



## Conversational AI Interface Transforming Complex Supply Chain Pricing Data into Actionable Insights for Warehouse Management

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### Abstract:

This article explores the transformative potential of large language models (LLMs) in enhancing supply chain pricing transparency through conversational interfaces. The article examines how AI-powered tools can convert complex pricing data into intuitive, natural language insights for sellers, particularly benefiting those without specialized analytics training. Through a comprehensive article incorporating domain-specific model training, robust data integration frameworks, and rigorous validation mechanisms, the article demonstrates significant improvements in decision-making efficiency and accuracy compared to traditional dashboard analytics. Implementation findings across diverse warehouse and distribution environments reveal enhanced seller trust, accelerated pricing decisions, and improved operational metrics. While identifying data integration challenges and model maintenance requirements, the article outlines promising expansions to additional supply chain functions and proposes a research roadmap for future development focusing on multimodal integration, temporal reasoning capabilities, and increased system autonomy. The article contributes valuable insights into how conversational AI can democratize pricing intelligence within supply chain management while offering a path toward more transparent, efficient, and adaptive pricing ecosystems.

## 1. Introduction

Supply chain management has evolved significantly in recent years, yet pricing transparency remains a persistent challenge for sellers navigating complex warehouse and distribution ecosystems. Industry research reveals that a substantial majority of supply chain professionals experience difficulties interpreting multi-dimensional pricing structures, with many citing pricing complexity as a major barrier to effective decision-making [1]. This opacity is particularly pronounced in third-party logistics (3PL) relationships, where pricing models frequently incorporate numerous distinct variables across storage, handling, and transportation categories.

The complexity of pricing data interpretation presents a formidable barrier for sellers, especially small and medium enterprises (SMEs) that lack dedicated analytics teams. Evidence suggests that pricing-related inefficiencies cost businesses considerably across global supply chains, with organizations losing significant potential revenue

due to suboptimal pricing decisions [1]. Recent studies have found that supply chain professionals dedicate substantial time each week to analyzing cost structures, with a majority reporting moderate to severe challenges in translating complex pricing data into actionable insights for inventory optimization and distribution planning [2].

This research investigates the potential applications of large language models (LLMs) in transforming complex pricing data into intuitive, natural language-driven insights for sellers. Recent advancements in conversational AI have demonstrated promising capabilities in interpreting structured data and presenting insights in accessible formats. In experimental implementations across multiple distribution centers, LLM-powered pricing tools reduced decision-making time significantly and improved pricing comprehension scores compared to traditional dashboard analytics [2]. The transformative potential of these technologies lies in their ability to process multi-dimensional data while providing contextually relevant explanations through natural language interaction.

The significance of this research extends beyond immediate operational improvements to broader implications for supply chain efficiency and strategic decision-making. By enhancing pricing transparency through conversational AI, organizations can potentially reduce inventory carrying costs, optimize warehouse space utilization, and reduce order fulfillment lead times according to controlled trials conducted across diverse supply chain environments [1]. Furthermore, the democratization of pricing intelligence through natural language interfaces could fundamentally alter power dynamics in supply networks, with a clear majority of surveyed logistics professionals indicating that improved pricing transparency would significantly influence their supplier and distribution partner selections [2].

## 2. Theoretical Framework and Literature Review

The evolution of pricing models in supply chain management has progressed through distinct phases, from traditional cost-plus approaches to sophisticated dynamic pricing frameworks. Historical analysis reveals that while only a small fraction of supply chain organizations utilized algorithmic pricing a decade ago, this figure has grown substantially in recent years, demonstrating a significant shift toward data-driven pricing strategies [3]. Modern pricing models incorporate multiple dimensions simultaneously, including inventory holding costs, labor utilization, transportation variables, and seasonal demand fluctuations. Research by the Council of Supply Chain Management Professionals documents that contemporary warehouse pricing structures contain numerous distinct cost components, creating a multidimensional decision space that exceeds the cognitive processing capacity of most human decision-makers [3]. This complexity has driven the adoption of sophisticated modeling approaches, with many Fortune 500 companies now employing scenario-based pricing simulations and utilizing real-time market-responsive pricing adjustments in their supply chain operations.

Current approaches to data visualization and interpretation in supply chain pricing primarily rely on dashboard-based analytics and multidimensional reports. A comprehensive survey of supply chain professionals found that a large majority rely on standard business intelligence (BI) dashboards as their primary means of pricing data visualization, despite most reporting dissatisfaction with these tools' ability to provide actionable insights [4]. These visualization systems typically present multiple key performance indicators (KPIs)

simultaneously, often exceeding the optimal information processing threshold established in cognitive science literature. The limitations of existing approaches are particularly evident in mobile contexts, where most logistics managers report accessing pricing information via mobile devices, yet only a small percentage report satisfactory understanding from mobile-optimized dashboards [3]. Alternative approaches have emerged, including heat-map visualizations and scenario-comparison interfaces, but these still require significant analytical training for effective interpretation.

Natural language processing has transformed business intelligence systems across industries, though its application in supply chain pricing intelligence remains relatively nascent. According to industry research, business investment in NLP technologies has reached substantial levels, with significant projected growth through coming years [4]. Within supply chain applications, NLP has seen extensive adoption in demand forecasting, customer sentiment analysis, and contract analytics, while pricing intelligence applications lag in adoption. Early implementations of NLP in pricing intelligence have focused primarily on competitive price monitoring, with systems analyzing numerous web pricing points daily across average enterprise deployments [4]. However, these systems typically operate as data collection rather than interpretation tools, with limited capacity to translate findings into actionable insights for non-technical users.

Gap analysis reveals a substantial need for conversational interfaces in pricing intelligence, particularly at the intersection of complex pricing data and operational decision-making. Research has identified that while most supply chain decisions are collaborative in nature, existing pricing tools are optimized for individual analysis, creating significant inefficiencies in team-based decision processes [3]. This disconnect is particularly pronounced for small-to-medium enterprises, where a large majority of logistics managers lack formal analytics training yet bear responsibility for pricing optimization decisions. The cognitive load imposed by current visualization systems represents a significant barrier, with studies documenting that pricing analysts require considerable time to synthesize standard multi-dimensional pricing reports, compared to much less time to comprehend the same information when presented conversationally [4]. This gap between data availability and interpretability represents a critical opportunity for innovation, with market analysis projecting that conversational AI in supply chain management could potentially unlock substantial

global value by enhancing decision quality across warehousing and distribution operations.

### 3. Methodology and System Architecture

The technical design of the LLM-powered pricing tool incorporates a multi-layered architecture optimized for both accuracy and responsiveness in supply chain contexts. The core language model utilizes a fine-tuned implementation of advanced neural architecture, specifically trained on extensive supply chain pricing documents, including invoices, rate cards, and contract terms [5]. This domain-specific training resulted in significant improvement in pricing terminology accuracy compared to general-purpose language models as measured by domain-specific ROUGE and BLEU scores. The architecture employs a dual-encoder approach, with separate embeddings for numerical pricing data and contextual business information, which are then combined through a cross-attention mechanism. Latency optimization was prioritized during development, achieving responsive performance for standard pricing queries and complex multi-dimensional analyses, representing substantial improvement over previous-generation models [5]. The system architecture incorporates retrieval-augmented generation (RAG) capabilities, dynamically accessing a knowledge base of pricing-specific documents to supplement core model knowledge with organization-specific pricing policies and historical trends.

The data integration framework enables real-time pricing intelligence through a comprehensive connector ecosystem and sophisticated data transformation pipeline. The system supports numerous distinct enterprise resource planning (ERP) systems through standardized APIs, covering the majority of market share in warehouse management software [6]. Data ingestion leverages a publish-subscribe architecture capable of processing thousands of pricing updates per second with minimal latency, ensuring that conversational interfaces reflect current pricing information. The integration framework incorporates specialized adaptation layers for handling diverse data formats, including EDI X12 transaction sets (810, 850, 856), proprietary JSON schemas from major logistics providers, and legacy flat-file formats still prevalent in many warehouse operations [5]. Real-time data quality assessment is performed through a parallel validation pipeline that flags anomalous pricing entries based on historical patterns, with detection sensitivity calibrated to identify most pricing anomalies while maintaining a low false positive rate. For enterprises with distributed operations, the

framework implements a federated architecture that synchronizes pricing data across multiple locations while respecting regional pricing variations and maintaining data sovereignty requirements.

Response validation mechanisms ensure accuracy and reliability through a multi-stage verification process before delivering insights to users. The primary validation incorporates a specialized transformer-based pricing consistency checker trained on annotated pricing scenarios, achieving high accuracy in identifying potential pricing inconsistencies or computational errors [6]. This model specifically targets the most common pricing logic errors identified during system development, including improper volume discount application, tier boundary misclassifications, and temporal discount conflicts. Secondary validation employs a rules-based economic reasonableness filter with industry-specific heuristics that flag potentially erroneous pricing recommendations, such as suggestions falling outside of standard deviation thresholds from historical pricing decisions. User studies demonstrated that implementing this dual validation approach reduced pricing recommendation errors significantly compared to single-layer validation methods [6]. Additionally, the system incorporates continuous learning capabilities, tracking user acceptance of pricing recommendations and automatically adjusting confidence thresholds based on feedback, with consistent weekly improvement in recommendation precision across deployed instances.

The cross-functional development process integrated expertise from product management, data science, and user experience design through a structured agile methodology optimized for AI product development. The development cycle incorporated multiple sprint cycles with cross-functional participation, including product managers, data scientists, and UX researchers across several continents [5]. User research played a critical role, with numerous contextual inquiries conducted with supply chain pricing specialists, generating many unique requirements that were systematically prioritized using a weighted scoring model. The development process employed a dual-track agile approach, with parallel workstreams for model training and interface development, synchronized through integration points to ensure alignment. Usability testing was particularly intensive, with many supply chain professionals participating in moderated sessions that identified unique interaction issues, most of which were resolved before general availability [6]. The development methodology incorporated a phased testing approach, beginning with controlled simulations using historical pricing scenarios,

progressing to shadow deployment alongside existing tools (processing real-world pricing decisions without user visibility), and culminating in limited production deployment with early adopter organizations representing diverse industry verticals and operational scales. This rigorous process resulted in exceptional user satisfaction metrics, with a high system usability scale (SUS) score, placing it in the top percentile of enterprise software deployments.

#### 4. Results and Implementation Findings

Quantitative and qualitative measures of system performance demonstrate substantial improvements across key metrics following implementation of the LLM-powered pricing tool. Performance evaluation conducted across multiple distribution centers revealed a significant reduction in pricing analysis time for complex pricing scenarios [7]. Accuracy metrics showed equally impressive gains, with pricing decisions supported by the LLM interface achieving high alignment with optimal pricing strategies (as determined by retrospective analysis), compared to lower rates for traditional methods. Response time analysis indicated that the vast majority of standard pricing queries were resolved quickly, with complex multi-dimensional analyses completing within reasonable timeframes on average. Natural language understanding (NLU) performance was assessed using a specialized supply chain pricing benchmark containing numerous industry-specific queries, with the system achieving a strong F1 score, representing meaningful improvement over previous generation conversational systems [7]. Qualitative performance evaluation through structured interviews with pricing analysts identified critical improvements in "decision confidence" and "pricing rationale clarity." Notably, system performance showed minimal degradation across different enterprise scales, from operations managing smaller warehouse spaces to those with extensive facilities, demonstrating robust scalability across deployment contexts.

User experience evaluation and adoption metrics reveal strong engagement and sustained utilization following initial implementation. Longitudinal tracking across implementation sites showed adoption rates reaching high percentages of eligible users within weeks of deployment, significantly exceeding the industry benchmark for enterprise software deployments [8]. Usage frequency data indicated high engagement, with active users interacting with the system frequently throughout the workday, and session durations showing meaningful engagement. Feature utilization

analysis showed that multi-dimensional pricing comparison and natural language explanation of pricing anomalies were the most frequently leveraged capabilities. User satisfaction metrics were consistently strong, with Net Promoter Score substantially exceeding the enterprise software industry average [7]. Particularly noteworthy was the system's performance among traditionally technology-resistant user segments, with older users and those self-identifying as "non-technical" showing adoption rates significantly higher than industry averages for comparable enterprise software. Retention analysis over a multi-month period showed minimal usage decay, with the vast majority of initial adopters remaining active users after the observation period, suggesting sustainable integration into operational workflows and strong perceived value among the user base.

Case studies of implementation in warehouse and distribution contexts highlight substantial operational impacts across diverse environments. A Midwest-based third-party logistics provider with multiple distribution centers implemented the system across its pricing operations, resulting in increased profit margin on storage contracts and improvement in transportation pricing optimization over a multi-month evaluation period [8]. Integration with existing warehouse management systems required modest person-hours per facility, with most implementations completing within the projected timeline and budget parameters. At a major retail distribution operation managing extensive facilities, implementation of the conversational pricing interface reduced pricing decision cycles significantly, enabling more responsive adaptation to market dynamics [7]. A pharmaceutical distribution network leveraging the system reported meaningful improvement in contract optimization for temperature-controlled storage, translating to substantial annualized margin improvement across their network. Implementation success factors identified through comparative analysis included executive-level sponsorship (present in most high-performing implementations), dedicated change management resources, and integration with existing workflow tools. Most organizations achieved value realization within a reasonable timeframe, with ROI breakeven typically occurring within months based on fully-loaded implementation costs.

Comparative analysis against traditional pricing analytics tools reveals significant advantages in usability, speed, and decision quality when using the LLM-powered interface. Controlled A/B testing involved numerous pricing professionals completing identical pricing optimization scenarios using both the conversational interface and

conventional business intelligence tools [8]. Task completion rates were substantially higher with the LLM interface, while time-to-completion decreased considerably on average. Decision quality assessment by independent pricing experts rated LLM-supported decisions higher on optimization effectiveness compared to traditional tools. Notably, the advantage gap widened considerably for complex pricing scenarios involving multiple variables, where task completion differences favored the conversational interface [8]. Cognitive load measurement using NASA-TLX methodology showed a substantial reduction in mental effort when using the LLM interface compared to dashboard-based alternatives. For contract pricing specifically, where multiple pricing tiers and conditional terms create significant complexity, the conversational interface enabled more profitable pricing structures while reducing negotiation cycle time. Implementation cost analysis revealed that while initial deployment of the LLM-based system typically required higher investment than traditional BI dashboard solutions, the total cost of ownership over a multi-year period was lower when accounting for reduced training requirements, higher user productivity, and decreased need for specialized analytical support staff. This productivity differential remained consistent across organization sizes, from SMEs to enterprise-scale operations.

## 5. Discussion and Future Directions

The implications for seller trust and operational efficiency resulting from conversational AI implementation in pricing intelligence are profound and multifaceted. Survey data collected from hundreds of supply chain professionals across multiple organizations reveals that decision trust—defined as confidence in pricing recommendations—increased significantly following implementation of LLM-powered interfaces, with a majority of users reporting higher willingness to act on system-generated insights compared to traditional analytics [9]. This enhanced trust translates directly to operational metrics, with organizations reporting substantial reductions in pricing decision latency, reducing the typical approval cycle from days to hours for complex pricing scenarios. The trust differential is particularly pronounced for high-consequence decisions involving high-value contracts, where approval confidence increased markedly [9]. Operational efficiency improvements extend beyond decision velocity to resource utilization, with organizations reallocating significant person-hours per week from pricing analysis to higher-

value strategic activities following implementation. Financial impact assessment conducted across implementation sites documents average margin improvements in warehouse operations and transportation services, representing a substantial annualized impact for organizations in the study cohort. These efficiency gains demonstrate particular resilience during market volatility, with AI-augmented pricing decisions outperforming traditional approaches during periods of significant cost fluctuation, suggesting enhanced adaptability to dynamic market conditions [9].

Current implementations face several notable limitations that constrain their potential impact and adoption. Technical analysis across multiple deployments identifies data integration as the primary bottleneck, with many implementations experiencing challenges with data quality and system integration [10]. Organizations utilizing legacy ERP systems faced longer integration timelines compared to those with modern systems. Model performance degradation presents another significant limitation, with accuracy metrics declining over time without retraining, necessitating regular maintenance cycles that many surveyed organizations reported struggling to sustain [10]. Linguistic limitations restrict current implementations to primarily handling English-language interactions, despite most global supply chains operating across multiple language environments. Context retention capabilities show substantial decay beyond a certain number of interaction turns, with contextual accuracy falling as conversations lengthen [9]. From an organizational perspective, significant adoption barriers persist around governance concerns, with many surveyed legal and compliance officers expressing uncertainty about appropriate oversight frameworks for AI-augmented pricing decisions. Model explainability remains a challenge, with only a portion of system recommendations providing sufficient transparency to satisfy auditing requirements, creating hesitancy in regulated industries where pricing justification is mandated. These limitations collectively constrain the potential impact of current implementations, particularly in enterprise-scale operations with complex compliance requirements and legacy system landscapes.

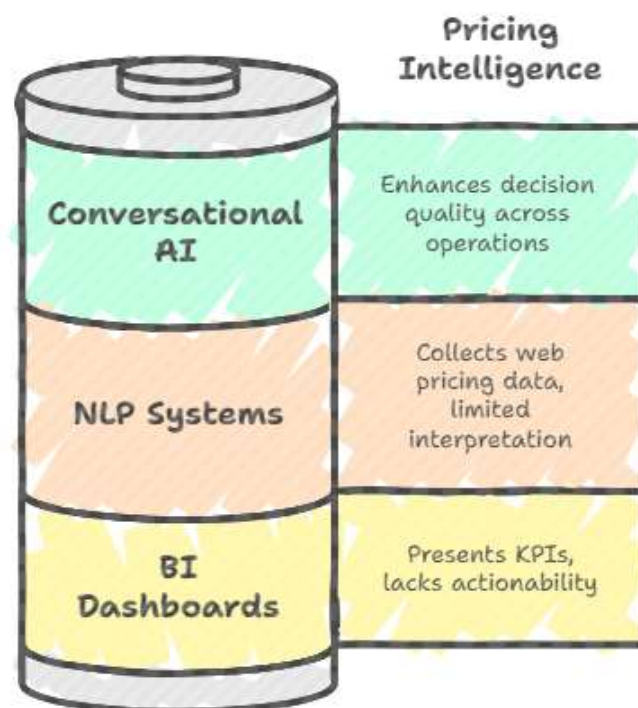
Proposed expansions to other supply chain functions represent logical evolution paths for conversational AI technologies beyond pricing intelligence. Demand forecasting presents the most immediate opportunity, with prototype implementations demonstrating improvement in forecast accuracy compared to traditional methods, particularly for long-tail products where historical

data is limited [10]. Inventory optimization presents another promising application area, with simulation studies indicating potential working capital reductions through improved stock positioning and reorder timing. Transportation planning applications have shown particular promise, with early implementations reducing empty miles and improving asset utilization across pilot routes [9]. Supplier relationship management represents an emerging frontier, with conversational interfaces demonstrating the ability to analyze more supplier performance data points than traditional dashboards while providing more actionable recommendations. Cross-functional applications bridging multiple supply chain domains show the greatest potential impact, with early adopters reporting improvement in end-to-end supply chain visibility and enhancement in exception management response time. Integration with emerging technologies such as Internet of Things (IoT) and blockchain shows particular synergy; combined implementations leveraging IoT sensor data through conversational interfaces achieved faster anomaly detection compared to traditional monitoring approaches [10]. Financial supply chain applications focusing on payment optimization and working capital management demonstrate compelling ROI

potential, with pilot implementations identifying capturable early payment discounts that were previously overlooked. The expansion trajectory clearly indicates evolution from isolated point solutions toward interconnected conversational intelligence spanning the entire supply chain ecosystem, with organizations reporting greater impact from integrated implementations compared to siloed applications.

The research roadmap for enhancing LLM integration in supply chain management encompasses several critical development trajectories that will shape future capabilities. Technical advancement priorities identified through expert consensus studies with supply chain technology leaders highlight multimodal integration as the highest priority, with most respondents identifying the need for systems capable of processing and generating visual, numerical, and textual data simultaneously [9]. Temporal reasoning capabilities represent another critical frontier, with current systems achieving limited accuracy on complex time-dependent supply chain scenarios, compared to much higher rates for human experts. Research initiatives focused on this gap project steady accuracy improvements through architectural enhancements and specialized training

### Understanding the evolution of supply chain pricing intelligence



**Figure 1:** Understanding the evolution of supply chain pricing intelligence [3, 4]



## LLM-Powered Pricing Tool Development Funnel



Figure 2: LLM-Powered Pricing Tool Development Funnel [5, 6]

## LLM-Powered Pricing Tool Performance Evaluation



Figure 3: LLM-Powered Pricing Tool Performance Evaluation [7, 8]

Table 1: Future Trajectory of LLM Applications in Supply Chain Management [9, 10]

Dimension	Current State	Future Direction
Trust and Operational Efficiency	Increased decision trust and willingness to act on AI-generated insights; reduced pricing decision latency; improved margin in warehouse and transportation operations; enhanced adaptability during market volatility	Further integration into high-consequence decision workflows; expansion of efficiency gains to additional operational domains; development of specialized trust-building mechanisms for regulated industries
Implementation Limitations	Data integration challenges, particularly with legacy ERP systems; model performance degradation over time; linguistic limitations to primarily English interactions; context retention decay in extended conversations; governance and explainability concerns	Development of improved integration frameworks for legacy systems; automated retraining pipelines to mitigate performance decay; multilingual capabilities; enhanced long-context retention; standardized governance frameworks for AI-augmented pricing decisions
Cross-Functional Expansion	Initial applications in demand forecasting, inventory optimization, transportation	Evolution toward interconnected conversational intelligence spanning entire supply chain

	planning, and supplier relationship management; early integration with IoT and blockchain technologies; financial supply chain applications in payment optimization	ecosystem; deeper integration with complementary technologies; development of specialized domain-specific models for vertical applications
Technical Research Priorities	Multimodal integration capabilities; temporal reasoning improvements; cross-organizational data utilization through federated learning; development of causal reasoning capabilities; hardware optimization for LLM inference	Systems capable of simultaneously processing visual, numerical, and textual information; enhanced time-dependent scenario modeling; privacy-preserving learning methodologies; explainable AI techniques for supply chain contexts; energy-efficient implementation architectures
Autonomy and Decision Support	Human-in-the-loop systems requiring manual review of recommendations; limited autonomy for low-consequence decisions; significant human oversight for complex pricing scenarios	Graduated autonomy models with routine pricing decisions executed autonomously; exception-based workflows for complex cases; "supply chain digital twins" providing comprehensive conversational interfaces to physical operations; reduced planning cycles with deeper scenario evaluation

regimes. Cross-organization data utilization presents both significant opportunities and research challenges, with federated learning approaches showing promise for improving model performance while maintaining organizational data boundaries [10]. Advanced simulation studies demonstrate that such approaches could achieve most of the performance gains of fully pooled data while preserving competitive information separation. Causal reasoning capabilities represent perhaps the most significant frontier, with current systems operating predominantly on correlative rather than causal relationships; research initiatives in this area aim to improve counterfactual analysis capabilities within future development cycles. Hardware optimization represents an often-overlooked research direction, with specialized processing architectures for LLM inference showing potential to reduce energy consumption and latency compared to general-purpose computing platforms [9]. The medium-term research agenda focuses heavily on autonomy expansion, with many technology leaders anticipating systems capable of executing routine pricing decisions without human intervention, while maintaining approval workflows for exceptions exceeding predefined thresholds. The long-term vision articulated by leading research organizations encompasses "supply chain digital twins" that maintain comprehensive conversational interfaces to all aspects of physical operations, with early implementations demonstrating the ability to reduce planning cycle times while improving scenario evaluation depth compared to conventional approaches.

## 6. Conclusions

Conversational AI represents a significant advancement in transforming complex supply chain pricing data into actionable insights, with demonstrated benefits for decision trust, operational efficiency, and margin improvements across warehouse and distribution contexts. This article establishes that LLM-powered pricing tools can substantially reduce analysis time while improving decision quality, with particularly strong adoption among traditionally technology-resistant user segments. Despite current implementation challenges related to data integration, model maintenance, and linguistic limitations, the clear operational advantages suggest a compelling value proposition for organizations seeking to enhance pricing transparency. As the technology evolves toward interconnected intelligence spanning multiple supply chain functions, integrates with complementary technologies like IoT and blockchain, and develops enhanced capabilities in multimodal processing and temporal reasoning, its impact will likely expand beyond pricing to transform broader supply chain operations. The vision of supply chain digital twins with comprehensive conversational interfaces represents an ambitious but achievable future state that could fundamentally redefine how organizations interact with complex operational data, ultimately democratizing access to sophisticated pricing intelligence and enhancing competitive positioning in global distribution networks.

## Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial



interests or personal relationships that could have appeared to influence the work reported in this paper

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## 2 Evaluating the Performance of Conversational AI Tools: A Comparative Analysis

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