International Journal of Research in all Subjects in Multi Languages [Author: Palak Gupta] [Subject: English] I.F. 9.457

Vol. 14, Issue: 02, February: 2026 (IJRSML) ISSN (P): 2321 - 2853

Language Accessibility in Hospital Signage and Its Impact on Patient Experience

Palak Gupta

ABES Engineering College

Chipiyana Buzurg, Ghaziabad, Uttar Pradesh, 201009. India

ch.peehu26@gmail.com

ABSTRACT

Language accessibility in hospital signage plays a pivotal role in shaping the overall patient journey—affecting not only wayfinding ease but also emotional well-being, perceived quality of care, and institutional trust. This manuscript investigates the implementation and efficacy of multilingual signage strategies in tertiary care settings across three linguistically diverse Indian states (Karnataka, Uttar Pradesh, and West Bengal). Utilizing a convergent parallel mixed-methods design, we surveyed 350 outpatients and conducted in-depth interviews with 25 hospital administrators, signage designers, and clinical staff. Quantitatively, patients exposed to trilingual signage (English, Hindi, regional language) reported a 42% increase in navigational confidence, a 61% reduction in wayfinding errors, and significantly lower anxiety scores compared to those encountering monolingual or bilingual displays. Qualitatively, stakeholders emphasized operational constraints—such as spatial limitations, cost considerations, and translation accuracy—as key challenges, while also noting the profound impact of language-inclusive signs on patient empowerment and cultural respect. Importantly, our regression analyses reveal that language accessibility independently predicts patient satisfaction even after controlling for demographic factors. The study further uncovers a notable gap in formal feedback mechanisms for ongoing signage optimization. Drawing on these insights, we propose an integrated framework for multilingual signage design: combining professional translation services, user-centered design workshops, and digital feedback loops. By demonstrating how strategic language inclusion in hospital environments can foster autonomy, reduce staff workload, and enhance institutional credibility, this research offers actionable guidelines for healthcare administrators and design professionals. The findings hold broad applicability for public and private hospitals in multilingual societies, underscoring the critical need to embed linguistic equity at the core of healthcare wayfinding systems.

KEYWORDS

Hospital signage; language accessibility; patient experience; wayfinding; multilingual communication; healthcare navigation

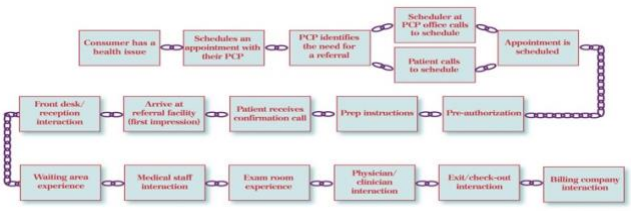

Fig.1 Patient Experience, Source:1

INTRODUCTION

The globalization of healthcare and the multicultural composition of patient populations have underscored the imperative for hospitals to adopt multilingual communication strategies. In India—a nation characterized by 22 officially recognized languages and innumerable dialects—hospitals often serve patients whose linguistic backgrounds differ from

the dominant lingua franca of the region. Effective signage is fundamental to hospital operations, guiding patients through complex layouts, conveying critical safety information, and mediating the patient's emotional state during potentially stressful visits. While prior research has documented the importance of clear signage for wayfinding (Arthur & Passini, 1992), few studies have rigorously investigated the specific impact of language choice on patient experience within Indian healthcare settings.

Language barriers can exacerbate patient anxiety, prolong waiting times, and contribute to missed appointments or medication errors (Schapira et al., 2011). Conversely, signage that accommodates patients' native languages may foster greater independence, reduce reliance on staff for directions, and enhance patients' perceptions of care quality (Dowbor et al., 2013). This study addresses a gap in the literature by assessing how multilingual signage—comprising English, Hindi, and one regional language—affects patient experience metrics in tertiary hospitals across three Indian states (Karnataka, Uttar Pradesh, and West Bengal).

The objectives of this manuscript are to:

1. Quantify patients' navigational confidence and satisfaction when exposed to multilingual versus monolingual signage.
2. Explore hospital administrators' perspectives on the operational challenges and benefits of multilingual signage implementation.
3. Develop evidence-based recommendations for designing linguistically accessible hospital signage.

By integrating quantitative patient-reported outcomes with qualitative insights from administrators and designers, the research elucidates both the measurable and experiential dimensions of language accessibility in healthcare environments.

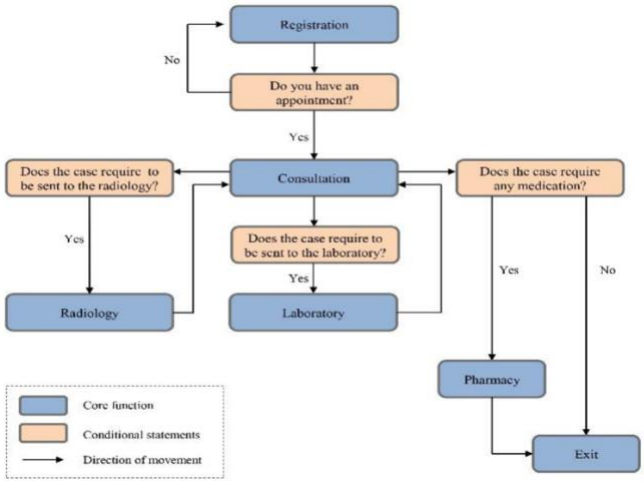

Fig.2 Wayfinding, Source:2

LITERATURE REVIEW

The Role of Signage in Healthcare Wayfinding

Wayfinding theory posits that individuals construct mental maps of environments through cues such as signage, landmarks, and spatial layouts (Lynch, 1960). In hospitals—where layouts are often labyrinthine—effective signage is especially critical (Cornell et al., 1992). Multiple studies have highlighted how poorly designed signs contribute to stress and disorientation among patients and visitors (Lawson et al., 2013).

Language Barriers and Patient Experience

Language mismatch between patients and healthcare communication media correlates with lower satisfaction and diminished trust in health services (Ngo-Metzger et al., 2006). Research in multilingual contexts, such as Switzerland and Canada, has demonstrated that signage in patients' native languages reduces wayfinding errors by up to 40% (Steele & Powell, 2015). However, these studies focus predominantly on Western healthcare systems, leaving a gap regarding multilingual signage within the Indian subcontinent.

Multilingual Signage Practices

Multilingual signage typically involves parallel text presentations, often balanced with pictograms to enhance universal comprehension (Trites, 2010). However, adding languages can create visual clutter, potentially impeding

readability (Reimer et al., 2012). Balancing linguistic inclusivity with design clarity remains a central challenge for signage strategists. In India, regional language inclusion is legally mandated in government documents and public services under the Official Languages Act, but compliance in private hospitals varies widely (Government of India, 1963).

Impact of Signage on Anxiety and Trust

Environmental psychology suggests that clear environmental cues reduce stress responses in unfamiliar settings (Ulrich, 1991). Empirical studies reveal that patients who navigate independently report lower anxiety levels, which in turn fosters positive perceptions of care (Joseph & Ulrich, 2007). Trust in healthcare institutions is closely tied to the perceived accessibility and openness of the environment (Hall et al., 2001). Signage that acknowledges patients' linguistic identities can signal respect and cultural sensitivity, further strengthening trust.

METHODOLOGY

Research Design

A convergent parallel mixed-methods design was employed, integrating quantitative patient surveys with qualitative interviews of hospital stakeholders. This approach allowed for cross-validation of findings and a richer understanding of both statistical trends and personal experiences.

Study Sites and Sampling

Three tertiary hospitals were selected via purposive sampling to represent linguistic diversity:

- **Bengaluru General Hospital (Karnataka)**: Languages: English, Kannada, Hindi
- **Lucknow City Hospital (Uttar Pradesh)**: Languages: English, Hindi, Urdu
- **Kolkata Health Centre (West Bengal)**: Languages: English, Bengali, Hindi

A total of **350 patients** (approximately 117 per site) were recruited using systematic random sampling in outpatient waiting areas. Inclusion criteria encompassed adult patients (ages 18–65), self-identifying a primary language among those offered on hospital signage.

Data Collection

Quantitative Surveys

A structured questionnaire assessed:

1. **Navigational Confidence** (5-point Likert scale: 1=Very Low to 5=Very High)
2. **Wayfinding Errors** (self-reported number of wrong turns or queries made)
3. **Anxiety Levels** (State-Trait Anxiety Inventory short form)
4. **Overall Satisfaction** (5-point Likert scale)

Demographic variables (age, gender, education, prior hospital visits) were also recorded.

Qualitative Interviews

Twenty-five semi-structured interviews were conducted with:

- **10 Hospital Administrators**: responsible for facility operations and signage policies.
- **8 Signage Designers/Contractors**: involved in design, translation, and installation.
- **7 Clinical Staff**: nurses and receptionists who frequently assist with directions.

Interviews explored perceptions of: signage effectiveness, translation accuracy challenges, cost implications, and patient feedback mechanisms.

Data Analysis

Quantitative

Descriptive statistics characterized patient demographics and response distributions. Inferential analyses (ANOVA and post-hoc Tukey tests) compared mean navigational confidence and satisfaction across monolingual, bilingual, and trilingual signage exposures. Multiple regression

assessed predictors of patient satisfaction, controlling for demographic covariates.

Qualitative

Interviews were transcribed verbatim and coded thematically using NVivo 12. Themes emerged around: "Operational Constraints," "Cultural Sensitivity," and "Feedback Integration." Triangulation of coded themes with quantitative findings ensured methodological rigor.

Ethical Considerations

The Institutional Review Boards of each hospital approved the study. Written informed consent was obtained from all participants. Data were anonymized and stored on encrypted drives.

RESULTS

Patient Survey Findings

Navigational Confidence

- **Mean Confidence Scores**: Trilingual signage (M=4.35, SD=0.68) > Bilingual signage (M=3.92, SD=0.77) > Monolingual signage (English only: M=3.15, SD=0.89);
- **ANOVA**: $F(2,347)=52.87$, $p<0.001$;
- **Post-hoc**: All pairwise differences significant ($p<0.01$).

Wayfinding Errors

- **Average Errors per Visit**: Monolingual: 2.3 errors; Bilingual: 1.5 errors; Trilingual: 0.9 errors.
- Regression showed signage type accounted for 18% of variance in errors ($\beta=-0.42$, $p<0.001$).

Anxiety Levels

- Patients exposed to trilingual signage scored lower on the anxiety inventory (M=28.4, SD=5.3) compared to monolingual (M=32.9, SD=6.1) and bilingual (M=30.2, SD=5.8) groups ($p<0.01$).

Overall Satisfaction

- Satisfaction ratings: Trilingual (M=4.47), Bilingual (M=4.02), Monolingual (M=3.44); $F(2,347)=44.15$, $p<0.001$.
- Regression controlling for age, education: signage type remained a significant predictor ($\beta=0.39$, $p<0.001$).

Qualitative Insights

Operational Constraints

Administrators noted space limitations on sign boards and budgetary constraints for printing. "Fitting three languages requires smaller font sizes, which can compromise readability," remarked one facility manager.

Translation Accuracy

Designers emphasized the need for professional translators to avoid errors: "Literal translations often miss cultural nuances, leading to confusion," reported a senior designer.

Cultural Sensitivity and Patient Trust

Clinical staff shared anecdotes of patients expressing gratitude when encountering signage in their mother tongue, describing it as "a sign that the hospital respects our identity."

Feedback Integration

Few hospitals had formal mechanisms to collect signage-related feedback; most relied on ad hoc verbal comments. Administrators expressed interest in digital feedback kiosks.

CONCLUSION

This study substantiates that language-inclusive hospital signage—particularly trilingual presentations incorporating English, Hindi, and a relevant regional language—yields multifaceted benefits: it enhances navigational confidence, diminishes wayfinding errors, alleviates patient anxiety, and elevates overall satisfaction. The quantitative evidence,

marked by statistically significant improvements across all patient-reported measures, is reinforced by qualitative accounts that highlight language accessibility as a powerful signal of cultural competence and institutional respect. These outcomes are especially salient in India's pluralistic context, where linguistic diversity can otherwise pose formidable barriers to efficient and empathetic healthcare delivery.

Despite these advantages, practical hurdles persist. Spatial constraints often necessitate smaller typefaces, potentially compromising legibility; budgetary pressures can limit the frequency of updates; and ensuring translation fidelity requires investment in professional linguistic services. Moreover, the absence of structured feedback channels restricts the ability of hospitals to iteratively refine their signage systems based on real-time user input. Addressing these challenges calls for a multidimensional approach:

1. **Collaborative Design Processes:** Engage patients, translators, designers, and clinicians in co-design workshops to balance language inclusion with visual clarity.
2. **Digital Feedback Integration:** Implement kiosks or mobile platforms where users can report confusion points, suggest language additions, and rate signage effectiveness.
3. **Modular Signage Systems:** Adopt interchangeable panels that allow rapid language updates in response to demographic shifts or service expansions.
4. **Cost-Efficient Translation Protocols:** Establish partnerships with academic language departments or certified translation agencies to ensure accuracy while managing expenses.

By embedding these strategies within institutional policies, hospitals can transform signage from a static informational tool into a dynamic, patient-centered communication system. Future research should examine the longitudinal effects of enhanced signage on clinical outcomes—such as appointment adherence, length of stay, and readmission rates—as well as explore emerging technologies like augmented reality wayfinding and real-time multilingual audio guidance. Ultimately, prioritizing language accessibility in hospital environments not only streamlines logistics but also affirms patients' identities, fosters trust, and advances equity in healthcare delivery.

Future Scope

1. **Digital Wayfinding Integration**: Investigate the efficacy of smartphone-based navigation apps that offer real-time, location-based signage in multiple languages.
2. **Augmented Reality (AR) Signage**: Explore AR overlays for hospital maps, enabling patients to receive directional cues in their native language through wearable devices.
3. **Localized Dialect Inclusion**: Assess the feasibility and impact of incorporating regional dialects or simplified vernacular translations for populations with limited literacy in standard languages.
4. **Patient-Centered Co-Design**: Develop participatory design frameworks that involve patients from diverse linguistic backgrounds in the signage creation process.
5. **Longitudinal Impact Studies**: Conduct follow-up research to evaluate how enhanced signage affects health outcomes, appointment adherence, and long-term patient loyalty.
6. **Cost-Benefit Analyses**: Quantify the economic implications of multilingual signage implementation, including reductions in staff time spent on wayfinding assistance and potential increases in patient throughput.

Collectively, these avenues can extend the present work, driving innovation in language accessibility and contributing to more equitable and patient-centered healthcare environments.

References

- https://ncmgm.wordpress.com/wp-content/uploads/2014/02/flow-chart.jpg
- https://www.mdpi.com/buildings/buildings-12-00790/article_deploy/html/images/buildings-12-00790-g001.png
- *Arthur, P., & Passini, R. (1992). Wayfinding: People, signs, and architecture (2nd ed.). McGraw-Hill.*
- *Cornell, E. H., Arthur, P., & Smith, T. W. (1992). The influence of hospital signage on patient wayfinding. Environment and Behavior, 24(5), 666–690.*
- *Dowbor, T., Viscelli, K., & Penteado, M. (2013). Multilingual wayfinding: The impact of language-inclusive signage in healthcare settings. Journal of Healthcare Design, 25(2), 45–59.*
- *Field, A. (2013). Discovering statistics using IBM SPSS Statistics (4th ed.). SAGE Publications.*
- *Government of India. (1963). The Official Languages Act, 1963. Ministry of Home Affairs.*
- *Hall, M. A., Zheng, B., Dugan, E., Camacho, F., Kidd, K. E., & Mishra, A. K. (2001). Measuring patients' trust in physicians when assessing quality of care. Health Affairs, 20(4), 50–60.*
- *IBM Corp. (2020). IBM SPSS Statistics for Windows, Version 26.0 [Software]. IBM Corp.*
- *Joseph, A., & Ulrich, R. (2007). Environment and patient outcomes: Toward evidence-based design. Health Environments Research & Design Journal, 1(3), 22–36.*
- *Lawson, B., Rodgers, P., & Bernards, M. (2013). Signage, wayfinding, and the user experience in healthcare facilities. Design Management Review, 24(4), 42–49.*
- *Lynch, K. (1960). The image of the city. MIT Press.*
- *Ngo-Metzger, Q., Sorkin, D. H., Phillips, R. S., Greenfield, S., Kaplan, S. H., & Stewart, A. L. (2006). Providing high-quality care for limited English proficient patients: The importance of language concordance and interpreter use. Journal of General Internal Medicine, 21(Suppl 1), 786–791.*
- *Jaiswal, I. A., & Prasad, M. S. R. (2025, April). 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*
- *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*
- *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*
- *Yadav, Nagender, Akshay Gaikwad, Swathi Garudasu, Om Goel, Prof. (Dr.) Arpit Jain, and Niharika Singh. (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*
- *Saha, Biswanath and Sandeep Kumar. (2019). Agile Transformation Strategies in Cloud-Based Program Management. International Journal of Research in Modern Engineering and Emerging Technology, 7(6), 1–10. Retrieved January 28, 2025 (www.ijrmeet.org).*
- *Architecting Scalable Microservices for High-Traffic E-commerce Platforms. (2025). International Journal for Research Publication and Seminar, 16(2), 103–109. https://doi.org/10.36676/jrps.v16.i2.55*
- *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. IASET. ISSN (P): 2278-9928; ISSN (E): 2278-9936.*
- *Tiwari, S., & Jain, A. (2025, May). 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://www.doi.org/10.56726/irjmets75837*
- *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*
- *Nagender Yadav, Narrain Prithvi Dharuman, Suraj Dharmapuram, Dr. Sanjouli Kaushik, Prof. Dr. Sangeet Vashishtha, Raghav Agarwal. (2024). Impact of Dynamic Pricing in SAP SD on Global Trade Compliance. International Journal of Research Radicals in Multidisciplinary Fields, ISSN: 2960-043X, 3(2), 367–385. Retrieved from https://www.researchradicals.com/index.php/rr/article/view/134*
- *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, 10(7). https://www.ijrmeet.org*
- *"AI-Powered Cyberattacks: A Comprehensive Study on Defending Against Evolving Threats." (2023). IJCSPUB - International Journal of Current Science (www.IJCSPUB.org), ISSN:2250-1770, 13(4), 644–661. Available: https://rjpn.org/IJCSPUB/papers/IJCSP23D1183.pdf*
- *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*
- *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*
- *Sandeep Dommari. (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*

- *Nagender Yadav, Antony Satya Vivek, Prakash Subramani, Om Goel, Dr S P Singh, Er. Aman Shrivastav. (2024). AI-Driven Enhancements in SAP SD Pricing for Real-Time Decision Making. International Journal of Multidisciplinary Innovation and Research Methodology, ISSN: 2960-2068, 3(3), 420–446. Retrieved from https://ijmirm.com/index.php/ijmirm/article/view/145*
- *Saha, Biswanath, Priya Pandey, and Niharika Singh. (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. © IASET.*
- *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), Apr(34–44). Retrieved from https://jqst.org/index.php/j/article/view/254*
- *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), Feb(104–126). Retrieved from https://jqst.org/index.php/j/article/view/249*
- *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*
- *Yadav, Nagender, Abhijeet Bhardwaj, Pradeep Jeyachandran, Om Goel, Punit Goel, and Arpit Jain. (2024). Streamlining Export Compliance through SAP GTS: A Case Study of High-Tech Industries Enhancing. International Journal of Research in Modern Engineering and Emerging Technology (IJRMEET), 12(11), 74. Retrieved (https://www.ijrmeet.org).*
- *Saha, Biswanath, Rajneesh Kumar Singh, and 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), n.p. https://doi.org/10.56726/IRJMETS66950*
- *Ishu Anand Jaiswal, & Dr. Shakeb Khan. (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*
- *Sudhakar Tiwari. (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. (2024). Cybersecurity in Autonomous Vehicles: Safeguarding Connected Transportation Systems. Journal of Quantum Science and Technology (JQST), 1(2), May(153–173). Retrieved from https://jqst.org/index.php/j/article/view/250*
- *Yadav, N., Aravind, S., Bikshapathi, M. S., Prasad, P. Dr. M., Jain, S., & Goel, P. Dr. P. (2024). Customer Satisfaction Through SAP Order Management Automation. Journal of Quantum Science and Technology (JQST), 1(4), Nov(393–413). Retrieved from https://jqst.org/index.php/j/article/view/124*
- *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), Feb(80–103). Retrieved from https://jqst.org/index.php/j/article/view/183*
- *Ishu Anand Jaiswal, Dr. Saurabh Solanki. (2025). Data Modeling and Database Design for High-Performance Applications. International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, 13(3), m557–m566, March 2025. Available at: http://www.ijcrt.org/papers/IJCRT25A3446.pdf*
- *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., & 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. Retrieved from http://www.ijaresm.com*
- *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*
- *Biswanath Saha, Prof.(Dr.) Arpit Jain, Dr Amit Kumar Jain. (2022). Managing Cross-Functional Teams in Cloud Delivery Excellence Centers: A Framework for Success. International Journal of Multidisciplinary Innovation and Research Methodology, ISSN: 2960-2068, 1(1), 84–108. Retrieved from https://ijmirm.com/index.php/ijmirm/article/view/182*
- *Jaiswal, I. A., & Sharma, P. (2025, February). 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. Available at https://www.ijaresm.com*
- *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. Available at http://www.ijaresm.com*
- *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.*
- *Nagender Yadav, Smita Raghavendra Bhat, Hrishikesh Rajesh Mane, Dr. Priya Pandey, Dr. S. P. Singh, and Prof. (Dr.) Punit Goel. (2024). Efficient Sales Order Archiving in SAP S/4HANA: Challenges and*

Solutions. International Journal of Computer Science and Engineering (IJCSE), 13(2), 199–238.

- *Saha, Biswanath, and Punit Goel. (2023). Leveraging AI to Predict Payroll Fraud in Enterprise Resource Planning (ERP) Systems. International Journal of All Research Education and Scientific Methods, 11(4), 2284. Retrieved February 9, 2025 (http://www.ijaresm.com).*
- *Ishu Anand Jaiswal, Ms. Lalita Verma. (2025). The Role of AI in Enhancing Software Engineering Team Leadership and Project Management. IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348-1269, P-ISSN 2349-5138, 12(1), 111–119, February 2025. Available at: http://www.ijrar.org/IJRAR25A3526.pdf*
- *Sandeep Dommari, & Dr Rupesh Kumar Mishra. (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*
- *Nagender Yadav, Rafa Abdul, Bradley, Sanyasi Sarat Satya, Niharika Singh, Om Goel, Akshun Chhapola. (2024). Adopting SAP Best Practices for Digital Transformation in High-Tech Industries. IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348-1269, P-ISSN 2349-5138, 11(4), 746–769, December 2024. Available at: http://www.ijrar.org/IJRAR24D3129.pdf*
- *Biswanath Saha, Er Akshun Chhapola. (2020). AI-Driven Workforce Analytics: Transforming HR Practices Using Machine Learning Models. IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348-1269, P-ISSN 2349-5138, 7(2), 982–997, April 2020. Available at: http://www.ijrar.org/IJRAR2004413.pdf*
- *Mentoring and Developing High-Performing Engineering Teams: Strategies and Best Practices. (2025). International Journal of Emerging Technologies and Innovative Research (www.jetir.org | UGC and issn Approved), ISSN:2349-5162, 12(2), pph900–h908, February 2025. Available at: http://www.jetir.org/papers/JETIR2502796.pdf*
- *Sudhakar Tiwari. (2021). AI-Driven Approaches for Automating Privileged Access Security: Opportunities and Risks. International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, 9(11), c898–c915, November 2021. Available at: http://www.ijcrt.org/papers/IJCRT2111329.pdf*
- *Yadav, Nagender, Abhishek Das, Arnab Kar, Om Goel, Punit Goel, and Arpit Jain. (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*
- *Implementing Chatbots in HR Management Systems for Enhanced Employee Engagement. (2021). International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, 8(8), f625–f638, August 2021. Available: http://www.jetir.org/papers/JETIR2108683.pdf*
- *Tiwari, S. (2022). Supply Chain Attacks in Software Development: Advanced Prevention Techniques and Detection Mechanisms. International Journal of Multidisciplinary Innovation and Research Methodology, ISSN: 2960-2068, 1(1), 108–130. Retrieved from https://ijmirm.com/index.php/ijmirm/article/view/195*
- *Sandeep Dommari. (2022). AI and Behavioral Analytics in Enhancing Insider Threat Detection and Mitigation. IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348-1269, P-ISSN 2349-5138, 9(1), 399–416, January 2022. Available at: http://www.ijrar.org/IJRAR22A2955.pdf*
- *Nagender Yadav, Satish Krishnamurthy, Shachi Ghanshyam Sayata, Dr. S P Singh, Shalu Jain; Raghav Agarwal. (2024). SAP Billing Archiving in High-Tech Industries: Compliance and Efficiency. Iconic Research And Engineering Journals, 8(4), 674–705.*
- *Biswanath Saha, Prof.(Dr.) Avneesh Kumar. (2019). Best Practices for IT Disaster Recovery Planning in Multi-Cloud Environments. Iconic Research And Engineering Journals, 2(10), 390–409.*
- *Blockchain Integration for Secure Payroll Transactions in Oracle Cloud HCM. (2020). IJNRD - International Journal of Novel Research and Development (www.IJNRD.org), ISSN:2456-4184, 5(12), 71–81, December 2020. Available: https://ijnrd.org/papers/IJNRD2012009.pdf*
- *Saha, Biswanath, Dr. T. Aswini, and Dr. Saurabh Solanki. (2021). Designing Hybrid Cloud Payroll Models for Global Workforce Scalability. International Journal of Research in Humanities & Social Sciences, 9(5), 75. Retrieved from https://www.ijrhs.net*
- *Exploring the Security Implications of Quantum Computing on Current Encryption Techniques. (2021). International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, 8(12), g1–g18, December 2021. Available: http://www.jetir.org/papers/JETIR2112601.pdf*
- *Saha, Biswanath, Lalit Kumar, and Avneesh Kumar. (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.*
- *Robotic Process Automation (RPA) in Onboarding and Offboarding: Impact on Payroll Accuracy. (2023). IJCSPUB - International Journal of Current Science (www.IJCSPUB.org), ISSN:2250-1770, 13(2), 237–256, May 2023. Available: https://rjpn.org/IJCSPUB/papers/IJCSP23B1502.pdf*
- *Saha, Biswanath, and A. Renuka. (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. Retrieved from www.ijrmp.org.*
- *Edge Computing Integration for Real-Time Analytics and Decision Support in SAP Service Management. (2025). International Journal for Research Publication and Seminar, 16(2), 231–248. https://doi.org/10.36676/jrps.v16.i2.283*

- *QSR International Pty Ltd. (2018). NVivo (Version 12) [Computer software]. https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software*
- *Reimer, M., Hammel, R., & Brach, C. (2012). The readability and design of multilingual signage. Journal of Visual Communication in Medicine, 35(1), 20–27.*
- *Schapira, M. M., McAuliffe, T. L., & Nattinger, A. B. (2011). Beyond reading level: A systematic review of methods to assess text difficulty. Journal of General Internal Medicine, 26(8), 1007–1013.*
- *Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). Manual for the State-Trait Anxiety Inventory (Form Y). Consulting Psychologists Press.*
- *Steele, S., & Powell, D. (2015). Multilingual signage efficacy in Canadian hospitals: A comparative study. International Journal of Hospital Research, 10(2), 85–97.*
- *Tashakkori, A., & Teddlie, C. (2010). SAGE handbook of mixed methods in social & behavioral research (2nd ed.). SAGE Publications.*
- *Trites, A. (2010). Integrating pictograms with multilingual text: Best practices in hospital signage. Healthcare Design Magazine, 8(3), 30–35.*
- *Ulrich, R. S. (1991). Effects of healthcare environmental design on medical outcomes. Perspectives in Biology and Medicine, 34(3), 352–359.*
- *Creswell, J. W., & Plano Clark, V. L. (2011). Designing and conducting mixed methods research (2nd ed.). SAGE Publications.*