjftcse.v1.i3.101*
- *Tiwari, S. (2022). Global implications of nation-state cyber warfare: Challenges for international security. International Journal of Research in Modern Engineering and Emerging Technology (IJRMEET), 10(3), 42. https://doi.org/10.63345/ijrmeet.org.v10.i3.6*
- *Dommari, S., & Jain, A. (2022). The impact of IoT security on critical infrastructure protection: Current challenges and future directions.*

International Journal of Research in Modern Engineering and Emerging Technology (IJRMEET), 10(1), 40. https://doi.org/10.63345/ijrmeet.org.v10.i1.6

- *Saha, B., & Chhapola, A. (2020). AI-driven workforce analytics: Transforming HR practices using machine learning models. IJRAR - International Journal of Research and Analytical Reviews, 7(2), 982-997. http://www.ijrar.org/IJRAR2004413.pdf*
- *Yadav, N., Aravind, S., Bikshapathi, M. S., Prasad, M., Jain, S., & Goel, P. (2024). Customer satisfaction through SAP order management automation. Journal of Quantum Science and Technology (JQST), 1(4), 393-413. https://jqst.org/index.php/j/article/view/124*
- *Gupta, S. K. (2025). Designing scalable data warehouses for analytics. International Journal of Creative Research Thoughts (IJCRT), 13(7), h868-h876. ISSN: 2320-2882. http://www.ijcrt.org/papers/IJCRT2507898.pdf*
- *Jaiswal, I. A. (2025). AI-orchestrated microservice security for high-performance scalable systems. International Journal of Advanced Research in Computer Science and Engineering (IJARCSE), 1(4), 101. https://doi.org/10.63345/ijarcse.v1.i4.101*
- *Tiwari, S., & Gola, D. K. K. (2024). Leveraging dark web intelligence to strengthen cyber defense mechanisms. Journal of Quantum Science and Technology (JQST), 1(1), 104-126. https://jqst.org/index.php/j/article/view/249*
- *Dommari, S. (2024). Cybersecurity in autonomous vehicles: Safeguarding connected transportation systems. Journal of Quantum Science and Technology (JQST), 1(2), 153-173. https://jqst.org/index.php/j/article/view/250*
- *Saha, B. (2021). Implementing chatbots in HR management systems for enhanced employee engagement. International Journal of Emerging Technologies and Innovative Research (JETIR), 8(8), f625-f638. ISSN: 2349-5162. http://www.jetir.org/papers/JETIR2108683.pdf*
- *Yadav, N., Prasad, R. V., Kyadasu, R., Goel, O., Jain, A., & Vashishtha, S. (2024). Role of SAP order management in managing backorders in high-tech industries. Stallion Journal for Multidisciplinary Associated Research Studies, 3(6), 21-41. https://doi.org/10.55544/sjmars.3.6.2*
- *Gupta, S. K. (2025). Best practices for Oracle to PostgreSQL migration. International Journal of Science and Research Archive, 16(01), 1337-1344. https://doi.org/10.30574/ijsra.2025.16.1.2083*
- *Jaiswal, I. A., Renuka, A., Kumar, L., & Singh, N. (2025). Uncovering transactional anomalies in blockchain systems through graph neural networks. Proceedings of the International Conference on Computational Technologies for Research in Data Science.*
- *Tiwari, S. (2023). Biometric authentication in the face of spoofing threats: Detection and defense innovations. Innovative Research Thoughts, 9(5), 402-420. https://doi.org/10.36676/irt.v9.i5.1583*
- *Dommari, S., & Mishra, R. K. (2024). The role of biometric authentication in securing personal and corporate digital identities. Universal Research Reports, 11(4), 361-380. https://doi.org/10.36676/urr.v11.i4.1480*
- *Saha, B. (2020). Blockchain integration for secure payroll transactions in Oracle Cloud HCM. International Journal of Novel Research and Development (IJNRD), 5(12), 71-81. ISSN: 2456-4184. https://ijnrd.org/papers/IJNRD2012009.pdf*
- *Yadav, N., Bhat, S. R., Mane, H. R., Pandey, P., Singh, S. P., & Goel, P. (2024). Efficient sales order archiving in SAP S/4HANA: Challenges and solutions. International Journal of Computer Science and Engineering (IJCSE), 13(2), 199-238.*
- *Gupta, S. K. (2025). Metadata lineage frameworks for data governance. International Journal of Creative Research Thoughts (IJCRT), 13(9), c895-c903. ISSN: 2320-2882. http://www.ijcrt.org/papers/IJCRT2509332.pdf*
- *Janapareddy, V. P. K., Sundaresan, S. S. K., Bonikela, H. R., Jaiswal, I. A., Rana, N., et al. (2025). AI-powered vulnerability detection for secure software development. Proceedings of the 2nd International Conference on New Frontiers in Communication and Intelligent Systems.*
- *Tiwari, S., & Agarwal, R. (2022). Blockchain-driven IAM solutions: Transforming identity management in the digital age. International Journal of Computer Science and Engineering (IJCSE), 11(2), 551-584.*
- *Dommari, S. (2022). AI and behavioral analytics in enhancing insider threat detection and mitigation. IJRAR - International Journal of Research and Analytical Reviews, 9(1), 399-416. http://www.ijrar.org/IJRAR22A2955.pdf*
- *Saha, B., Aswini, T., & Solanki, S. (2021). Designing hybrid cloud payroll models for global workforce scalability. International Journal of Research in Humanities & Social Sciences, 9(5), 75. https://www.ijrhs.net*
- *Yadav, N., Abdul, R., Bradley, Satya, S. S., Singh, N., Goel, O., & Chhapola, A. (2024). Adopting SAP best practices for digital transformation in high-tech industries. IJRAR - International Journal of Research and Analytical Reviews, 11(4), 746-769. http://www.ijrar.org/IJRAR24D3129.pdf*
- *Gupta, S. K. (2025). Machine learning integration in Spark-based pipelines. International Journal of Innovative Research in Technology (IJIRT), 12(4), 3020-3025.*
- *Maddula, L. P., Cherukuri, P. A. A., Jaiswal, I. A., Ganesan, S. K., Rana, N., & Khera, M. (2025). Optimization of code efficiency with the utilization of artificial intelligence. Proceedings of the 2nd International Conference on New Frontiers in Communication and Intelligent Systems.*
- *Tiwari, S., & Mishra, R. (2023). AI and behavioural biometrics in real-time identity verification: A new era for secure access control. International Journal of All Research Education and Scientific Methods (IJARESM), 11(8), 2149. http://www.ijaresm.com*
- *Dommari, S., & Khan, S. (2023). Implementing zero trust architecture in cloud-native environments: Challenges and best practices. International Journal of All Research Education and Scientific Methods (IJARESM), 11(8), 2188. http://www.ijaresm.com*
- *Saha, B. (2023). Robotic process automation (RPA) in onboarding and offboarding: Impact on payroll accuracy. International Journal of Current Science (IJCSPUB), 13(2), 237-256. ISSN: 2250-1770. https://rjpn.org/IJCSPUB/papers/IJCSP23B1502.pdf*
- *Yadav, N., Das, A., Kar, A., Goel, O., Goel, P., & Jain, A. (2024). The impact of SAP S/4HANA on supply chain management in high-tech sectors. International Journal of Current Science (IJCSPUB), 14(4), 810. https://www.ijcspub.org/ijcsp24d1091*
- *Jaiswal, I. A. (2023). Intelligent cybersecurity framework for large-scale RESTful service architectures. International Journal of Research Radicals in Multidisciplinary Fields, ISSN: 2960-043X, 2(1), 178-184. https://www.researchradicals.com/index.php/rr/article/view/252*
- *Jaiswal, I. A. (2023). High-performance AI-augmented content management systems for distributed clouds. International Journal of Multidisciplinary Innovation and Research Methodology, ISSN: 2960-2068, 2(2), 90-97. https://ijmirm.com/index.php/ijmirm/article/view/243*
- *Jaiswal, I. A. (2024). AI-optimized content delivery strategies in secure high-performance applications. International Journal of Research and Review Techniques, ISSN: 3006-1075, 3(2), 128-134. https://ijrrt.com/index.php/ijrrt/article/view/256*
- *AI-powered load prediction for ultra-scalable high performance APIs. (2024). International Journal of Engineering Fields, ISSN: 3078-4425, 2(4), 46-53.*
- *Cloud-based secure high-performance application clustering with AI optimization. (2026). AI Tech International Journal, ISSN: 3079-4749,*

4(1), 1-8. https://techaijournal.com/index.php/AIjournal/article/view/37

- *Gupta, S. K. (2025). AI powered query optimization console: A review of intelligent approaches for real-time query performance enhancement in database systems. ESP Journal of Engineering & Technology Advancements, 5(4), 180-192.*
- *M. Rana, S. Srinivas, L. K. Jamili, I. A. Jaiswal, S. Nakka and S. Kasetti, "Real-Time Monitoring and Prediction of Blood Sugar Levels in Diabetic Patients with Functional Models," 2025 International Conference on Engineering, Technology & Management (ICETM), Oakdale, NY, USA, 2025, pp. 1-6, doi: 10.1109/ICETM63734.2025.11051853.*
- *Tiwari, S. (2021). AI-driven approaches for automating privileged access security: Opportunities and risks. International Journal of Creative Research Thoughts (IJCRT), 9(11), c898-c915. ISSN: 2320-2882. http://www.ijcrt.org/papers/IJCRT2111329.pdf*
- *Dommari, S. (2021). Exploring the security implications of quantum computing on current encryption techniques. International Journal of Emerging Technologies and Innovative Research (JETIR), 8(12), g1-g18. ISSN: 2349-5162. http://www.jetir.org/papers/JETIR2112601.pdf*
- *Saha, B., Kumar, L., & Kumar, A. (2019). Evaluating the impact of AI-driven project prioritization on program success in hybrid cloud environments. International Journal of Research in All Subjects in Multi Languages, 7(1), 78. ISSN (P): 2321-2853.*
- *Yadav, N., Krishnamurthy, S., Sayata, S. G., Singh, S. P., Jain, S., & Agarwal, R. (2024). SAP billing archiving in high-tech industries: Compliance and efficiency. Iconic Research and Engineering Journals, 8(4), 674-705.*
- *Gupta, S. K. (2026). Cloud ETL optimization with AWS Glue and Spark. World Journal of Advanced Engineering Technology and Sciences, 18(03), 207-214. https://doi.org/10.30574/wjaets.2026.18.3.0076*
- *Prabhagaran, S., Jaiswal, I. A., & Gandhi, H. (2025). Real-time big data processing in cloud: Scalable, cost-efficient, and AI-driven solutions for financial analytics. [Conference proceedings].*
- *Tiwari, S. (2022). Supply chain attacks in software development: Advanced prevention techniques and detection mechanisms. International Journal of Multidisciplinary Innovation and Research Methodology, 1(1), 108-130. ISSN: 2960-2068. https://ijmirm.com/index.php/ijmirm/article/view/195*
- *Dommari, S., & Kumar, S. (2021). The future of identity and access management in blockchain-based digital ecosystems. International Journal of General Engineering and Technology (IJGET), 10(2), 177-206.*
- *Saha, B., & Renuka, A. (2020). Investigating cross-functional collaboration and knowledge sharing in cloud-native program management systems. International Journal for Research in Management and Pharmacy, 9(12), 8. https://www.ijrmp.org*
- *Yadav, N. (2025). Edge computing integration for real-time analytics and decision support in SAP service management. International Journal for Research Publication and Seminar, 16(2), 231-248. https://doi.org/10.36676/jrps.v16.i2.283*
- *Bhatia, R., Alonge, M., Gupta, S., Lopez, L., John, B., Adeola, P., & Khan, O. (2025). Challenges and mitigation strategies in migrating legacy ETL pipelines to hybrid cloud ELT architectures for BCBS 239 compliance in banking.*
- *G. Tavva, S. K. Gupta, S. Karuppiah, S. Dachepelly and R. Verma, "AI-Driven Data Platforms: Real-Time Pipelines and Governance," 2025 International Conference on Sustainability, Innovation & Technology (ICSIT), Nagpur, India, 2025, pp. 1-5, doi: 10.1109/ICSIT65336.2025.11294412.*
- *K. Ande, S. K. Gupta, A. Ohja, J. Shaturaev and B. Mirzayev, "Generative AI and Cloud Data Engineering for Business Intelligence," 2025 International Conference on Sustainability, Innovation & Technology (ICSIT), Nagpur, India, 2025, pp. 1-5, doi: 10.1109/ICSIT65336.2025.11295004.*
- *S. Sachi, R. Kiran Pagidi, S. Karunakaran, S. K. Gupta, S. Dharmapuram and O. Goel, "Data Lake Validation Strategies: Ensuring Quality in Data Warehousing Pipelines," 2025 International Conference on Intelligent and Secure Engineering Solutions (CISES), Greater Noida Gautam Budh Nagar, India, 2025, pp. 918-922, doi: 10.1109/CISES66934.2025.11265447.*
- *T. Alrwbaye and S. K. Gupta, "A Hybrid Model for Cloud Resource Utilization Forecasting Using Machine Learning and Evolutionary Optimization," 2025 International Conference on Next Generation of Green Information and Emerging Technologies (GIET), Gunupur, India, 2025, pp. 1-7, doi: 10.1109/GIET65294.2025.11234881.*
- *P. Kumar, S. K. Venugopal, S. Sachi, S. Handa, S. K. Gupta and A. Jain, "Bias Mitigation in Generative Chatbots Through Adversarial Debiasing," 2025 International Conference on Sustainability, Innovation & Technology (ICSIT), Nagpur, India, 2025, pp. 1-6, doi: 10.1109/ICSIT65336.2025.11294625.*
- *Matthew, B., Gupta, S., & Sen, A. (2024). Migrating legacy MES system data containing BOM, routing, and serialization records to a cloud-native lakehouse.*
- *Thomas, C. M., & Willig, J. H. (2021). Integrating virtual assistants into clinical workflows to enhance patient care. BMJ Health & Care Informatics, 28(1), e100380. https://doi.org/10.1136/bmjhci-2021-100380*
- *Wirtz, B. W., Weyerer, J. C., & Geyer, C. (2019). Artificial intelligence and the public sector—Applications and challenges. International Journal of Public Administration, 42(7), 596–615. https://doi.org/10.1080/01900692.2018.1498103*