Prototyping a protocol-driven deterministic-mapping based system for the evaluation of abdominal pain in OPD setting

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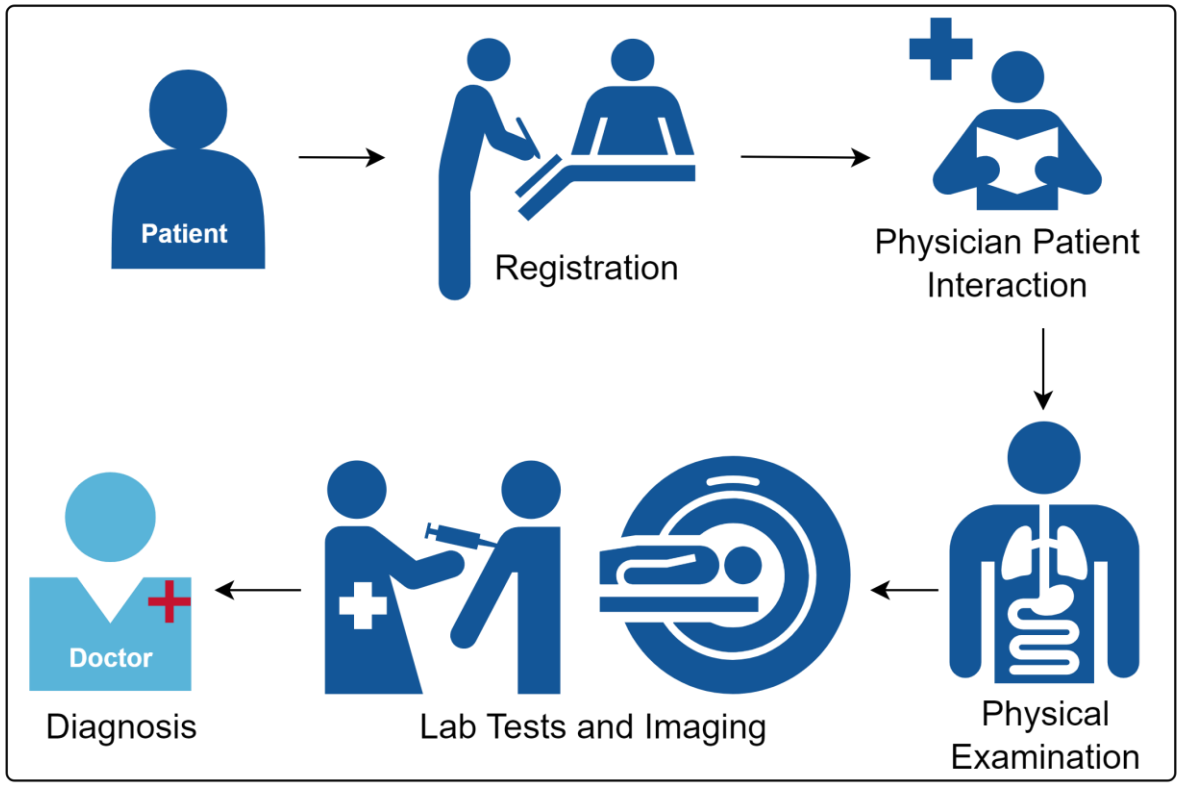
Content

Diagnosis of Abdominal Pain in Clinical Setting (OPD)



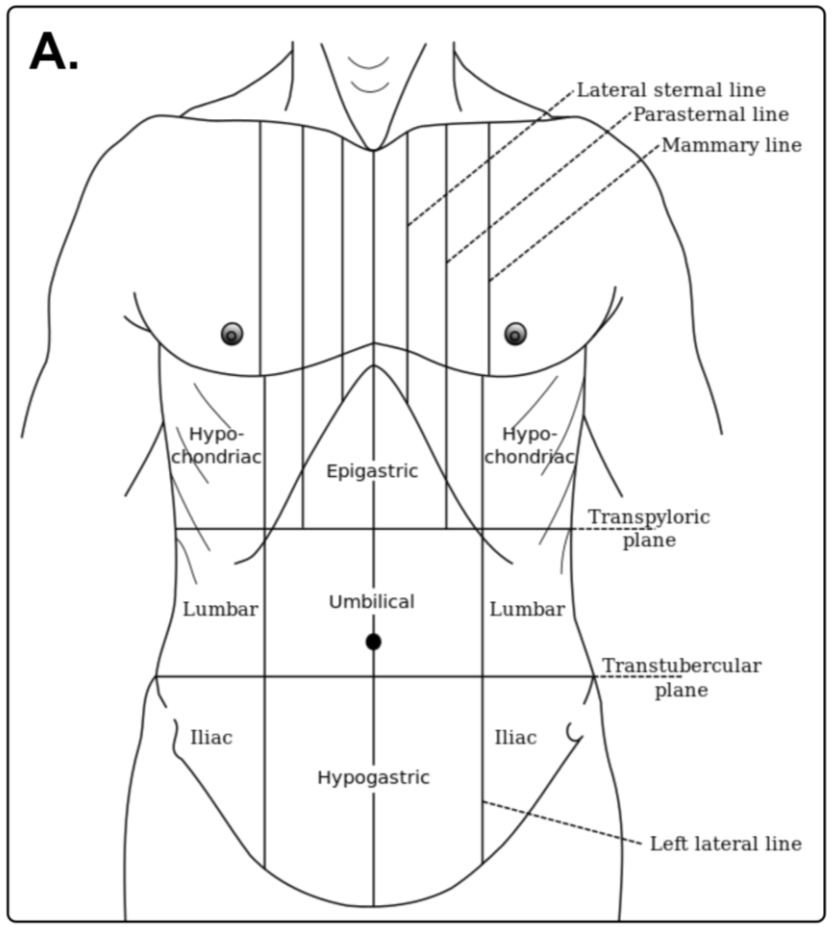
The step-by-step process of a patient undergoing an evaluation of abdominal pain

Abdominal pain is one of the most common and diagnostically challenging chief complaints encountered in clinical practice [1].

The evaluation of abdominal pain in regular OPD involve the following steps:

- **Physician-Patient Interaction** involves questioning by physician and reporting of symptoms.
- **Physical Examination** involves visual and hands-on inspection with the patient in a supine position bent knees to relax the abdominal muscles [2,3].
- **Lab Test and Imaging** involves blood test, ultrasound imaging, MRI, etc.)

Diagnosis of Abdominal Pain in Clinical Setting (OPD)



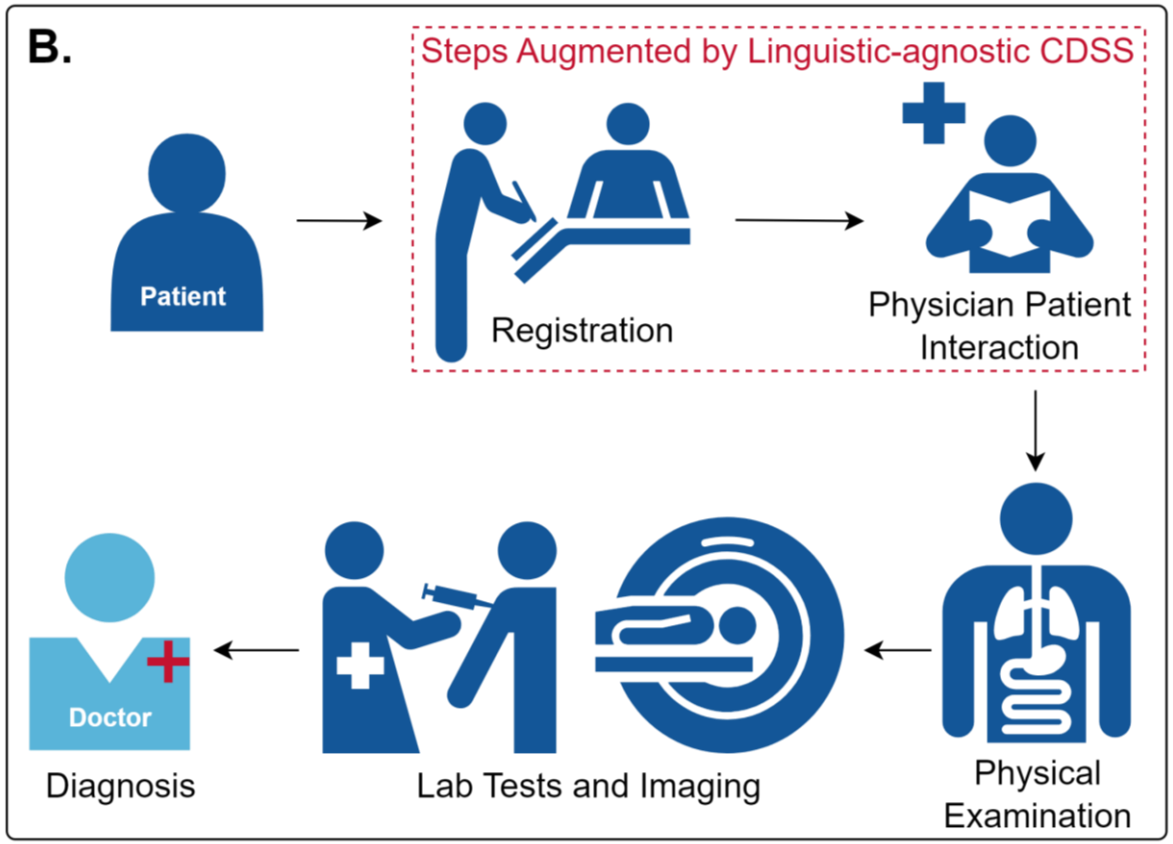
The nine regions of the abdomen.

The physician-patient interaction involves multiple clinical dimensions such as:

- **Location of Pain** based on the nine regions of the abdomen. The specific region of pain often serves as an essential diagnostic clue.
- **Presence of Danger Signs** such as light-headedness
- **Severity of Pain** reported by the patient
- **Onset of Pain** over the minutes or hours
- **Character of Pain** such as stabbing, pin-pricking, etc.
- **Duration of Pain** as short (<3 months) or long (>3 months) term
- **Radiation of Pain** to other parts of body
- **Aggravating Factors** such as food intake, movement, etc.
- **Associated Symptoms** like fever, nausea, vomiting, jaundice, etc.
- **Comorbidities** such as diabetes, kidney disease, etc.
- **Surgical History** of gallbladder, intestines, etc.

[*] Image Source: Anatomy of the Human Body, Henry Gray

Diagnosis of Abdominal Pain in Clinical Setting (OPD)



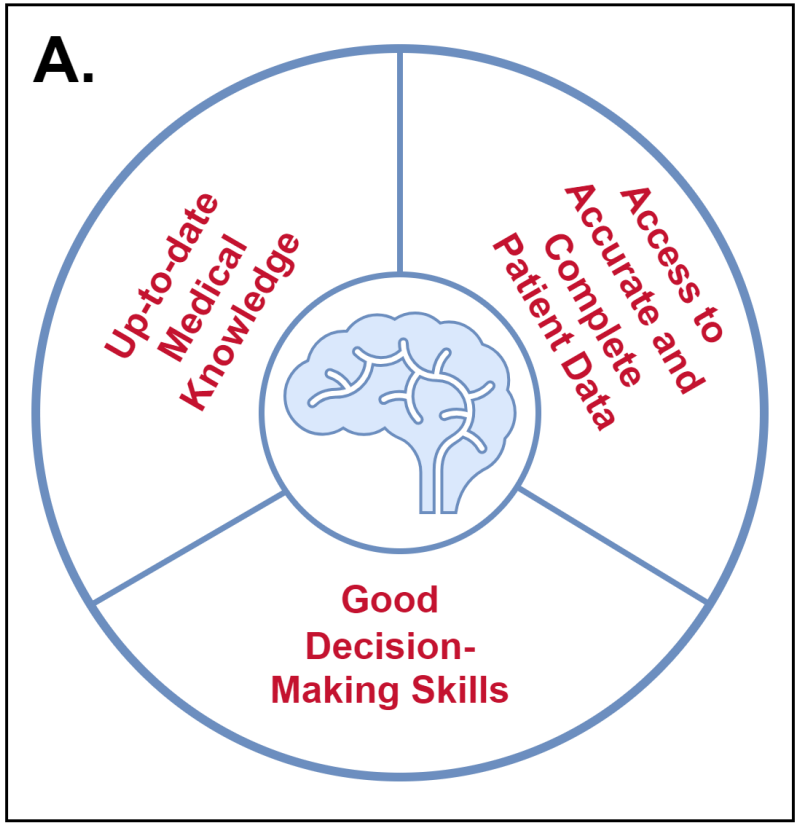
The step-by-step process of a patient undergoing an evaluation of abdominal pain. The dotted red box show where the application will be augmented.

The application developed as part of this capstone project aims to augment the physician-patient interaction phase of abdominal pain evaluation workflow.

It collects essential patient information regarding the dimensions mentioned earlier to identify a probable diagnosis and organ of origin using a deterministic approach.

The physical examination, subsequent steps and final diagnosis remain under the physician's control.

Brief Introduction to Clinical Decision Support Systems (CDSS)



Effective clinical decision-making principles

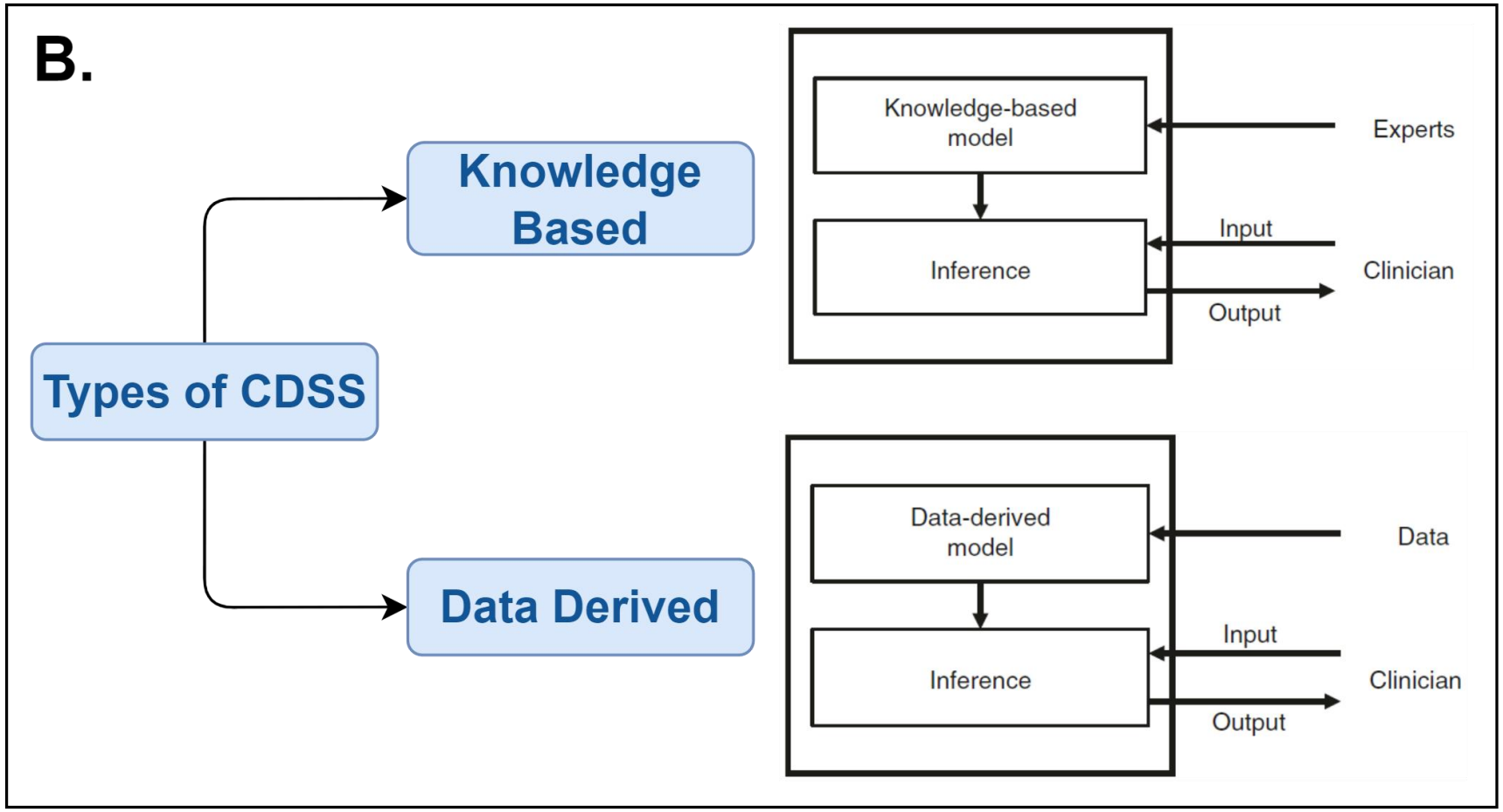
Any system making clinical decision should follow the effective clinical decision-making principles.

These principles make sure that the several significant changes that that are emerging in healthcare landscape such as

- Exponential Growth of Medical Knowledge
- Rapid Accumulation of Patient Data
- Clinical Data Capture and Documentation Burden

are tackled effectively [4]

Brief Introduction to Clinical Decision Support Systems (CDSS)

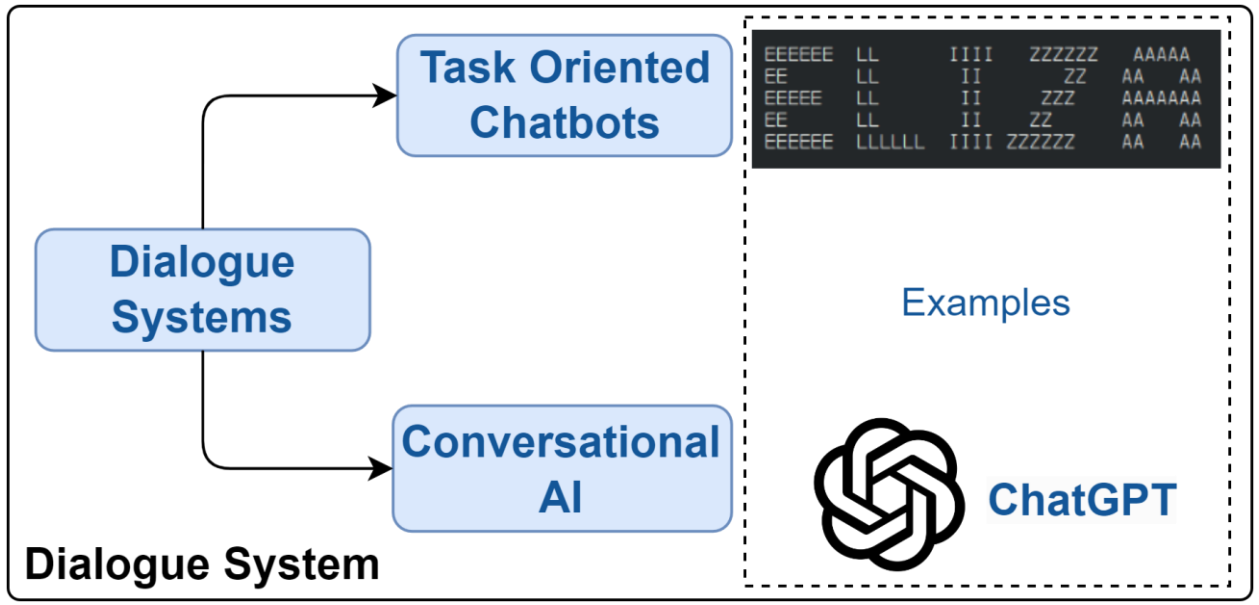


The two types of CDSS systems, Knowledge-based and Data-derived [4]

Such decision making systems can be broadly classified as:

- **Knowledge-based**: The key components of a knowledge-based system includes expert-derived rules and an inference mechanism for these rules.
- **Data Derived**: The key components of a data-derived include a model, such as a neural network, and an inference mechanism such as forward propagation in a neural network model

Brief Introduction to Conversational AI in Healthcare



Types of Dialogue Systems

Types of Dialogue Systems:

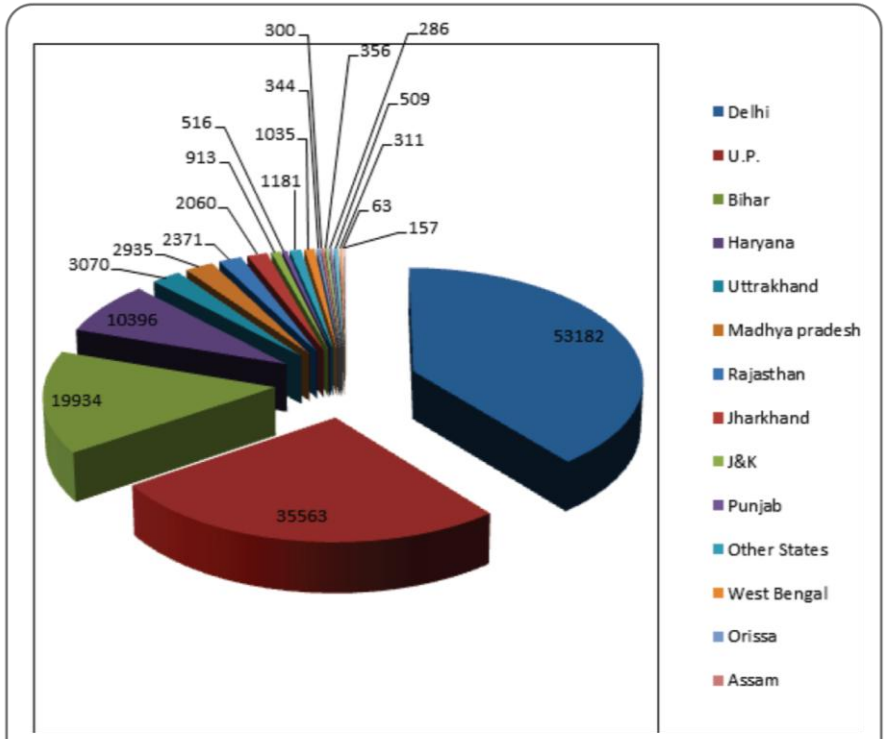
- **Task-oriented** chatbots such as ELIZA [5] follow a rigid workflow.
- **Conversational AI** such as ChatGPT [6] understand intent, manage multi-turn dialogues, and evolve with user interactions.

Assisting Physicians in OPD settings

The Department of Gastroenterology and Human Nutrition at AIIMS New Delhi managed a total of **1,35,944** outpatient department (OPD) cases of total **10,39,523** cases at the main hospital [7]

The routine gastroenterology OPD operates from Monday to Friday, 8:30 a.m. to 1:00p.m. [8]. Given this limited time frame of 270 minutes daily over 5 working days, approximately **8,500 new cases are handled per day**, with multiple physicians addressing various chief complaints.

The patients also belong to a **diverse background** as shown by the geographic distribution of inpatients of year 2021-2022.



Geographical Distribution of inpatients (Main Hospital, CN Centre, and CDER) - 2021-2022

The application aims to **assist physicians** by generating probable diagnoses and identifying the organ of origin.

Year	New Cases	Follow-up Cases	Total Cases
2020-2021	7,920	11,956	19,876
2021-2022	17,790	35,622	53,412
2022-2023	42,586	93,358	1,35,944

Problem Statement:

The volume of patients at OPD settings related to gastrointestinal complaints is large. Given the time constraints (270 minutes) and the large in influx of patients (around 8,500 cases per day), automation of the initial physician-patient interaction, specifically for evaluating the chief complaint of abdominal pain, will significantly assist physicians in managing the high volume of patients in the OPD setting.

Objectives:

1. **Development of an application** to assist physicians in the evaluation of abdominal pain in the OPD setting. This application will collect patient responses through a structured, protocol-driven questionnaire and generate a report with a probable diagnosis and organ of origin through a deterministic rule-based system.

2. **Implementing** a conversational agent that interacts with patients to help collect responses for the questionnaire.

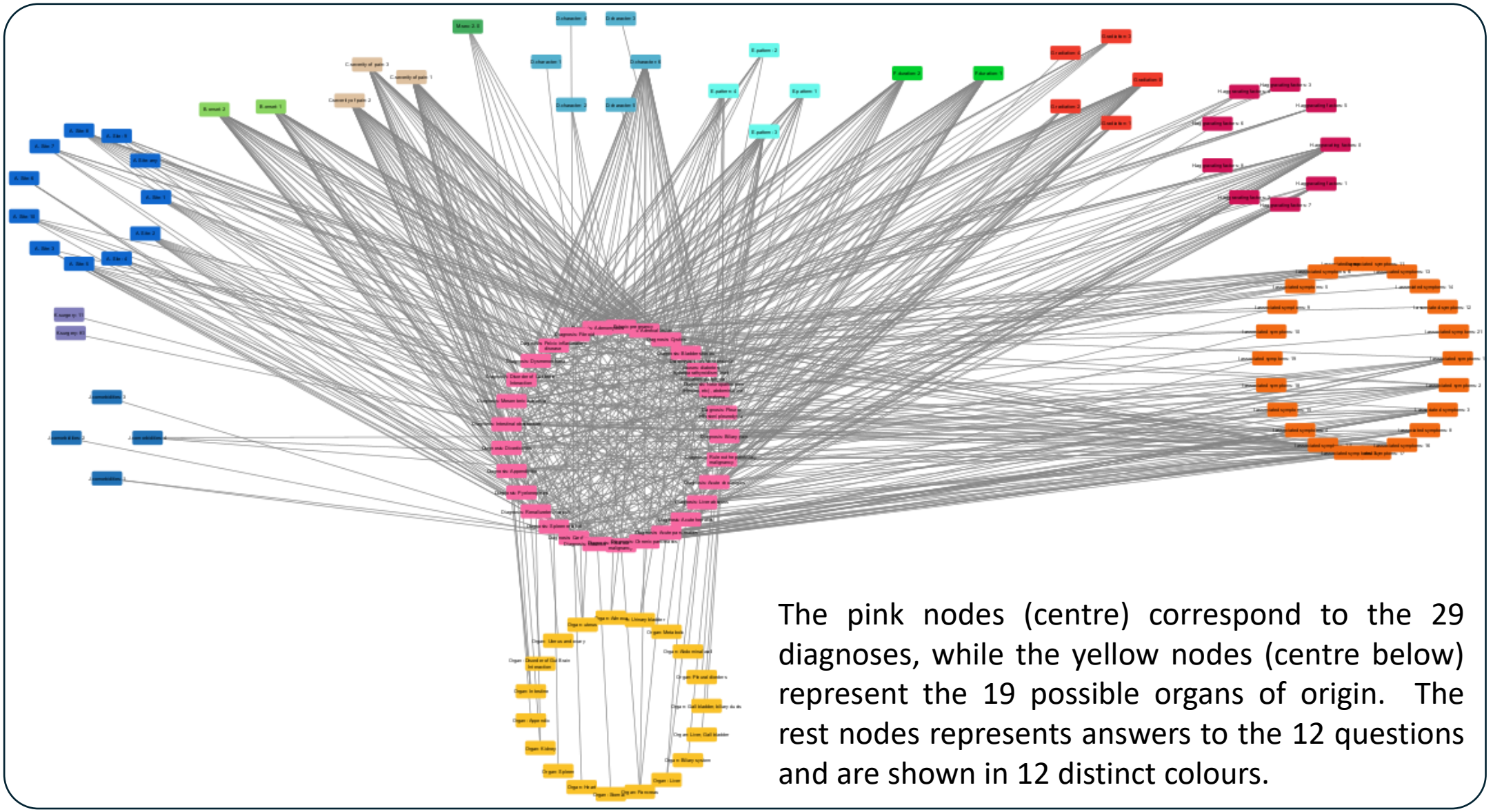
3. **Evaluation and assessment** of the impact of the rule-based deterministic system with the conversational agent in the OPD setting for abdominal pain evaluation. The evaluation will be performed by comparing no system (baseline), option-based system with help of a healthcare staff , and a fully conversational system.

The physician shared the following data related to abdominal pain.

Questionnaire:
The physicians share a set of a **12 questions** that addressed key clinical dimensions of abdominal pain discussed previously. These questions explored aspects like pain location, intensity, aggravating factors, associated symptoms, etc. All the questions had various options as possible answers

Probable Diagnosis and Organ of Origin Spreadsheet:
They physicians also shared spreadsheet relating **29 probable diagnoses** with **19 organ of origin**. This spreadsheet also contained relation of all 29 probable diagnosis with the option-based answers to above mentioned 12 questions.

Probable Diagnosis and Organ of Origin Mapping



The pink nodes (centre) correspond to the 29 diagnoses, while the yellow nodes (centre below) represent the 19 possible organs of origin. The rest nodes represents answers to the 12 questions and are shown in 12 distinct colours.

The figure shows the graphical representation of patient responses to 12 questions mapped to probable diagnoses and organs of origin

Protocol & Patient Workflow

Discriminators

- Please rate the severity of the pain on a scale of 1 to 10
- Have you experienced any trauma?
- Are there any danger signs present?

Demographic

- Choose your gender
- Choose your age group

Female-Specific

- Have you experienced any recent changes in your menstrual cycle?
- Have you noticed any of the following abnormalites?

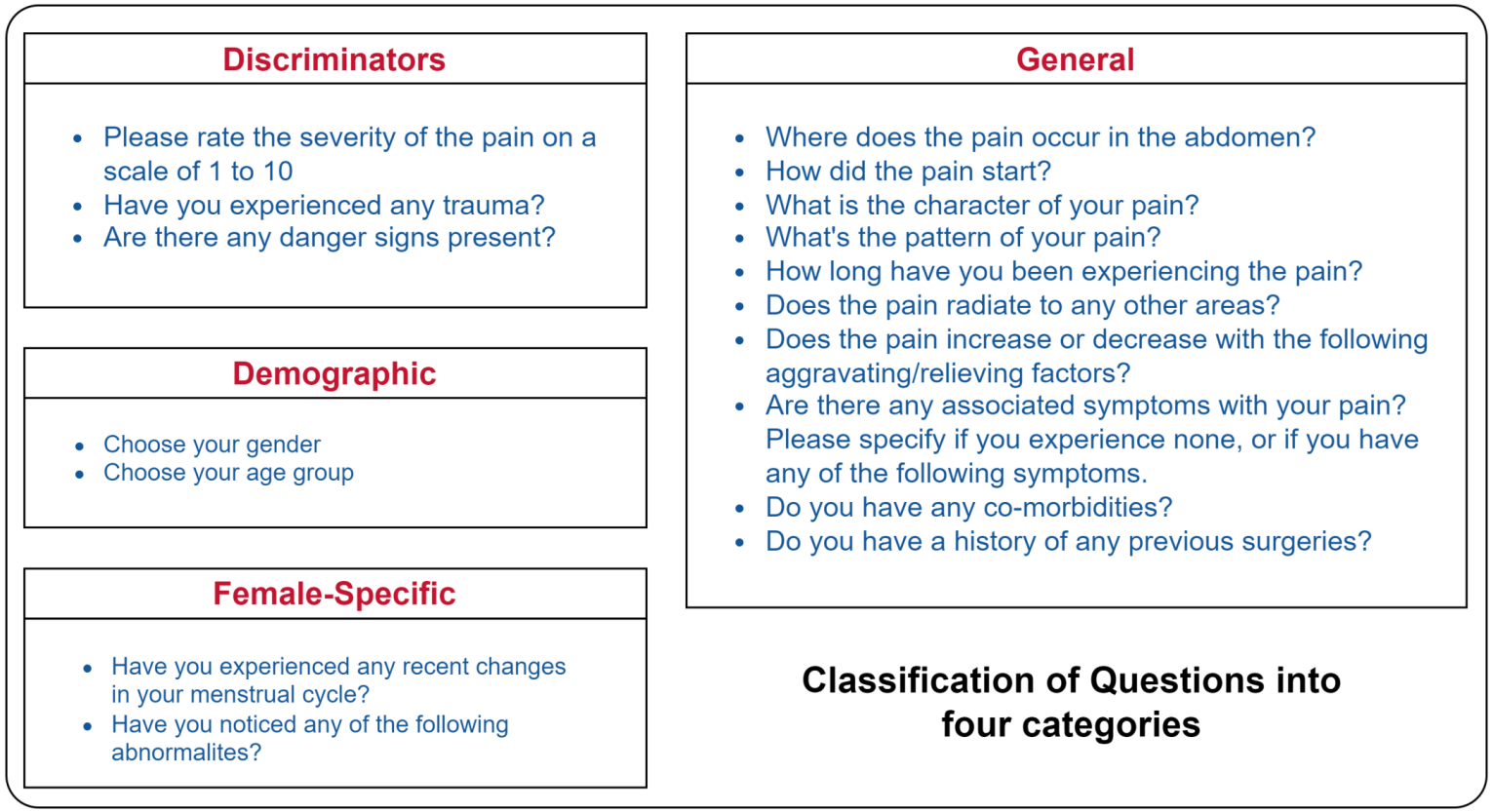
General

- Where does the pain occur in the abdomen?
- How did the pain start?
- What is the character of your pain?
- What's the pattern of your pain?
- How long have you been experiencing the pain?
- Does the pain radiate to any other areas?
- Does the pain increase or decrease with the following aggravating/relieving factors?
- Are there any associated symptoms with your pain? Please specify if you experience none, or if you have any of the following symptoms.
- Do you have any co-morbidities?
- Do you have a history of any previous surgeries?

Classification of Questions into four categories

Categorization of the 17 questions into four categories

Protocol & Patient Workflow

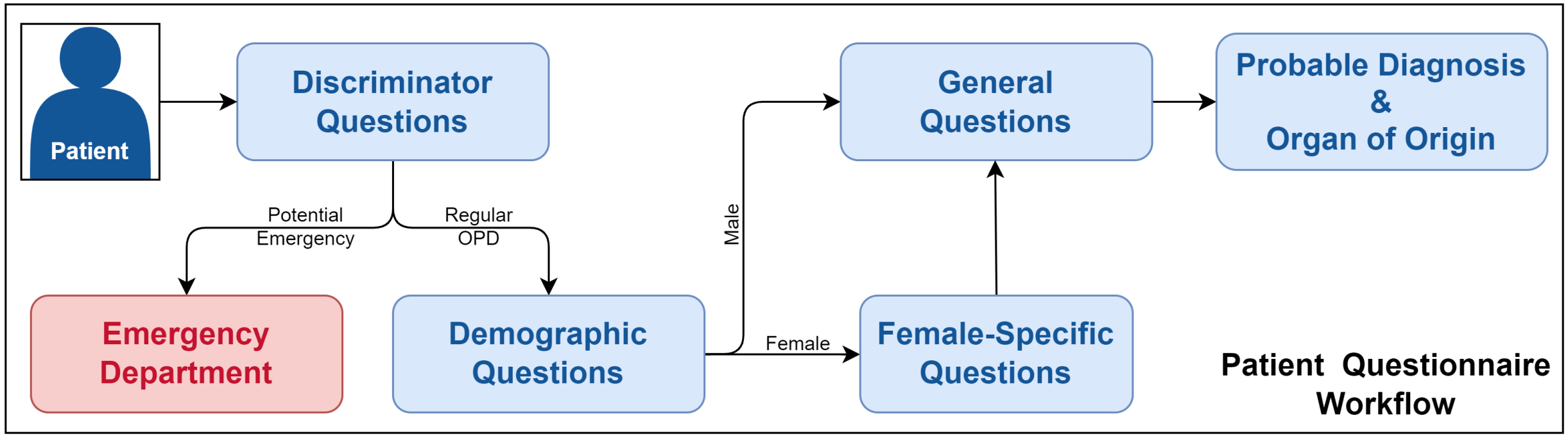


Categorization of the 17 questions into four categories

After obtaining the questionnaire, it was broken down to a set of 17 questions for more controlled and streamlined workflow. This allowed for a categorization of questions as follows:

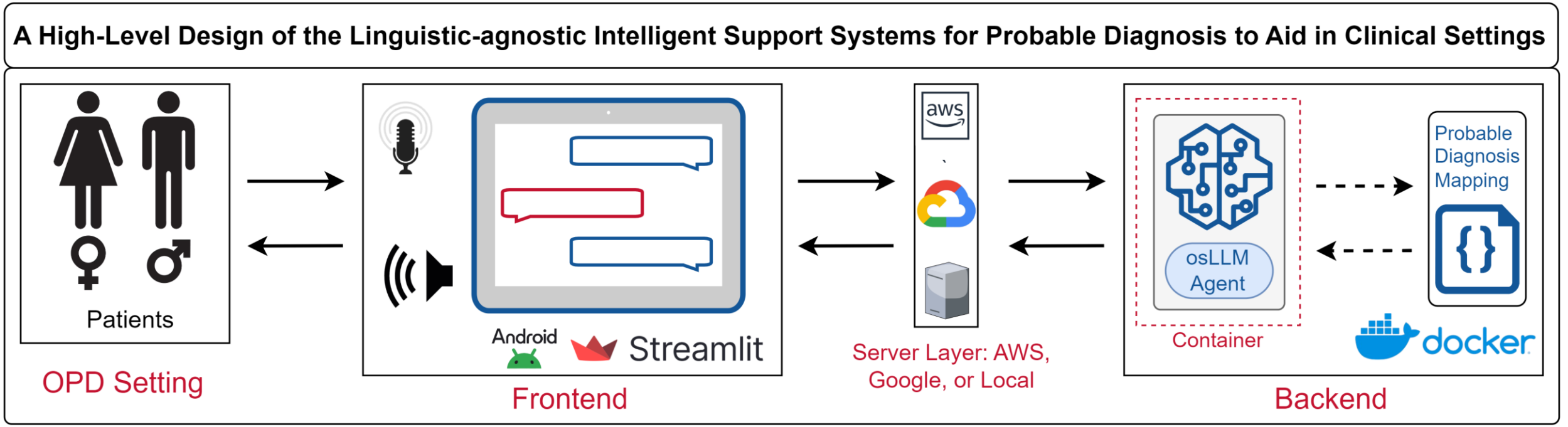
- **Discriminators**: These questions are used to differentiate between emergency and regular OPD cases.
- **Demographic**: Questions related to the patient's demographic information, such as age and gender.
- **Gender-Specific**: Questions specific to female menstrual health.
- **General**: These are common questions applicable to all patients.

Protocol & Patient Workflow



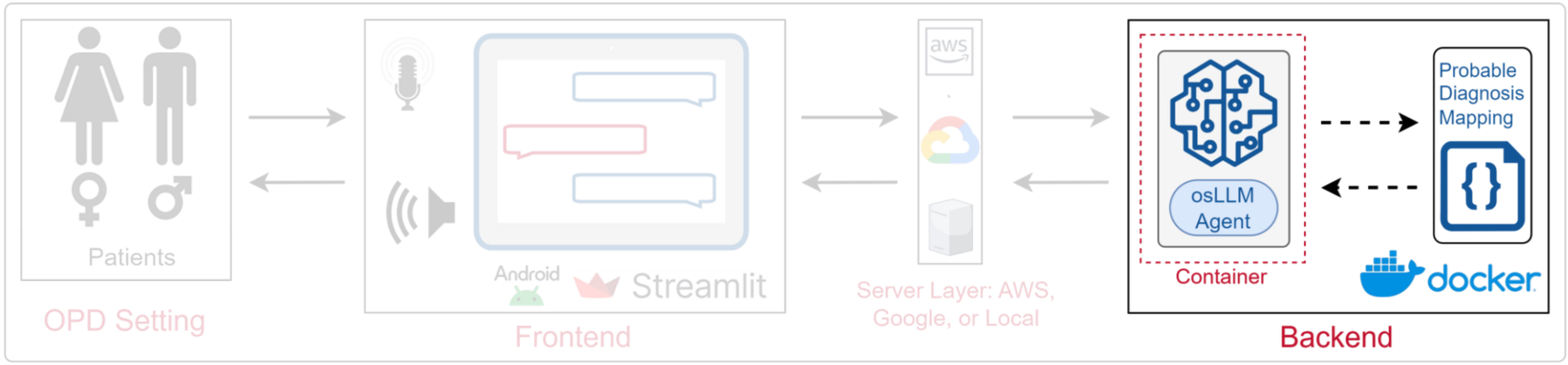
Design of the step-by-step workflow of the patient's interaction through a structured questionnaire

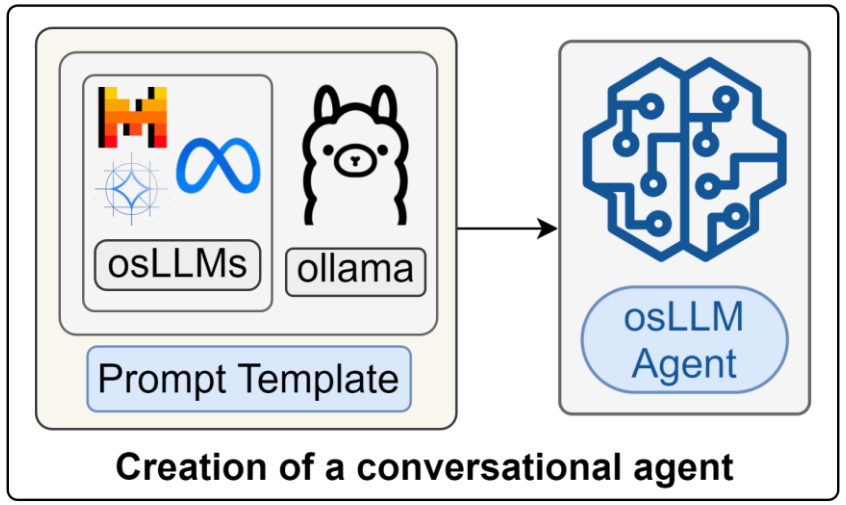
High Level System Design



The system consists of two main components: the **frontend** and the **backend**.
The frontend consists of the Android and Web Applications (developed in Streamlit).
The backend includes the data dictionary and the conversational agent.
The containerized backend can be deployed on a local server or cloud platform such as AWS or Google Cloud

System Design: Backend



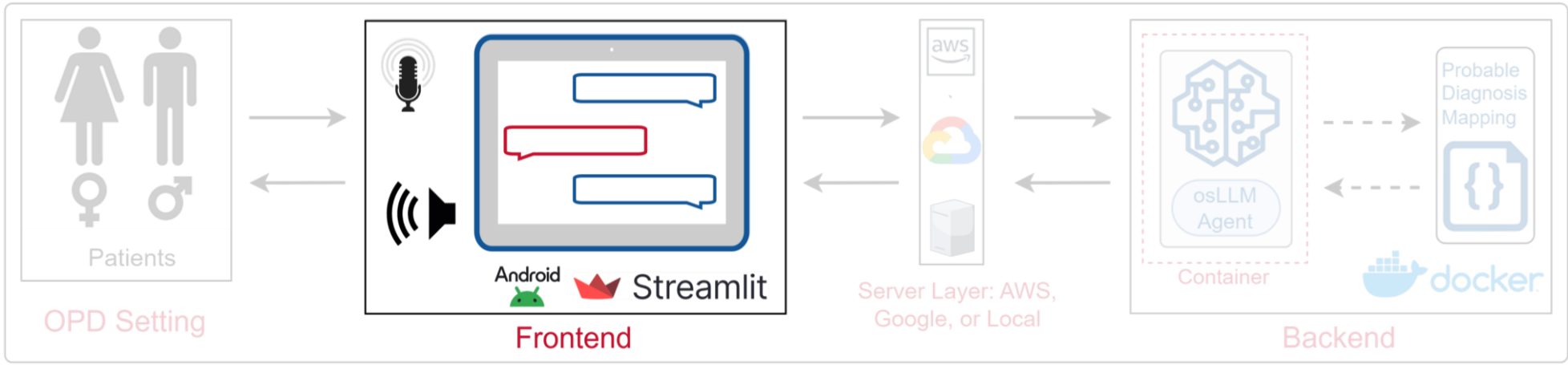


The backend of the application has two major components:

- **Data Dictionary** contain the mapping between patient responses and probable diagnoses and organs of origin
- **Conversational Agent** is responsible for interacting with the patient and guiding them through the questionnaire.

The conversational agent is created using the open source Large Language Models (osLLMs) and hosted and managed by using Ollama [9].

System Design: Backend

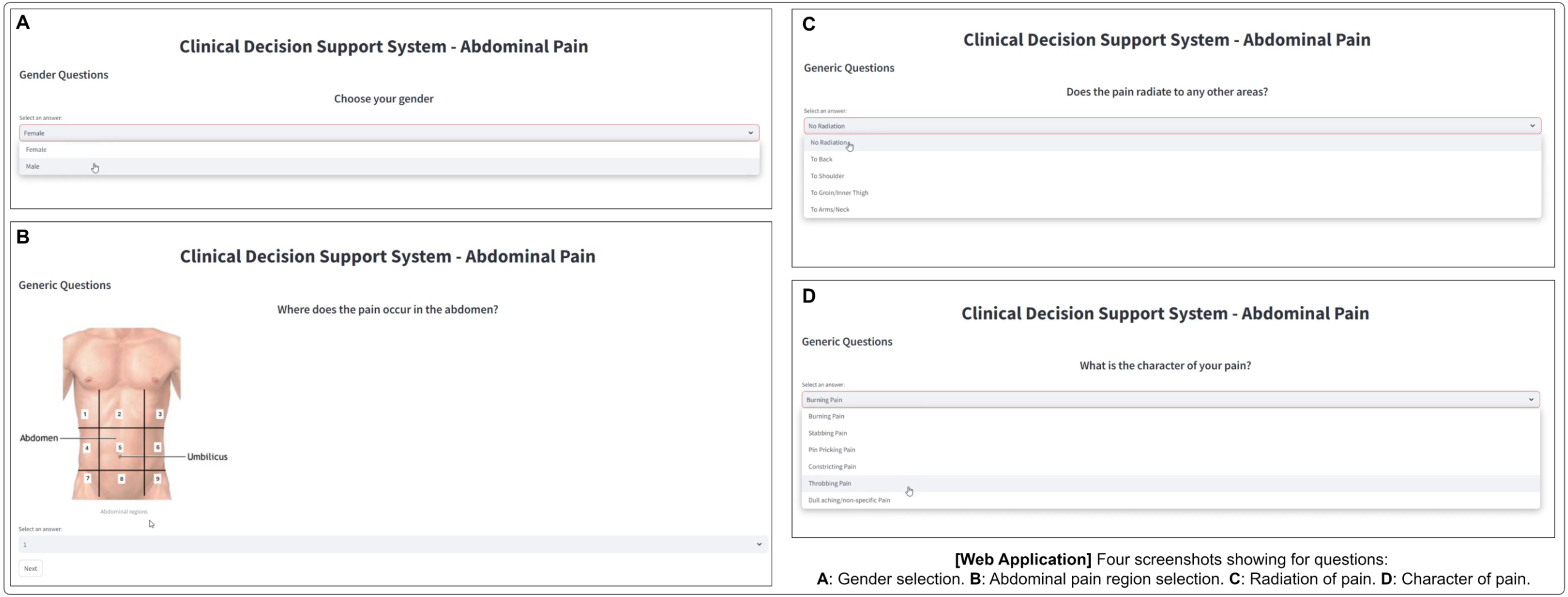


The frontend of the application is of two types

- **Web Application** is built using Streamlit framework in Python.
- **Android Application** is designed using Figma and being developed in Android Studio.

Both application prototypes follows a click-through option for patient interaction, where the patient could navigate the questions by answering each question sequentially.

System Design: Frontend — WebApp

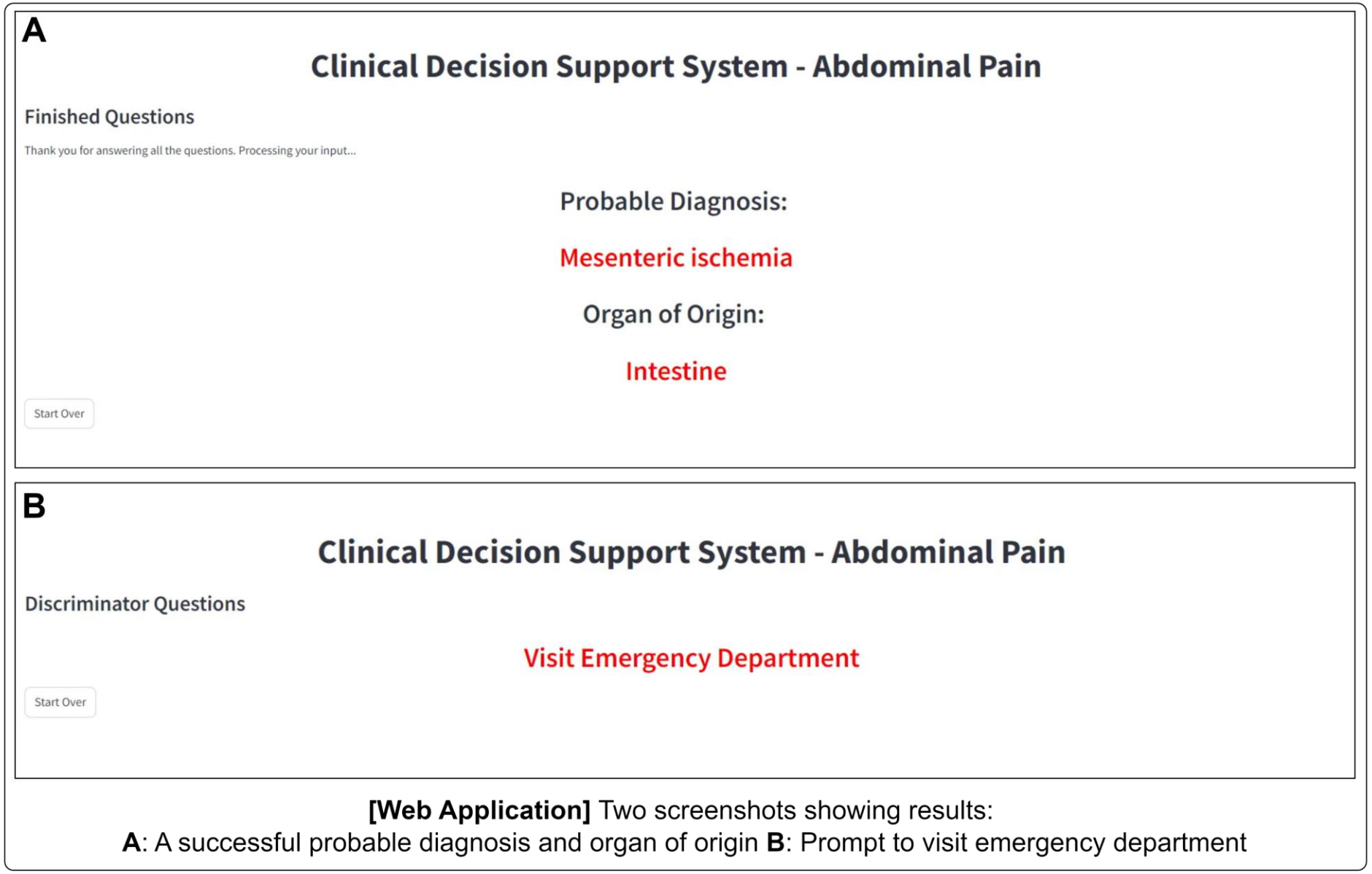


[Web Application] Four screenshots showing for questions:
A: Gender selection. **B**: Abdominal pain region selection. **C**: Radiation of pain. **D**: Character of pain.

System Design: Frontend — WebApp

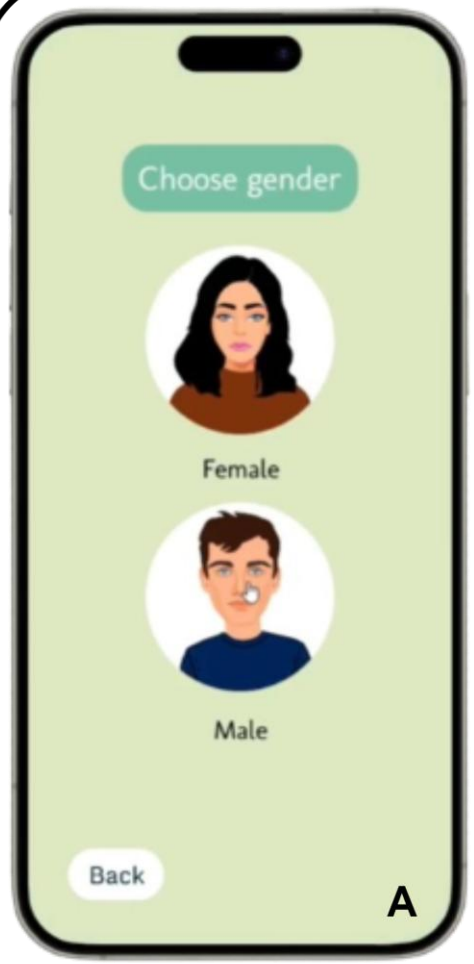
Live Streamlit Demo

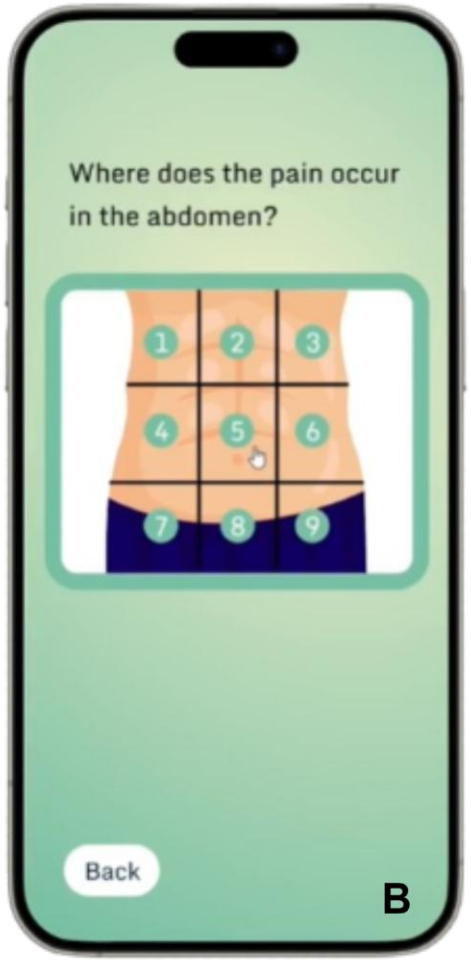
System Design Results — WebApp

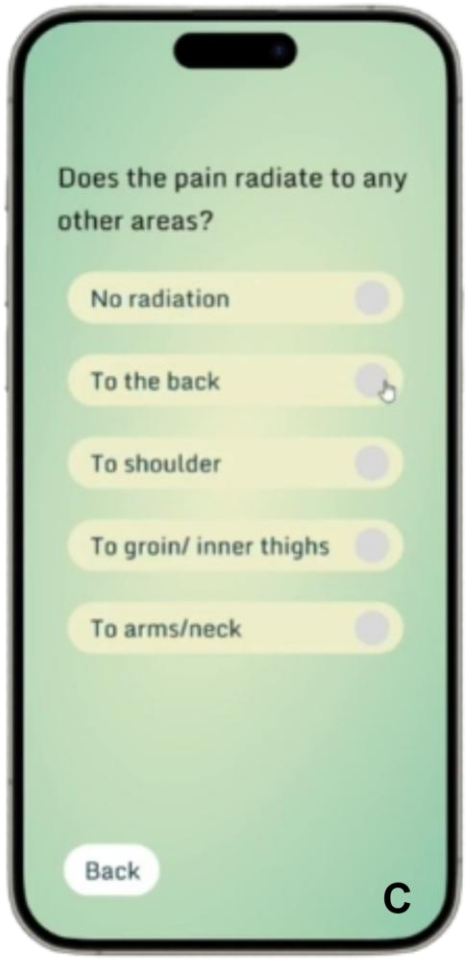


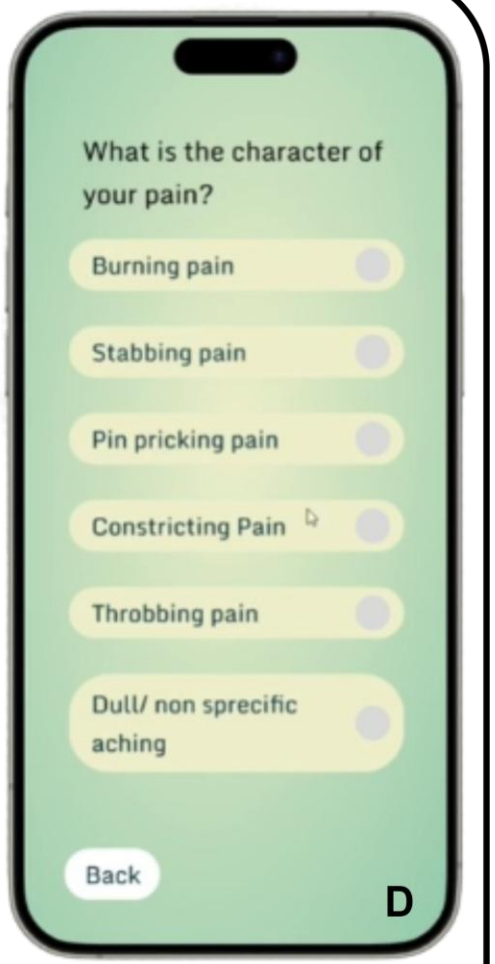
[Web Application] Two screenshots showing results:
A: A successful probable diagnosis and organ of origin **B**: Prompt to visit emergency department

System Design: Frontend — Android





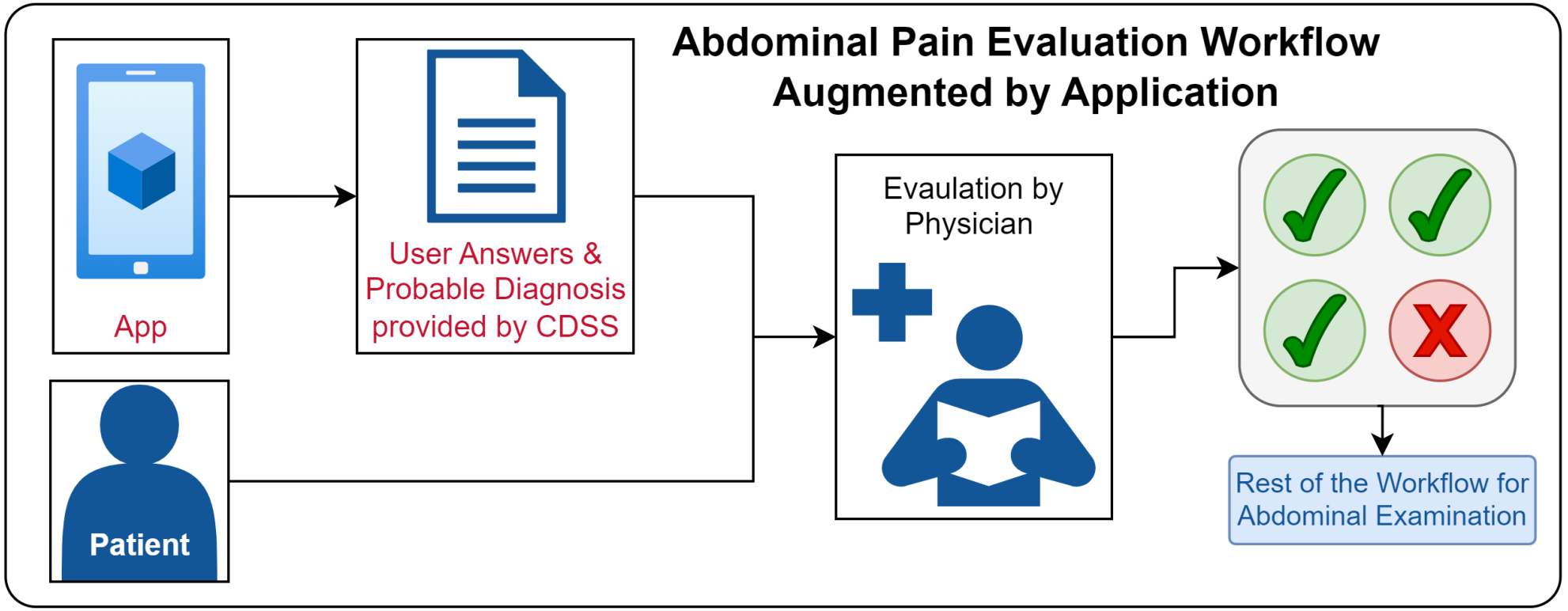




[Android Application] Four screenshots showing for questions:
A: Gender selection. **B**: Abdominal pain region selection. **C**: Radiation of pain. **D**: Character of pain.

Live Figma Demo

Augmented Patient Workflow



Abdominal pain evaluation workflow augmented using application

Future Work

Future development of the system will focus on several key areas:

- **Integration** of osLLMs agents to provide a conversational interface for patients. Additionally, the Android and web applications will be enhanced with additional features including voice based input, and final reports generation.
- **Incorporate** the support of **openCHA** [10] framework for empowering the conversational agent with voice-based functionality and external knowledge support with built-in translation tools as a part of the system
- **Comprehensive evaluation** to assess the impact of the system on the clinical workflow for abdominal pain evaluation.

Acknowledgment

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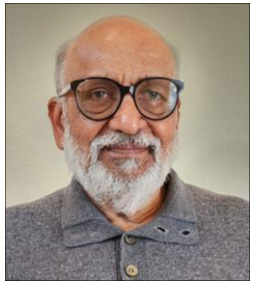

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Thank you & Questions