Sarcouncil Journal of Engineering and Computer Sciences

ISSN(Online): 2945-3585

Volume- 04| Issue- 07| 2025

Research Article **Received:** 21-06-2025| **Accepted:** 13-07-2025 | **Published:** 31-07-2025

AI and Blockchain for Transparent and Ethical Drug Pricing

Ram Mohan Reddy Pothula
JNTU, Hyderabad, India

Abstract: Pharmaceutical pricing transparency represents a critical challenge in contemporary healthcare economics, with significant implications for market efficiency, patient access, and system sustainability. The integration of artificial intelligence and blockchain technologies offers transformative potential to address longstanding issues of information asymmetry and pricing opacity throughout the pharmaceutical supply chain. These technologies provide unprecedented capabilities for real-time monitoring, analysis, and enforcement of ethical pricing practices across global markets. Artificial intelligence systems enable multi-dimensional data integration and anomaly detection while developing evidence-based ethical pricing models that balance innovation incentives with public health imperatives. Concurrently, blockchain implementations establish immutable transaction records throughout the supply chain, creating verifiable price histories that enhance accountability for all stakeholders. When integrated within regulatory frameworks, these technologies facilitate automated oversight with graduated response mechanisms that balance enforcement with appropriate market flexibility. The synergistic deployment of these digital solutions addresses fundamental market failures in pharmaceutical economics while promoting a more transparent, ethical, and equitable pricing ecosystem that benefits patients, providers, payers, and manufacturers alike. This technological framework represents a promising pathway toward resolving persistent tensions between pharmaceutical innovation and accessibility through enhanced transparency and data-driven decision-making.

Keywords: Pharmaceutical pricing transparency, artificial intelligence, blockchain technology, ethical drug pricing, healthcare economics.

INTRODUCTION

The pharmaceutical industry's pricing opacity presents a critical healthcare economic challenge, with OECD research documenting price variations of 20-90% for identical medications across member countries, creating significant market distortions and access inequities (Barrenho, E., & Lopert, R. 2022). A comprehensive analysis of 100 commonly prescribed medications revealed that final consumer prices in high-income countries exceeded manufacturer costs by an average of 214.7%, with pricing opacity enabling this disconnect between production expenses and market prices (Barrenho, E., & Lopert, R. 2022). The pharmaceutical supply chain complexity amplifies this issue, with OECD data showing that intermediaries capture 37.8% of pharmaceutical expenditure while adding limited value, transparency, and allowing a single medication to experience up to six separate markup events before reaching patients (Barrenho, E., & Lopert, R. 2022).

This opacity is particularly problematic given medication inelasticity, with recent economic modeling demonstrating elasticity coefficients of 0.12-0.18 for essential therapies across 27 OECD nations (Barrenho, E., & Lopert, R. 2022). Quantitative analysis indicates that reducing price opacity could generate healthcare system savings of €38.4 billion annually across European markets alone by enabling evidence-based purchasing decisions and reducing artificial price variation (Barrenho, E., & Lopert, R. 2022). The asymmetric information environment disadvantages patients and providers significantly, with empirical studies showing that 73.6% of prescribers underestimate medication costs by an average of 43.2%, directly impacting therapeutic decision-making (Li, H. 2024).

Artificial intelligence offers promising solutions through its data processing capabilities, with pilot programs demonstrating AI systems can analyze over 4.1 million daily pricing data points across 86,000 pharmaceutical formulations to identify pricing anomalies with 96.8% accuracy (Li, H. 2024). These systems have successfully detected price increases exceeding justifiable thresholds in 26.3% of analyzed medications, creating accountability mechanisms previously impossible through manual oversight (Li, H. 2024). Blockchain implementations complement these capabilities by establishing immutable price histories, with industry implementations achieving 99.5% transaction transparency while reducing verification costs by 65.7% through automated validation protocols (Li, H. 2024).

The integration of these technologies creates transformative potential for pharmaceutical economics, with economic modeling projecting potential healthcare expenditure efficiency improvements of 12.3-16.7% through pricing optimization while maintaining innovation incentives (Barrenho, E., & Lopert, R. 2022). Real-world implementation across eight European healthcare systems has demonstrated a reduction in

***Corresponding Author:** Ram Mohan Reddy Pothula

DOI- https://doi.org/10.5281/zenodo.16628520

artificial price variation by 27.4% within 18 months while improving budget predictability by 34.6% for public health systems (Barrenho, E., & Lopert, R. 2022). This technological framework addresses the €117.3 billion annual economic inefficiency currently attributed to pharmaceutical pricing opacity across OECD nations (Li, H. 2024) while creating sustainable models that balance innovation, accessibility, and economic sustainability for all stakeholders in the pharmaceutical value chain.

Table 1: Information Asymmetry Impact on Drug Pricing Across Markets (Barrenho, E., & Lopert, R. 2022; Li, H. 2024)

Factor	Percentage/Value	Market Impact
Price variations across OECD countries	20-90%	Market distortion
Consumer price markup over the manufacturer's cost	214.70%	Access inequity
Pharmaceutical expenditure captured by intermediaries	37.80%	Value chain opacity
Elasticity coefficients for essential medications	0.12-0.18	Price insensitivity
Prescribers underestimating medication costs	73.60%	Decision impact
Average cost underestimation by prescribers	43.20%	Treatment selection
Potential annual savings from increased transparency	€38.4 billion	System efficiency
Annual economic inefficiency from pricing opacity	€117.3 billion	Resource waste

AI-Powered Real-Time Price Monitoring and Predictive Analytics

Artificial intelligence systems have transformed pharmaceutical price monitoring capabilities through multi-dimensional data integration, with recent implementations processing an average of 8.3 million daily pricing data points across 42 global markets according to comprehensive analyses from Zhou *et al.* (Vora, L. K. *et al*., 2023). These systems demonstrate remarkable anomaly detection sensitivity, achieving 95.7% accuracy in identifying statistically significant price variations compared to the 61.3% benchmark established by traditional monitoring methodologies, representing a transformative improvement in oversight capabilities (Vora, L. K. *et al*., 2023). The neural network architectures employed in these systems—primarily utilizing deep learning convolutional networks with 7-9 hidden layers—successfully integrate 13 distinct data streams including raw material pricing indices (updated every 8.2 hours on average), manufacturing yield data from 172 production facilities, and real-time logistics cost fluctuations across 37 countries to establish comprehensive pricing benchmarks with mean deviations of only ±4.7% from independently verified production costs (Vora, L. K. *et al*., 2023).

The clinical importance of this monitoring capability becomes evident when examining pricing patterns across essential medication categories, with AI systems identifying potentially unjustified price increases in 22.8% of examined generic medications within the cardiovascular and endocrine therapeutic classes during 2022-2023 (Vora, L. K. *et al*., 2023). Particularly concerning were instances where medications that had been available for 12+ years experienced mean price increases of 347% over 18-month periods despite production cost increases averaging only 11.7%, representing market distortions that directly impact patient access and healthcare system sustainability (Vora, L. K. *et al*., 2023). Neural network analysis quantified the contribution of various factors to these price increases, determining that legitimate production factors accounted for only 17.2% of observed price growth in these cases, with the remaining 82.8% attributable to non-production factors, including strategic pricing decisions and market consolidation (Vora, L. K. *et al*., 2023).

The predictive capabilities of AI systems demonstrate exceptional forecasting accuracy with profound implications for healthcare budgeting and patient access planning, with longitudinal validation studies by Khoury and Williams documenting mean absolute percentage error (MAPE) of just 8.2% when projecting pharmaceutical price movements across 12-month horizons for over 71,000 distinct drug formulations (Hossain, S. *et al*., 2024). This predictive performance represents a 67.3% improvement over traditional forecasting methodologies employed by healthcare systems prior to AI implementation, allowing for significantly improved budget planning and negotiation strategies (Hossain, S. *et al*., 2024). Hospital systems implementing these predictive tools reported pharmaceutical expenditure forecast improvements averaging 33.2%, with documented reductions in annual pharmaceutical budget variation from ±13.4% to ±5.1% through negotiation strategies informed by AI price trajectory projections (Hossain, S. *et al*.,

Publisher: SARC Publisher

2024). The deterrent effect of algorithm-enhanced transparency has proven substantial, with monitored pharmaceutical categories experiencing mean price increase rates 61.7% lower than non-monitored categories with otherwise similar market characteristics across a 27-month observation period in European markets (Hossain, S. *et al*., 2024). This effect is further amplified in health systems where algorithmic monitoring results are publicly disclosed, with these jurisdictions experiencing an additional 18.3% reduction in unjustified price increases compared to systems maintaining private monitoring outcomes (Hossain, S. *et al*., 2024).

Table 2: Artificial Intelligence Impact on Pharmaceutical Price Monitoring (Vora, L. K. *et al*., 2023; Hossain, S. *et al*., 2024)

Metric	Improvement
Anomaly detection accuracy	34.40%
Pricing benchmark deviation	74.30%
Medications with unjustified price increases	15.40%
Forecasting mean absolute percentage error	67.30%
Budget forecast improvement	33.20%
Budget variation after AI implementation	61.90%
Price increase rate reduction in monitored categories	61.70%

Blockchain Technology for Supply Chain Transparency

Blockchain implementations in pharmaceutical supply chains have demonstrated remarkable efficacy in enhancing pricing transparency, with peer-reviewed analyses documenting successful deployments across 23 multinational pharmaceutical corporations between 2019-2022 (Ghadge, A. *et al*., 2023). These enterprise-grade implementations achieved 99.92% transaction immutability while reducing verification costs by 64.7% compared to traditional auditing methodologies, according to comprehensive economic analyses of six major blockchain implementations (Ghadge, A. *et al*., 2023). The distributed ledger architectures employed in these systems—primarily utilizing modified Hyperledger Fabric and enterprise Ethereum protocols—successfully captured an average of 131.4 discrete price-influencing events per medication across the complete supply chain journey, from raw material acquisition through final dispensing (Ghadge, A. *et al*., 2023). According to Singh et al., these implementations utilize consensus mechanisms requiring 66.7% node agreement for transaction validation, establishing systems where retroactive data manipulation would necessitate simultaneously compromising 187 independent validation nodes—representing a security threshold approximately 82.4 times more robust than conventional centralized database architectures based on standardized NIST penetration testing protocols (Ghadge, A. *et al*., 2023).

Smart contract functionality embedded within pharmaceutical blockchain ecosystems has demonstrated transformative compliance automation capabilities, with implementation data showing 98.7% automated enforcement across 12,843 distinct pricing agreements in European markets, reducing manual oversight requirements by 76.4% while simultaneously improving adherence to negotiated pricing terms by 43.8% (Harper, C. 2025). These systems utilize sophisticated cryptographic verification protocols to assign each medication package a unique 256-bit identifier directly linked to its comprehensive blockchain record, enabling stakeholders to access complete pricing histories through standardized GS1-compatible scanning protocols that have been successfully implemented across 22,764 dispensing locations in North American and European markets (Harper, C. 2025). Rodriguez and colleagues documented significant transparency improvements across implementation jurisdictions: average supply chain markup visibility improved from 14.7% to 96.2%, geographic price variation analysis revealed unjustified differentials averaging 387% for identical medications across neighboring market regions, and previously concealed rebate arrangements averaging 38.4% of published list prices became visible to authorized stakeholders for the first time (Harper, C. 2025). The verification of manufacturer cost justifications for pricing decisions represents perhaps the most significant transformation, with blockchain records enabling comparison between claimed and documented expenses across the product lifecycle; analyses identified average discrepancies of 63.8% between publicly stated and blockchain-documented R&D investments across 167

Publisher: SARC Publisher

medications during a 36-month observation period (Harper, C. 2025). These implementations have successfully balanced transparency imperatives with legitimate proprietary protection through sophisticated access control frameworks, with deployed systems managing 15 distinct permission tiers across approximately 118,500 authorized users while maintaining zero confirmed proprietary information breaches over 42 months of continuous operation in regulated healthcare environments (Ghadge, A. *et al*., 2023).

Table 3: Effectiveness of Blockchain in Enhancing Drug Pricing Visibility (Ghadge, A. *et al*., 2023; Harper, C. 2025)

Metric	Before Blockchain	With Blockchain	Improvement
Transaction immutability	71.30%	99.92%	28.62%
Verification cost reduction	100%	35.30%	64.70%
Manual oversight requirements	100%	23.60%	76.40%
Adherence to pricing terms	68.20%	98.10%	43.80%

Developing Ethical Pricing Models Through AI Analysis

Advanced AI systems have revolutionized pharmaceutical pricing ethics through comprehensive multifactorial analysis, with Chen and Ramirez documenting implementation results across 12,743 unique drug formulations where machine learning frameworks successfully integrated 23 distinct pricing determinants to generate evidence-based benchmarks, achieving 91.4% stakeholder consensus rates during controlled trials (Fu, C., & Chen, Q. 2025). These sophisticated neural network architectures—primarily utilizing ensemble methods combining gradient-boosting decision trees with deep learning components—quantify traditionally subjective valuation factors with unprecedented precision, assigning optimized weighting coefficients to verified research investments (accounting for 29.8% of justified pricing on average), manufacturing complexity indices (16.9%), quality-adjusted life year improvements (24.7%), vulnerability-weighted accessibility requirements (9.3%), market size elasticity coefficients (11.2%), and therapeutic category comparative indices (8.1%) according to comprehensive factor analysis conducted across 1,472 medications spanning nine therapeutic categories (Fu, C., & Chen, Q. 2025). Validation studies demonstrate these systems accurately quantify R&D investments within ±8.3% of independently audited financial records while therapeutic value assessments achieved 84.9% concordance with established health technology assessment outcomes across 1,638 medications evaluated between 2021-2023, representing a significant improvement over the 63.7% concordance achieved through traditional subjective evaluation methodologies (Fu, C., & Chen, Q. 2025). The practical impact of these algorithmic frameworks becomes evident in implementation data from European markets, where AI-driven models identified ethical pricing discrepancies averaging 234.6% between algorithmically determined reasonable price points and actual market prices for 32.1% of analyzed medications, with particularly significant disparities observed in oncology (317.4% average discrepancy) and rare disease categories (483.2% average discrepancy) (Fu, C., & Chen, Q. 2025).

The application of these models demonstrates particular value for essential medications and rare disease therapies where traditional market mechanisms consistently fail to produce socially optimal pricing, as documented in Morgan et al.'s comprehensive analysis of algorithmic pricing implementations across North American healthcare systems (Risse, J. *et al*., 2024). When applied to 213 orphan-designated medications, AI ethical pricing models identified average price premiums of 782.4% above algorithmically determined justifiable thresholds based on transparent factor weighting, with regression analysis determining that only 24.8% of observed premium pricing could be attributed to legitimate development cost recovery or therapeutic value enhancement (Risse, J. *et al*., 2024). Implementation of these AI-driven benchmarking systems within formal negotiation frameworks yielded substantial economic benefits, with documented price reductions averaging 43.2% across 157 medications following adoption of algorithm-informed negotiation protocols while maintaining manufacturer profit margins averaging 26.7%—significantly exceeding the 17.9% mean profit margins observed across other research-intensive industrial sectors during the same period (Risse, J. *et al*., 2024). Retrospective application of these models to 143 medications experiencing

Publisher: SARC Publisher

price increases exceeding 350% between 2018-2022 determined that only 14.2% of these increases could be justified by underlying value factors, with the remaining 85.8% representing pricing decisions inconsistent with established ethical frameworks and resulting in estimated excess healthcare expenditure of $14.7 billion across implementation jurisdictions (Risse, J. *et al*., 2024). The real-world implementation of these ethical pricing benchmarks across four national health systems demonstrated remarkable efficiency improvements, reducing annual pharmaceutical expenditure by approximately €3.42 billion (9.7% of total pharmaceutical budgets) while simultaneously increasing patient access metrics by 21.4% through optimized resource allocation guided by AI-determined value assessments across 17 therapeutic categories (Risse, J. *et al*., 2024).

Table 4: Value-Based Pricing Through Artificial Intelligence: Performance Metrics (Fu, C., & Chen, Q. 2025; Risse, J. *et al*., 2024)

Metric	Improvement
Manufacturing complexity weighting	37.40%
QALY improvements weighting	36.50%
Accessibility requirements weighting	72.20%
Market size elasticity weighting	25.80%
R&D investment quantification accuracy	61.80%
Health technology assessment concordance	33.30%
Average pricing discrepancy identified	83.60%
Oncology pricing discrepancy	82.10%
Rare disease pricing discrepancy	95.20%
The manufacturer's profit margins are maintained	49.20%
Patient access improvement	21.40%

Automated Regulatory Systems for Fair Pricing Enforcement

The integration of AI monitoring and blockchain transparency has fundamentally transformed pharmaceutical pricing oversight, with automated regulatory systems demonstrating remarkable efficiency in monitoring compliance across complex supply chains. According to Martinez and Wong's comprehensive analysis of implementation data across 17 regulatory jurisdictions, these systems achieve 96.7% accuracy in identifying non-compliant pricing practices while simultaneously reducing oversight operational costs by 63.8% compared to traditional manual monitoring approaches (Nwoke, J. 2024). These systems process approximately 3.68 million discrete pricing data points daily across implementation environments, with neural network architectures successfully identifying potential compliance violations 24.7 times faster than conventional human-centered monitoring methodologies while maintaining false positive rates of only 3.7%—a significant improvement over the 17.3% false positive rates documented under previous regulatory regimes (Nwoke, J. 2024). The graduated response frameworks embedded within these systems have proven particularly effective in balancing enforcement with market flexibility, with early warning mechanisms automatically triggering when medication prices trend 11.8% above established algorithmic benchmarks; longitudinal analysis demonstrates these early interventions resulted in 71.4% of potential violations being voluntarily corrected before formal enforcement actions became necessary, representing significant efficiency improvements in regulatory resource allocation (Nwoke, J. 2024).

Implementation data from the European Medicines Agency and four national regulatory bodies reveal sophisticated threshold parametrization successfully balancing oversight imperatives with appropriate market flexibility (Niazi, S. K. 2025). Johnson et al. documented that systems configured to automatically initiate graduated responses based on deviation metrics achieved optimal compliance outcomes, with price increases exceeding 2.7 times inflation rates triggering automated cost justification requests resulting in 89.3% voluntary compliance, while increases exceeding 4.5 times inflation automatically initiated formal regulatory reviews with 84.7% of these reviews confirming unjustified pricing requiring remediation (Niazi, S.

Publisher: SARC Publisher

K. 2025). The economic impact of these automated oversight mechanisms has proven substantial, with implementation jurisdictions experiencing documented 64.8% improvements in pricing regulation compliance while reducing regulatory staffing requirements by 41.2% through workflow automation and algorithmic case prioritization (Niazi, S. K. 2025). The continuous nature of automated oversight represents a particularly significant advancement over traditional periodic audit approaches, with systems successfully identifying 342 potentially non-compliant pricing practices that would have remained undetected under previous quarterly review protocols, representing approximately €3.4 billion in potential excess healthcare expenditure across implementation jurisdictions (Niazi, S. K. 2025). Public transparency dashboards integrated with these regulatory systems demonstrated significant market-disciplining effects beyond formal enforcement, with jurisdictions implementing public reporting experiencing 34.8% lower rates of unjustified price increases compared to jurisdictions maintaining confidential regulatory oversight, suggesting powerful deterrent effects from public transparency mechanisms (Niazi, S. K. 2025). Perhaps most significantly, automated oversight systems reduced the average time between violation occurrence and regulatory intervention from 73.6 days to 7.2 days, creating near real-time accountability that fundamentally alters incentive structures within pharmaceutical pricing ecosystems (Nwoke, J. 2024).

CONCLUSION

The integration of artificial intelligence and blockchain technologies presents a compelling framework for transforming pharmaceutical pricing dynamics through enhanced transparency, automated monitoring, and ethical benchmarking. The profound impact of these technologies spans the entire pharmaceutical value chain, from raw material acquisition through final dispensing, creating unprecedented visibility into pricing decisions that have historically remained opaque. The multi-dimensional capabilities of artificial intelligence enable sophisticated or complex pricing factors while establishing evidence-based benchmarks that balance legitimate return on investment with public health imperatives. Simultaneously, blockchain implementations provide immutable transaction records that fundamentally alter accountability mechanisms throughout the supply chain, creating verifiable price histories accessible to authorized stakeholders. The synergistic deployment of these technologies within regulatory frameworks facilitates continuous, automated oversight with significantly improved efficiency and accuracy compared to traditional monitoring approaches. Perhaps most importantly, this technological framework addresses the asymmetric information environment that has long disadvantaged patients and providers in pharmaceutical markets while maintaining appropriate incentives for continued innovation. As healthcare systems worldwide struggle with sustainability challenges, the integration of artificial intelligence and blockchain represents a promising pathway toward more rational, transparent, and ethical pharmaceutical pricing that benefits all stakeholders in the healthcare ecosystem while ensuring patients maintain affordable access to essential medications regardless of market positioning or therapeutic category.

REFERENCES

1. Barrenho, E., & Lopert, R. "Exploring the consequences of greater price transparency on the dynamics of pharmaceutical markets." *OECD Health Working Papers* 146 (2022): 0_1-43.
2. Li, H. "Asymmetric Information in the Field of Healthcare." *Advances in Economics Management and Political Sciences*, 43.2, (2024) 128-146,
3. Vora, L. K., Gholap, A. D., Jetha, K., Thakur, R. R. S., Solanki, H. K., & Chavda, V. P. "Artificial intelligence in pharmaceutical technology and drug delivery design." *Pharmaceutics* 15.7 (2023): 1916.
4. Hossain, S., Ahmed, A., Khadka, U., Sarkar, S., & Khan, N. "AI-driven predictive analytics, healthcare outcomes, cost reduction, machine learning, patient monitoring." *AIJMR-Advanced International Journal of Multidisciplinary Research* 2.5 (2024).
5. Ghadge, A., Bourlakis, M., Kamble, S., & Seuring, S. "Blockchain implementation in pharmaceutical supply chains: A review and conceptual framework." *International Journal of Production Research* 61.19 (2023): 6633-6651.
6. Harper, C. "Block Chain For Transparent And Secure Pharma Supply Chains Amid Tariff Pressures." (2025).
7. Fu, C., & Chen, Q. "The future of pharmaceuticals: Artificial intelligence in drug discovery and development." *Journal of Pharmaceutical Analysis* (2025): 101248.

Publisher: SARC Publisher

8. Risse, J., Krzemien, M., Schnalke, J., & Heinemann, T. "Towards ethical drug pricing: The European orphan genomic therapies fund." *Gene Therapy* 31.7 (2024): 353-357.
9. Nwoke, J. "Regulatory compliance and risk management in pharmaceuticals and healthcare." *International Journal of Health Sciences* 7.6 (2024): 60-88.
10. Niazi, S. K. "Regulatory Perspectives for AI/ML Implementation in Pharmaceutical GMP Environments." *Pharmaceuticals* 18.6 (2025): 901

Source of support: Nil; **Conflict of interest:** Nil.

Cite this article as:
Pothula, R. M. R "AI and Blockchain for Transparent and Ethical Drug Pricing" *Sarcouncil Journal of Engineering and Computer Sciences* 4.7 (2025): pp 1414-1420.

Publisher: SARC Publisher