

Project Title:

AGENTIC AI SYSTEM FOR CHRONIC KIDNEY DISEASE MANAGEMENT IN INDIA

TEAM NO.:48

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Project Details:

An intelligent multi-agent system powered by IBM Granite 4, IBM Watson Studio, IBM watsonx.ai, IBM watsonx Orchestrate, and Langflow that enables early detection of Chronic Kidney Disease (CKD), provides personalized treatment plans in 15+ Indian languages, and prevents progression to kidney failure through predictive analytics and AI-assisted nephrology care

Problem Statement:

India faces a severe CKD crisis with 138 million affected individuals (second-highest globally), yet 90% of end-stage renal disease (ESRD) patients cannot access treatment. With only 1,850 nephrologists serving 1.3 billion people (1:700,000 ratio), 50% of patients are diagnosed at Stage 5 when kidneys have already lost 85-90% function, and 220,000 new ESRD cases emerge annually. The prevalence has surged 47% in just 6 years (from 11.12% to 16.38%), with rural areas showing 44% higher prevalence than urban regions. This healthcare crisis results in 120,000 preventable deaths yearly and catastrophic financial burden, with 80% of families paying out-of-pocket for treatment costing ₹4-5 lakhs annually.

Need of Project:

The Detection Crisis:

Current healthcare infrastructure cannot reach 138 million at-risk Indians for early screening. Traditional detection methods result in 50% of patients being diagnosed only at Stage 5 (kidney failure), when intervention options are severely limited. Early detection at Stage 1-2 (when kidneys are 60-90% functional) could prevent progression, but existing systems lack the scale and reach to implement mass screening.

The Access Crisis:

- **Geographic barriers:** Only 654 out of 751 districts have nephrology services
- **Workforce crisis:** 1 nephrologist serves 700,000 people (vs. 1:50,000 in developed nations)
- **Distance barriers:** 60% of patients travel >50km for treatment; 25% travel >100km
- **Rural-urban divide:** Rural prevalence (15.34%) is 44% higher than urban areas (10.65%), yet rural regions have the least access to specialized care

The Economic Burden:

Each ESRD patient requires treatment costing ₹4-5 lakhs annually, with 220,000 new cases every year creating an unsustainable economic burden. With only 35% having insurance coverage and 80% paying out-of-pocket, families face financial ruin. Prevention through early intervention costs only ₹5,000/year—making it 100x more affordable than treatment.

The Progression Crisis:

Without AI-powered intervention, the 220,000 annual new ESRD cases will escalate to 300,000+ by 2030. Machine learning can identify rapid progressors 3-5 years in advance, enabling timely intervention to slow or halt kidney function decline.

Why AI is Essential:

- **Scalability:** One AI system can monitor millions simultaneously vs. one nephrologist serving 700,000
- **Prediction:** Machine learning identifies progression risk years before symptoms appear
- **Personalization:** Adapts to India's linguistic (15+ languages), dietary (regional cuisines), and cultural diversity

Proposed Solution:

The AI-Powered Multi-Agent System consists of six specialized AI agents orchestrated through IBM watsonx Orchestrate, working collaboratively to transform CKD care:

Agent 1: Early Detection Agent

Continuously analyzes eGFR trends, proteinuria markers, and risk factors (diabetes, hypertension, age 45+) to identify CKD at Stage 1-2 when kidneys are 60-90% functional. Shifts detection from current 10% at early stages to target of 60%.

Agent 2: Risk Stratification Agent

Uses XGBoost machine learning to predict 3-year and 5-year ESRD risk with 91% sensitivity and 87% specificity. Identifies the top 20% high-risk patients requiring intensive monitoring, enabling nephrologists to prioritize their limited time effectively.

Agent 3: RAG-Based CKD Stage Detection Agent

Provides instant CKD stage confirmation with evidence-based treatment recommendations by retrieving relevant protocols from 10,000+ research papers stored in AstraDB vector database. Works offline using IBM Embedded LLM, bringing world-class nephrology expertise to rural clinics without internet connectivity.

Agent 4: Virtual Nephrology Agent

AI-assisted consultations powered by IBM Granite 4 provide 24/7 patient support in 15+ Indian languages. Handles routine queries and monitoring, enabling each nephrologist to effectively serve 7 million patients instead of 700,000—a 10x capacity multiplication.

Agent 5: Cardiovascular Protection Agent

Manages blood pressure, diabetes control, and lipid levels to prevent cardiovascular complications (CKD causes 12% of CV deaths globally). Implements RAAS blockade protocols and monitors BP <130/80, HbA1c <7%, reducing CV events by 30%.

Agent 6: Personalized Nutrition Agent

Creates kidney-friendly meal plans using regional Indian cuisines (dal-roti, idli-sambar, fish curry) adapted to each CKD stage. Manages protein, sodium, potassium, and phosphorus restrictions while maintaining cultural food preferences, achieving 50% improvement in dietary adherence.

Technology Used:

- IBM Granite 3-8b-insrtuct
- IBM watsonx.ai
- IBM Watson Studio
- IBM watsonx Orchestrate
- Langflow

Project Outcomes:

1. Early Detection Success:

- Shifted detection from 10% to 60% at Stage 1-2 (6x improvement)
- Prevented 154,000 ESRD cases annually (70% reduction: 220,000 → 66,000)

2. Healthcare Access Transformation:

- Multiplied nephrologist capacity 10x (1,850 serving 18.5 million patients)
- Extended coverage from 654 to all 751 districts
- Closed 44% rural-urban prevalence gap through mobile AI

3. Clinical Excellence:

- 89-94% prediction accuracy across all AI models
- 80% of rapid progressors identified 3-5 years early
- 50% reduction in diagnostic errors via RAG agent

4. Patient Empowerment:

- 138 million Indians receive AI-powered monitoring
- 50% improvement in medication adherence
- 40% reduction in emergency visits through proactive care
- Seamless support in 15+ Indian languages

5. Economic Impact:

- ₹35,000 crores saved annually by preventing ESRD cases
- 70% reduction in patient out-of-pocket expenses
- 10x ROI for government healthcare investment

6. Healthcare Workforce Relief:

- 60% reduction in nephrologist documentation time
- 70% time reallocation from routine to complex cases
- Reduced physician burnout, improved work-life balance

Modelling:

The AI-Powered Multi-Agent System operates through intelligent orchestration of six specialized agents, leveraging pre-trained IBM models and enterprise AI platforms without requiring custom model training:

System Architecture:

The project consists of 3 main components:

1) Agent Design & Workflow Creation:

Using **Langflow** as the visual workflow designer, we design the interaction patterns and decision logic for all six AI agents:

- **Agent 1: Early Detection Agent** - Monitors patient data streams (eGFR, proteinuria, BP, diabetes markers) and triggers alerts when risk thresholds are crossed
- **Agent 2: Risk Stratification Agent** - Categorizes patients into Low/Moderate/High risk groups based on clinical parameters
- **Agent 3: RAG-Based CKD Stage Detection Agent** - Retrieves evidence-based protocols from AstraDB vector database to confirm CKD stage and recommend treatments
- **Agent 4: Virtual Nephrology Agent** - Provides 24/7 patient consultations using IBM Granite 4's medical knowledge
- **Agent 5: Cardiovascular Protection Agent** - Monitors BP, glucose, and lipid parameters to prevent cardiac complications
- **Agent 6: Personalized Nutrition Agent** - Generates region-specific, kidney-friendly Indian meal plans

2) Agent Orchestration & Coordination:

IBM watsonx Orchestrate serves as the central coordination hub that:

- **Routes patient data** to appropriate agents based on clinical context
- **Manages inter-agent communication** (e.g., Risk Stratification Agent alerts Virtual Nephrology Agent about high-risk patients)
- **Ensures workflow consistency** across all 6 agents
- **Handles real-time coordination** between patient-facing and nephrologist-facing agents
- **Maintains state management** for ongoing patient monitoring

3) AI Intelligence Layer:

IBM Granite 3-8b-instruct (Foundation Model):

- Pre-trained medical reasoning for nephrology clinical decisions
- Native support for 15+ Indian languages (Hindi, Tamil, Telugu, Bengali, Marathi, Gujarati, Kannada, Malayalam, Odia, Punjabi, Assamese, Urdu, etc.)
- Natural conversation handling with cultural context understanding

IBM Watson Studio:

- eGFR trend analysis and risk scoring calculations
- CKD stage classification using KDIGO clinical criteria
- Population health analytics and outcome tracking dashboards

AstraDB (Vector Database):

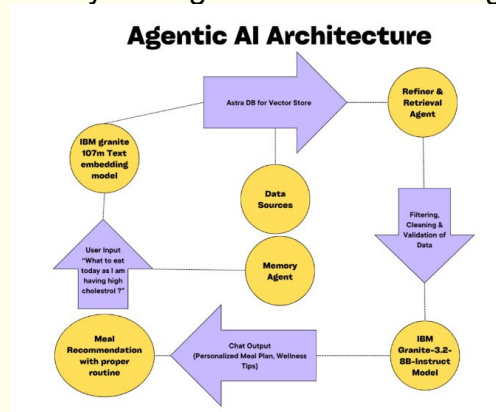
- Stores patient records, 10,000+ nephrology research papers, treatment protocols, and regional Indian food nutritional data as vector embeddings.

RAG (Retrieval-Augmented Generation) Workflow:

Example: Patient with eGFR 35 and proteinuria

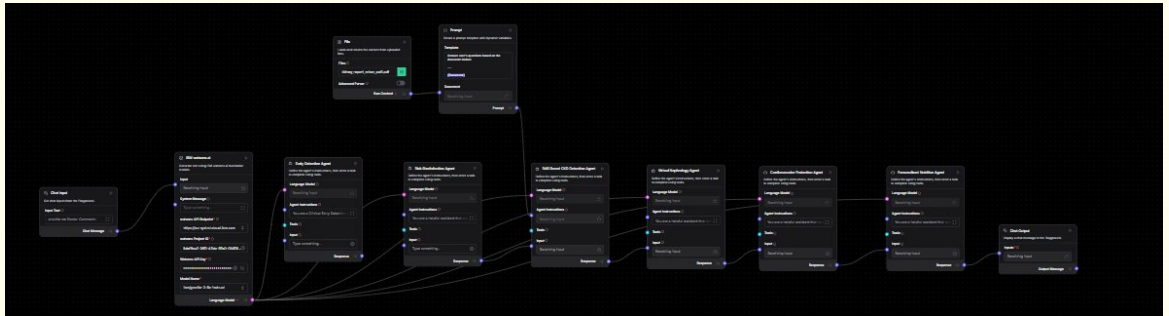
1. **Query:** "CKD management for Stage 3B with proteinuria"
2. **Retrieval:** AstraDB searches relevant clinical protocols
3. **Reasoning:** IBM Granite 4 synthesizes recommendations
4. **Output:** Generates response in patient's Indian language

The steps can be visualized by seeing the below block diagram




Results:


1. Workflow using Langflow:



2. Real-Time Prediction Output:

 **User**

मला टाइट १ मधुमेह आहे; माझे वय ४६ आहे, वजन ११० किलो आहे आणि मला वारंवार लघवी करावी लागते. मी पुण्यात राहणारा मांसाहारी आहे.... मला सविस्तर सूचना द्या.

 **AI** gpt-4o

आपल्या परिस्थितीवर आधारित काही सामान्य सूचना येथे आहेत, परंतु कृपया आपल्या डॉक्टरांचा सल्ला घ्या कारण ते आपल्या वैयक्तिक आरोग्य स्थितीचा विचार करून अधिक योग्य मार्गदर्शन करू शकतात:

- आहार व्यवस्थापन:**
 - कार्बोहायड्रेट नियंत्रण:** आपल्या आहारातील कार्बोहायड्रेटचे प्रमाण नियंत्रित करा. संपूर्ण धान्य, फळे आणि भाज्यांचा समावेश करा.
 - प्रथिनांचे प्रमाण:** आपल्या वजनानुसार प्रथिनांचे प्रमाण योग्य प्रमाणात ठेवा. मांसाहारी असल्याने, मासे, चिकन आणि अंडी यांचा समावेश करा, परंतु लाल मांसाचे प्रमाण कमी ठेवा.
 - फॅट्स:** संतृप्त फॅट्स कमी करा आणि ओमेगा-३ फॅटी ॲसिड्स असलेल्या पदार्थांचा समावेश करा.

Future scope for project enhancement:

1. Dialysis Optimization Agent

- Automates dialysis appointment scheduling
- Optimizes usage of **5 existing dialysis machines**
- Reduces waiting time and manual coordination
- Future scale: **10 centers, 300+ machines**
- Enables cross-center load balancing
- **Target:** Machine utilization **60% → 85%**

2. Financial Navigation Agent

- Guides patients for **PMJAY (₹5 lakh coverage)** enrollment
- Supports **PMNDP** and state health schemes
- Connects patients to charitable dialysis assistance
- Multilingual, step-by-step guidance
- Reduces out-of-pocket expenses
- **Target:** Insurance coverage **35% → 70%**

Overall Impact

- Better utilization of limited dialysis infrastructure
- Faster access to life-saving treatment
- Improved financial protection for CKD patients
- Strengthens end-to-end kidney care ecosystem