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A HYBRID AI CHATBOT FRAMEWORK FOR INTELLIGENT PHARMACY MANAGEMENT SYSTEMS

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Abstract
The evolution of digital healthcare demands a shift in Pharmacy Management Systems (PMS) from static inventory tools to intelligent, user-centric platforms. Existing PMS solutions are often hampered by rigid interfaces, limited decision support, and inefficient handling of complex queries. While some integrate basic chatbots, these are typically rule-based, lacking the capacity for nuanced understanding or adaptive interaction. This research proposes a dual-stage AI-powered PMS that integrates a smart chatbot to enhance efficiency, accuracy, and user experience. The first stage employs NLP-driven SQL query generation for fast, structured data retrieval (e.g., drug availability, expiry dates). For complex, unstructured queries requiring clinical reasoning, the system leverages a transformer-based model (e.g., GPT) to deliver context-aware responses. This hybrid architecture reduces computational overhead by offloading routine tasks to lightweight processes while preserving the capability for advanced interaction. Designed with modularity and scalability in mind, the system supports future extensions such as multilingual interfaces, voice input, and image-based drug recognition—positioning it as a robust, adaptive solution for next-generation pharmacy management.

INTRODUCTION

Pharmacy Management Systems (PMS) play a pivotal role in modern healthcare by streamlining critical operations such as inventory control, sales tracking, procurement, and patient data management. These systems ensure the efficient distribution of pharmaceuticals while maintaining accuracy in dispensing medications. However, traditional PMS platforms are largely constrained by their reliance on structured data and rigid interfaces, which limit their ability to process natural language queries or provide intelligent, context-aware responses. As healthcare shifts toward more patient-centric and digitally integrated solutions, there is a growing need for PMS to adopt advanced technologies that enhance usability and decision-making capabilities. Artificial Intelligence (AI), particularly conversational AI, presents a transformative opportunity to bridge this gap. AI-powered chatbots can interpret complex queries, retrieve real-time data, and even offer medical advisory support, significantly improving the efficiency and accessibility of pharmacy services. This paper explores the integration of a dual-stage AI chatbot within PMS frameworks, combining structured database querying with advanced natural language processing to deliver a seamless, intelligent user experience.

Pharmacy Management Systems are now essential to healthcare infrastructure, connecting the distribution and care of pharmaceuticals. They make it possible to do things like real-time stock views, order processing, analyzing sales, buying supplies automatically and keep full details of what medications patients have been given. Thanks to digital systems, current PMS systems are better able to manage supplies, ensuring that issues around medications, including interactions and expiration, are highlighted. Because medication errors still cause harm to patients and rules are becoming stricter, the reliable and accurate performance of pharma systems is extremely important in healthcare today.

Although they are popular, current PMS are unsatisfactory because of their many limitations. Frequently, the menus are hard to pick through, so users are forced to type in many correct phrases, making getting any information require more time. In addition, while some systems include simple chatbots, these cannot normally handle the details involved in checking drug interaction or suggesting dosages. Similarly, standing AI alone is not well suited for immediate tasks such as stock inquiries, waste resources and cause delays. Furthermore, traditional systems have trouble adjusting to newer innovations such as voice recognition or supporting several languages. This shows that a hybrid approach is needed that can offer good speed, accuracy and prices for different users in rapid healthcare environments.

To meet these challenges, the research suggests using a dual-stage AI chatbot within PMS, powered by a hybrid architecture for excellent results. At the first level, NLP analyses user questions and gets straight information from an SQL database, making sure these common inquiries are answered fast and precisely. At the second stage, a transformer-based AI (e.g., GPT) deals with hard, interpretive or medical questions by supplying appropriate, support-based answers. This approach means you don't have to depend on high-priced AI APIs for simple functions, but you can still take advantage of advanced reasoning. Using a C# user interface, an SQL Server database and GPT-based NLP, the system provides a real-time conversation feature that boosts performance and makes users happier. Bringing together AI intelligence and structured data gives this solution advantages now, supporting pharmacy operations and preparing for additional features including various languages and voice capabilities, supporting smarter and more sensitive healthcare systems in the future.

1. Literature Review

The integration of AI and pharmacy software significantly enhances pharmacy operations by improving patient care, predicting drug demand, and increasing dispensing accuracy (Khan et al., 2024). It streamlines administrative tasks and supports personalized services, yet challenges like data security, lack of human interaction, and technical barriers remain. The study also highlights the digital disparity in Pakistan's pharmaceutical industry compared to the U.S., EU, and Japan, stressing the need for tailored digital strategies and stronger data protection measures to ensure equitable access and technological advancement.

The Industry in Pakistan is only now beginning its digital transformation journey, while it is more advanced in other places. The healthcare industry can gain from AI in drug research, delivery and clinical trials, yet there are problems relating to infrastructure, data management and workers' skills. The study advises using AI tactics, with a focus on spending on R&D, building data systems, improving defense against hackers and arranging training schemes. Using modern technologies, including 5G and blockchain, can be helpful for scaling the technology, even though pilot programs have shown strong, yet limited success (Ahmed et al., 2023)

AI has revolutionized the life sciences sector, particularly in biomedicine, drug development, clinical trials, and mobile healthcare. It improves disease diagnosis, accelerates drug discovery, and reduces clinical trial costs. Real-world data (RWD) and real-world evidence (RWE) have enhanced decision- making, while AI applications during the COVID-19 pandemic demonstrated its potential in early detection and data analysis. However, challenges such as data standardization, privacy concerns, algorithmic bias, and accessibility disparities must be addressed to fully integrate AI into healthcare systems (ScienceDirect, 2021).

This qualitative study explored pharmacy students' perceptions of AI and ML using a Zoom-based focus group. Despite limited formal training, participants expressed positive attitudes toward AI/ML, highlighting benefits like improved accuracy, efficiency, and time-saving potential. Concerns included alert fatigue, AI errors, and reduced person-centered care. Students supported integrating AI/ML into pharmacy education. The study recommends curriculum development, broader research, and collaboration with AI industry partners to address implementation challenges and enhance future pharmacy practice (ScienceDirect, 2024).

This review highlights emerging virtual-based technologies in the pharmaceutical sector, including AI, blockchain, AR/VR, IoT, and quantum computing. AI aids in drug development and clinical trials, while blockchain improves supply chain transparency. AR/VR supports patient education and clinical training. However, real-world implementation is limited by data privacy risks, high costs, and regulatory challenges. The study urges stronger collaboration and ethical frameworks to advance digital integration (ScienceDirect, 2024).

This review checks AI-powered predictive modeling in drug development and sees how it speeds up the search for new molecules, saves money and helps advanced medicine. A lot of work in drug development includes deep learning and molecular docking. Although technology shows great promise, problems such as model bias, unclear approaches, weak oversight systems and privacy issues still exist (Patel, 2024).

It analyzes the benefits of GANs and transformers in pharmacovigilance, including better detection of adverse events, consistent real-time tracking and consistent case reporting. Although they increase efficiency and yield better outcomes, some obstacles are the quality of data, making their results easy to understand for users and carrying out these methods according to regulations (SAAP Journals, 2023).

The platform CURATE.AI is examined in this review, as it uses a person's data individually to set drug dosing, unlike other services that require extensive collections of data. Since it works with liver transplants, cancer and digital therapeutics, the platform makes dose changes in real time. Problems with this method include the need for data and issues that arise in urgent cases (Soh et al., 2020).

This review examines how machine learning is used to predict drug–target interactions by looking at data used, the features gathered and the algorithms employed. Recent models such as DeepDTA and learning-to-rank methods, look promising, still they face issues with data diversity, feature representations and fitting too well to the available data (Zheng et al., 2021). Here, I will review how AI is used in finding and developing drugs, looking at tools like CNNs, RNNs and Transformers used for virtual screening, prediction of pharmacokinetics and pharmacodynamics and improving different biologics. Companies Insilico Medicine and Exscientia have used AI and have found it can lessen both the time and resources needed. Despite the progress it could make, challenges with data bias, clear explanations, appropriate regulations and reasonable access are still present (Patel et al., 2024).

This review investigates how AI is being used in pharmacokinetics (PK) compared to standard tools such as NONMEM and GastroPlus. The authors explain that AI is capable of forecasting PK results, delivering personalized therapy and making regulatory procedures easier. Generative AI and machine learning allow companies to do in silico modeling faster and cut down on the time needed for development. Yet, difficulties involve the variability of data, less than perfect accuracy in the predicting models and the difficulty in simulating biological processes which could hold up acceptance from regulators (Frontiers Partnerships, 2024).

This systematic review (2013–2021) synthesizes 36 studies exploring AI and ML applications in drug discovery and development. AI models are used for drug design, repurposing, screening, and toxicity prediction. Techniques like neural networks, ResNet, and transfer learning improve accuracy and efficiency while reducing reliance on clinical trials and animal testing. Despite their promise, challenges include unstructured pharmaceutical data, limited interdisciplinary expertise, high costs, and the opacity of AI decision-making. Continued advancements aim to enable personalized medicine and faster drug development (ScienceDirect, 2022).

This editorial review explores the growing role of AI in hospital and community pharmacy practice, highlighting applications such as therapy optimization, adverse event prediction, automated dispensing, and personalized patient education. Tools like IBM Watson and Dosis support clinical decision-making and therapeutic drug monitoring. Community pharmacies benefit from AI in supply chain management and public health surveillance. Despite promise, challenges include limited real-world evidence, infrastructure costs, integration complexity, and the need for pharmacist training and transparent AI systems (Taylor & Francis, 2023).

This review highlights the transformative role of AI in pharmaceutical formulation and drug development, detailing its application from discovery to manufacturing. Techniques like ANN, genetic algorithms, and QSAR models enhance hit identification, formulation design, and trial optimization. AI improves predictions of solubility, stability, and bioavailability, especially in novel delivery systems. Despite advancements, challenges remain in data quality, model interpretability, and integration into traditional workflows, especially in regulatory environments. Ongoing efforts aim to develop more transparent, efficient AI systems and expand use in nanomedicine and chronic disease management (Springer, 2024).

This comprehensive 2023 review explores AI's impact on pharmacokinetics (PK) and pharmacodynamics (PD), highlighting its role in drug design, toxicity prediction, dosing, and personalized therapy. Techniques like QSAR, deep learning, and reinforcement learning enhance prediction accuracy and development speed. However, challenges persist in data integration, model interpretability, and regulatory acceptance, underscoring the need for explainable, ethical, and collaborative AI deployment.

This 2023 scope review highlights AI's practical applications in Iran's pharmaceutical manufacturing sector, excluding technical modeling to focus on industry impact. AI enhances quality control, HR, R&D, logistics, and CRM, supporting Industry 4.0 initiatives. While AI improves efficiency and decision-making, challenges include regulatory gaps, technological readiness, data quality, and workforce skill shortages. The study calls for AI governance frameworks, infrastructure investment, and cross-sector collaboration to drive responsible and effective AI integration in pharma.

This 2023 review explores how generative AI (e.g., GANs, VAEs, transformers) is reshaping pharmacovigilance by detecting adverse events, automating case reporting, and enabling real-time safety surveillance. AI integrates diverse data (EHRs, social media, genomics) to enhance drug safety, repurposing, and personalized risk assessment. Despite its promise, challenges persist in data quality, ethical use, and model interpretability. The study calls for regulatory clarity, ethical frameworks, and robust model validation for safe integration.

This 2024 narrative review explores the expansive role of AI across all major pharmaceutical disciplines—from drug design and formulation to pharmacovigilance and nanotechnology. Key techniques include ML, DL, NLP, and RPA, with AI driving predictive modeling, optimization, and personalized medicine. While promising cost savings and innovation, the review underscores limitations in data privacy, algorithmic bias, explainability, and regulatory readiness. It advocates for global collaboration, education, and ethical frameworks to support full AI integration by 2035.

The review from 2021 combines techniques from mathematical modeling with medicinal chemistry to look at AI in drug development. It discusses Bayesian methods, deep learning, reinforcement learning and generative models in tasks involving QSAR modeling, molecular docking and de novo design. The work focuses on decision-theoretic methods and recommends using Bayesian deep learning and probabilistic programming.

The use of AI in chemistry is challenged by the breakdown, comprehensibility and high resources demanded and also the need for people from diverse backgrounds to team up. Recent studies (including one in 2021) split AI and machine learning algorithms into SVM, CNN and GANs, looking at their use in drug design, like predicting binding affinity, toxicity, solubility and QSAR models. It highlights the need for explanatory AI models, the addition of multiple objectives and using fewer data through transfer learning. Some of the main obstacles are doubtful data, a lack of understanding with models, the difficulty to repeat findings and ethical concerns, prompting requests for rules and better quality in data.

2. Architecture

The Pharmacy Management System (PMS) is designed to streamline all essential pharmacy operations through integrated modules. The Customer Management module maintains customer records including names, contact details, and addresses, with auto-fill functionality for faster sales processing. The Supplier Management module tracks vendor information, while the comprehensive Product Management module handles all inventory details from basic product information to batch numbers, quantities, pricing, and expiration dates.

Sales and Purchase modules handle the main functions of transactional operations. Using the Sales module, customers' purchases are registered, product information is read and stock items are updated immediately, while the Purchase module manages replenishing supplies and maintaining the line of suppliers. An invoice is created for every delivery using the Billing module and is shown with each listed item and what was paid. The Reports & Backup module is added to cover needs for insightful reporting and secure handling of data by storing it in the backup. When united, these modules allow for effective management of a pharmacy.

3.1 Dual-Stage Framework

The architecture of the chatbot is strategically designed to utilize both structured data and intelligent language processing through a two-layer approach:

1. **Layer One: SQL Query Handler** This layer processes the user's natural language input using Natural Language Processing (NLP) techniques to identify the intent and key parameters. If the query aligns with information available in the pharmacy database—such as medicine names, stock levels, or expiry dates—it is converted into a corresponding SQL statement and executed. For example, a question like "Do you have Augmentin in stock?" is translated into:

```
SELECT quantity FROM Product WHERE pname = 'Augmentin';
```

The chatbot then presents the result in a user-friendly conversational format.

2. **Layer Two: AI Reasoning Module** If the first layer cannot provide a response (e.g., if the query requires medical advice or comparisons), the chatbot activates the AI engine based on the transformer architecture (e.g., GPT). The AI model processes the question contextually and uses its training on medical and pharmaceutical texts to generate a suitable response. For instance, for a query like "What is the safest antibiotic for a child with a mild infection?" the AI engine interprets the intent, assesses context, and offers an informed answer.

This hybrid approach ensures that the chatbot is both data-efficient and capable of deep reasoning, making it suitable for a wide range of queries in pharmacy operations.

Technologies Used

Component	Tool/Technology
Chatbot Engine	OpenAI GPT API / Local NLP Model
Backend	C# (.NET Framework)
Database	SQL Server
Integration	REST API / Local function calls
UI Interface	Windows Forms (WinForms)
Data Access	ADO.NET or Entity Framework

3.2 Working Of Chatbot

Step 1: NLP Parsing + Intent Detection

Tokenization & Parsing of user input: breaks down the sentence. Detect intent (e.g., getPrice, checkStock).

Extract entities: medicine name, date, quantity, etc.
Intent = DetectIntent("What is the price of Panadol?"); Entity = ExtractProduct("Panadol");

Step 2: Try SQL First (Rule-Based Answering)
Based on intent, generate a SQL query:
SELECT sale_rate FROM Product WHERE pname = 'Panadol';
If result is found, convert it to: "Panadol is available at Rs. 20 per unit."

Step 3: If SQL Fails (No match, No entity found)
Example: question is "Which antibiotic is safest for children?" Not answerable using structured data.

Step 4: Forward to GPT (AI Engine)
The question is now passed to the AI using an API or local model.

```
{
"prompt": "Which antibiotic is safest for children?",
"model": "gpt-4",
"temperature": 0.7
}
```

3.3 Mathematical Insights
The AI (e.g., GPT-4) uses a Transformer model, based on the following concepts:

Tokenization
Input is split into tokens (words/pieces).
Example: "Panadol is safe" → [Token1, Token2, Token3].

Embedding
Each token is converted to a vector (a list of numbers) representing its meaning. Uses Word Embeddings: maps words into a semantic space.

Attention Mechanism (Self-Attention)
AI computes which words are important in relation to others. Uses scaled dot-product attention:

$$Attention(Q, K, V) = softmax\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

Q,K,V = Query, Key, Value matrices for input tokens
d_k = dimension of key vectors
The attention layer lets the model focus on relevant parts of the input.

Transformer Layers
Several layers apply attention and feed-forward neural networks to extract context. Each layer improves understanding of meaning and relationships in text.

Language Modeling Head
AI predicts next tokens based on previous context. Repeats this until a full response is generated.

Example:
Input: "What is the best antibiotic for kids?"

The model:
Identifies context = children
Matches known drugs and health rules

Outputs:
"Amoxicillin is commonly recommended for children, but consult a doctor before use.

Example Use-Cases with Flow

Question	Goes To	Why
"Stock of Panadol?"	SQL	Structured data exists
"What is Augmentin price?"	SQL	Mapped directly
"Which medicine is good for high fever?"	AI	Advice needed
"How to add a new product?"	AI	Instructional, not stored in DB

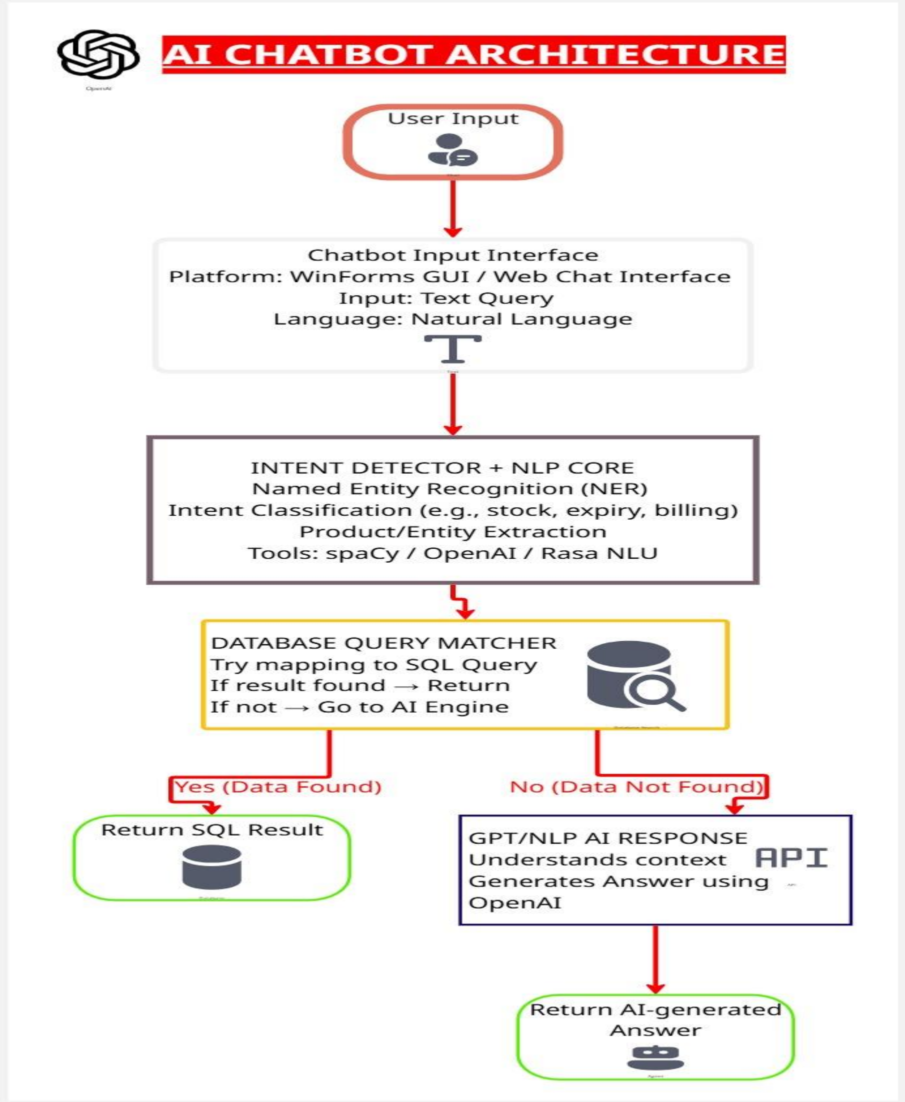

Figure 1/ rchitecture Diagram

3. Results

The Pharmacy Management System successfully achieved its intended objectives by streamlining day-to-day operations within a pharmacy setting. The application provided a user- friendly interface built with C# and Windows Forms, ensuring efficient navigation and interaction. Major modules including Sales, Purchase, Stock Management, Customer and Supplier Records, and Billing were fully operational.

Real-time data processing allowed instant retrieval and updating of product details, stock levels, and customer profiles. The integration of auto-fill features enhanced transaction speed and accuracy, reducing manual input errors. The system automatically generated unique Sales IDs, Purchase IDs, and Bill Numbers, ensuring proper record tracking.

Among the important achievements was making facial login with AI and a smart chatbot part of the platform. Customers could get stock information, find out prices, check expiry dates and find help with bills, all through the chatbot. Beyond this, a backup module was put into the database so that information can be securely held and retrieved.

The project was evaluated using a sample database and all the features worked well under average circumstances. In short, the system improved the pharmacies' work processes, reduced mistakes and

provided a state-of-the-art digital solution targeted at regions aiming to transform healthcare solutions.
With this model, solutions in Pharmacy Management Systems respond quickly and correctly to stock and pricing queries while using AI decisions for more challenging or advice-related tasks. Using this way, we help improve usability via natural language and also lower our AI API expenses. Assistant B is designed to scale well, allowing for more languages and voice commands in the future and can be adjusted with data from different places for better accuracy. This system's main features come together to ensure it remains adapting and reliable in pharmacy applications.

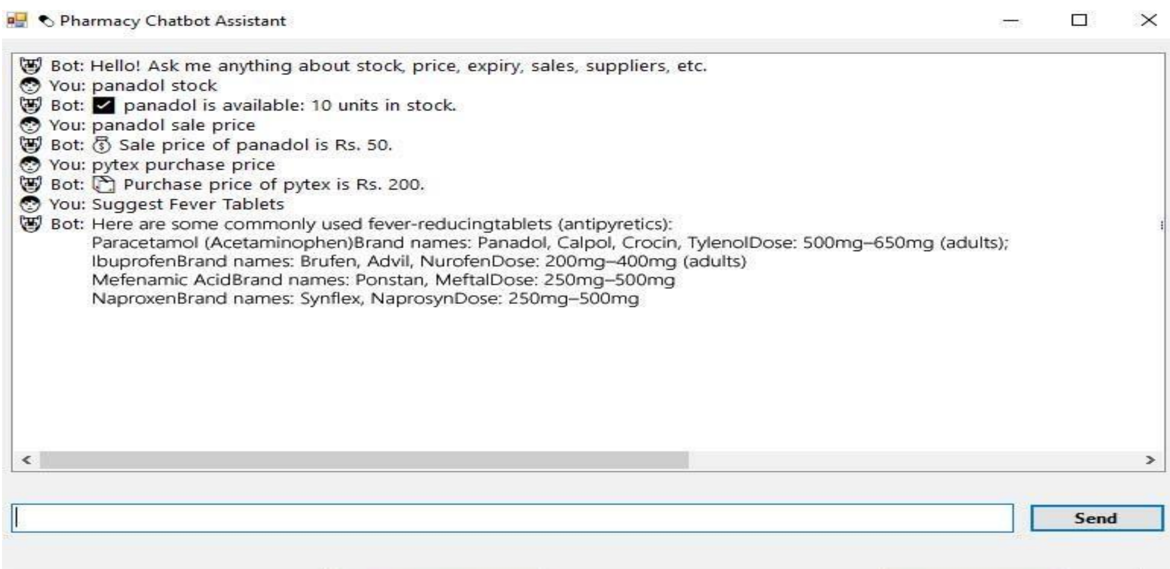

Figure 2/ Results

4. Conclusion

The introduction of the dual-stage AI chatbot framework moves Pharmacy Management Systems (PMS) forward by bringing together the organization of rule-based data with the smart reasoning of transformer-based AI. As the system uses a Natural Language Processing (NLP) query handler along with the GPT transformer model, it is simple for it to process both carefully crafted queries and communication-based requests.
Because of this approach, available data can be retrieved faster and more accurately and the system can further provide expert medical advice, useful instruction and helpful suggestions, all using speech. Because the design is modular, the system can be scaled and adapted in the future, allowing additions such as voice interaction, multiple languages and integration with IoT or mobile health technology.
Traditionally, C# WinForms and SQL Server ensure stability and security and adding GPT through APIs means AI services can be expanded with ease. Using a hybrid structure guarantees high performance with low cost, setting aside the powerful AI features for those queries that exceed simple SQL logic.
As a result, this hybrid model both streamlines work in pharmacies and improves how easy it is to get and use digital healthcare services. Creating a smart, real-time helper for pharmacists and patients is a key first step in making AI-enabled pharmacies that can match the needs of today's healthcare.

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