

# Healthcare Meets AI: Smarter Decisions, Better Outcomes

## Bridging Data and Decisions: AI's Role in Modern Healthcare

Medical Assistant: Post Graduate AI/ML Business Applications

June 1, 2025

# Contents / Agenda

- Question Answering using LLM
- Question Answering using LLM with Prompt Engineering
- Data Preparation for RAG
- Question Answering using RAG
- Output Evaluation

# Executive Summary

The analysis evaluates the evolution of responses from **LLM-based answering** (with and without prompt engineering) to **RAG-assisted generation**, including fine-tuning adjustments on RAG-assisted generation and LLM Judging the responses with a **relative rating score**.

## Key Findings

1. **Baseline LLM Response (No Prompt Engineering):**
  - **Issue:** The response lacked **structured clinical guidance** and omitted **validated scoring systems** for risk assessment.
  - **Limitation:** While generally correct, it remained **surface-level**, failing to reference diagnostic standards or laboratory evaluations.
2. **LLM Response with Prompt Engineering:**
  - **Improvement:** The engineered prompt improved **clarity** and introduced **multidisciplinary care**, highlighting the **Sequential Organ Failure Assessment (SOFA)** scoring.
  - **Gap:** Despite enhancements, **fact-grounded specificity** was still limited to **generalized recommendations** rather than **verified clinical protocols**.

# Executive Summary

## 3. RAG-Powered Response with System Prompt and User Query:

- **Advantage:** Retrieval augmentation introduced **laboratory markers** (procalcitonin, C-reactive protein) and **source identification methodologies** (serial blood cultures, urinalysis).
- **Significance:** This response **grounded** itself in **clinical best practices**, enhancing **accuracy and decision-support relevance**.

## 4. Fine-Tuned RAG Response (Temperature Adjusted):

- **Further Improvement:** Adjusting the **temperature parameter** refined **conciseness**, making directives **more actionable**.
- **Key Differentiation:** The fine-tuned response **optimized factual retrieval** while reinforcing **infection control strategies** (sterile techniques, monitoring protocols).

# Executive Summary

## 5. LLM-as-a-Judge

- **LLM judge** makes sure the **AI's response correctly** uses the information it found, without adding false or misleading details. It also checks if the answer makes sense and actually addresses the question.
- **Additionally**, LLMs ensure the response **is well-structured**, flows smoothly, and stays consistent throughout.
- **LLM judge helps with better evaluations:** Using an AI model as a judge makes it easier to **consistently check** whether answers are relevant, and factually correct in RAG systems.

# Executive Summary

## Comparative Analysis: LLM vs. RAG in Medical Question-Answering

Approach	Grounding & Accuracy	Clinical Guidance	Structured Presentation
LLM (No Prompt Engineering)	Basic	Generalized	Minimal
LLM (Prompt Engineering)	Moderate	Some guidance (SOFA, organ function)	Improved coherence
RAG-Based Response	High	Includes diagnostic tests & source control	Strong
Fine-Tuned RAG	Very High	Adds <b>infection control measures</b> & structured evaluation	Optimized for decision-making

# Executive Summary Recommendations

The transition from **LLM-based response generation** to **retrieval-augmented generation (RAG)** significantly enhances the **accuracy, clinical relevance, and structured guidance** for management in critical care settings. Fine-tuning further refines the output by optimizing temperature settings, which improves response **coherence and actionability** for real-world medical applications.

## Recommendations for Further Improvement

### Optimized Retrieval Strategies

- Enhance **document-ranking mechanisms** within RAG to prioritize **peer-reviewed guidelines** (e.g., Surviving Sepsis Campaign).
- Implement **context-aware retrieval filtering** to ensure relevance and prevent outdated protocols.

### Dynamic Temperature Tuning for Adaptive Responses

- Adjust temperature dynamically based on query complexity—higher for **exploratory discussions**, lower for **critical protocol adherence**.
- Experiment with **multi-turn adaptation**, where temperature shifts across response phases improve engagement and precision.

# Executive Summary Recommendations

## Hybrid Prompt Engineering for Structured Medical AI

- Merge **template-based prompting** with **retrieved factual information** to create well-structured, clinically relevant outputs.
- Introduce **prompt chaining** where retrieval-informed responses refine subsequent queries for deeper diagnostics.

## Integration of Real-Time Clinical Data Feeds

- Connect RAG-powered models with **electronic health record (EHR) systems** to **contextualize responses** based on patient-specific parameters.
- Enable **dynamic updates** from trusted medical sources to reflect the latest clinical findings.

## Evaluation Metrics for Medical AI Accuracy

- Define **precision and recall benchmarks** to compare **LLM vs. RAG accuracy** in medical query resolution.
- Use **clinician feedback loops** to validate the alignment of AI-generated responses with practical clinical workflows.

## Ethical & Regulatory Compliance in Medical AI

- Ensure adherence to **HIPAA-compliant retrieval frameworks** to safeguard patient confidentiality.
- Validate responses against **FDA and WHO guidelines** for AI-assisted healthcare recommendations.



# Business Problem Overview and Solution Approach

The **healthcare industry** is rapidly evolving, with professionals facing increasing challenges in managing vast volumes of medical data while delivering accurate and timely **diagnosis**. The need for quick access to comprehensive, reliable, and up-to-date medical knowledge is critical for improving patient outcomes and ensuring informed decision-making in a fast-paced environment.

**Healthcare professionals** often **encounter** information **overload**, **struggling** to sift through extensive research and data **to create accurate diagnoses** and treatment plans. This challenge is amplified by the need for efficiency, particularly in emergencies, where time-sensitive decisions are vital. Furthermore, access to trusted, current medical information from renowned manuals and research papers is essential for maintaining high standards of care.

**To address these challenges**, healthcare centers can focus on **integrating systems** that **streamline access to medical knowledge**, provide tools to support **quick decision-making**, and enhance efficiency. Leveraging centralized knowledge platforms and ensuring healthcare providers have continuous access to reliable resources can significantly improve patient care and operational effectiveness.

# Business Problem Overview and Solution Approach

- The task involves developing a Retrieval-Augmented Generation (RAG)-based AI solution utilizing renowned **Merck Medical Manuals** to **tackle healthcare challenges**. The primary goal is to comprehend issues such as information overload, implement AI techniques to enhance decision-making efficiency, assess its influence on diagnostics and patient outcomes, examine its capability to standardize care practices, and construct a functional prototype that demonstrates its feasibility and effectiveness. Through rigorous analysis and innovation, this initiative aims to refine healthcare methodologies and improve accessibility to critical medical knowledge.

# Question Answering using LLM

○ **Question:** What is the protocol for managing sepsis in a critical care unit?

○ **Response:** **Sepsis is a life-threatening condition** that can arise from an infection, and it requires prompt recognition and aggressive management in a critical care unit. The following are general steps for managing sepsis in a critical care unit. Early recognition: Recognize the signs and symptoms of sepsis early and initiate treatment as soon as possible. Sepsis can present with various clinical features, including fever or hypothermia, tachycardia or bradycardia, altered mental status, respiratory distress, and lactic acidosis..  
Source control

○ **Observations:**

## **Strengths:**

1. **Accurate Definition:** Clearly states that sepsis is a **life-threatening condition caused by infection**, reinforcing its urgency.
2. **Early Recognition Emphasis:** Starts with **identifying symptoms**, ensuring proper diagnostic approach.
3. **Logical Step-by-Step Approach:** Introduces **source control**, aligning with sepsis guidelines.

## **Areas for Improvement:**

1. **Incomplete Response:** The output cuts off mid-sentence. The full response should cover **medications, medical interventions**, and possibly **alternative therapies**.
2. **Limited Depth in Medical Treatments:** No mention of common hypertension medications

# Question Answering using LLM

- **Question:** What are the common symptoms for appendicitis, and can it be cured via medicine? If not, what surgical procedure should be followed to treat it?
- **Response:** Appendicitis is a medical condition characterized by **inflammation of the appendix**, a small tube-shaped organ located in the lower right side of the abdomen. The symptoms of appendicitis can vary from person to person, but some common signs and symptoms include. **Abdominal pain:** The pain is typically located in the lower right quadrant of the abdomen and may be dull at first, but it can quickly become sharp and severe. The pain may worsen with movement or pressure on the area. **Loss of appetite:** People with appendicitis may lose their
- **Observation**

## Strengths:

1. **Accurate Medical Definition:** Defines appendicitis clearly, noting its location and nature.
2. **Relevant Symptoms:** Correctly lists **abdominal pain** as a key indicator.
3. **Logical Progression:** Begins by covering symptoms before transitioning into treatment.

## Areas for Improvement:

1. **Incomplete Response:** Cuts off mid-sentence before listing additional symptoms (e.g., nausea, fever, tenderness).
2. **Lack of Treatment Discussion:** Does not answer whether **medication alone can cure appendicitis** or mention **surgical options like an appendectomy**.

# Question Answering using LLM

- **Question:** What are the effective treatments or solutions for addressing sudden patchy hair loss, commonly seen as localized bald spots on the scalp, and what could be the possible causes behind it?
- **Response:** Sudden **patchy hair loss**, also known as alopecia areata, is a **common autoimmune disorder** that affects the hair follicles. It can result in round or oval bald patches on the scalp, but it can also occur on other parts of the body such as the beard area, eyebrows, or eyelashes.

The exact cause of **alopecia areata** is not known, but it's believed to be related to a problem with the immune system. Some possible triggers for this condition include stress, genetics, viral infections, and certain medications.

- **Observation:** Correctly identifies **alopecia areata** as the medical term for sudden patchy hair loss

## Strengths:

1. **General Cause Explanation:** Mentions **immune system dysfunction** as a key contributor, which aligns with clinical understanding.
2. **Recognizable Triggers:** Includes **stress, genetics, viral infections, and medications**, which are commonly associated with alopecia areata.

**Areas for Improvement:** Incomplete Response: The output does **not address treatments**

# Question Answering using LLM

- **Question:** What treatments are recommended for a person who has sustained a physical injury to brain tissue, resulting in temporary or permanent impairment of brain function?
- **Response:** A person who has sustained a physical injury to the brain, resulting in temporary or permanent impairment of brain function, is referred to as having a traumatic brain injury (TBI). The treatment for TBI depends on the severity and location of the injury. Here are some common treatments. Emergency care: If the injury is severe, the person may require emergency care, including surgery to remove hematomas or other clots that can compress the brain. They may also need to be placed in a coma to reduce brain activity and prevent further damage. Medications: Dep

- **Observation:**

**Strengths:**

1. **Accurate Definition:** Correctly identifies **Traumatic Brain Injury (TBI)** as the medical condition associated with brain tissue damage.
2. **Structured Treatment Breakdown:** Begins with **emergency care**, explaining surgical interventions like hematoma removal.

**Areas for Improvement:**

1. **Incomplete Response:** The answer **cuts off mid-sentence** when listing **medication treatments**, leaving it unfinished

# Question Answering using LLM

- **Question:** What are the necessary precautions and treatment steps for a person who has fractured their leg during a hiking trip, and what should be considered for their care and recovery?
- **Response:** First and foremost, if you suspect that someone has fractured their leg while hiking, it's essential to ensure their safety and prevent further injury. Here are some necessary precautions. Keep the person calm and still: Encourage them to remain as still as possible to minimize pain and prevent worsening the injury. Assess the situation: Check for any signs of shock, such as pale skin, rapid heartbeat, or shallow breathing. If you notice these symptoms, seek medical help immediately. Immobilize the leg: Use a splint
- **Observation:**
  - Strengths:**
    1. **Immediate First Aid Measures:** Starts with **safety, calming the person, and assessing shock**, which are critical first steps.
    2. **Relevant Emergency Response:** Correctly emphasizes **immobilization** as a priority in fracture management.
  - Areas for Improvement:**
    1. **Lack of Long-Term Recovery Details:** Does not mention **pain management, rehabilitation, or physical therapy**, which are crucial for healing.

# Question Answering using LLM with Prompt Engineering

- **System prompt:** You are an experienced medical assistant specializing in medical diagnosis and treatment. Your primary responsibility is to provide evidence-based recommendations in response to relevant medical inquiries. Ensure all responses are accurate, aligned with established clinical guidelines, and considerate of patient safety. When offering treatment suggestions, cite appropriate medical sources, consider contraindications, and provide alternative options when necessary. Your tone should be professional, empathetic, and clear to assist both healthcare professionals and patients in making informed decisions
- **Best parameters for all the questions**
  - Max tokens: **128** - Maximum tokens return in response
  - Temperature: **0** More **deterministic** responses, where the model **always picks the most probable token**
  - Top Probability: **95** The model Consider more diverse token
  - Top K: **50** - Select the most top 50 most probable next tokens



# Question Answering using LLM with Prompt Engineering

○ **Question:** What is the protocol for managing sepsis in a critical care unit?

○ **Response:** **Sepsis is a life-threatening condition** that requires prompt recognition and intervention. In a critical care unit, the management of sepsis involves a multidisciplinary approach aimed at addressing the underlying infection, supporting organ function, and preventing complications. Here are the key steps in managing sepsis in a critical care unit. Early recognition and diagnosis: Recognize sepsis early based on clinical signs and symptoms such as **fever, tachycardia, respiratory distress**, altered mental status, and lactic acidosis. Use validated scoring systems like the Sequential Organ

## ○ **Observations**

1. **Correct Emphasis on Early Recognition:** Accurately highlights **clinical symptoms** (e.g., fever, tachycardia, respiratory distress).
2. **Multidisciplinary Approach Acknowledged:** Recognizes **infection management, organ function support, and complication prevention** as key priorities.
3. **Reference to Scoring Systems:** Introduces **Sequential Organ Failure Assessment (SOFA)**, aligning with established sepsis guidelines.

# Question Answering using LLM with Prompt Engineering

- **Question:** What are the common symptoms for appendicitis, and can it be cured via medicine? If not, what surgical procedure should be followed to treat it?
- **Response:** Appendicitis is a medical condition characterized by inflammation of the appendix, a small pouch located at the beginning of the large intestine. Common symptoms include: Abdominal pain, usually starting around the navel and then shifting to the lower right side. Loss of appetite. Nausea and vomiting. Fever.. Constipation or diarrhea. General feeling of malaise. Appendicitis cannot be cured via medicine alone as it requires surgical intervention to remove the infl
- **Observations**
  1. **Correct Symptoms Identification:** Accurately lists key symptoms such as **abdominal pain, nausea, vomiting, fever, and digestive disturbances**, aligning with clinical findings.
  2. **Accurate Explanation of Treatment Necessity:** Rightly states that **medication alone cannot cure appendicitis**, reinforcing the need for **surgical intervention**.
  3. **Logical Flow:** Organizes symptoms before addressing treatment, ensuring clarity for the reader.

# Question Answering using LLM with Prompt Engineering

- **Question:** What are the effective treatments or solutions for addressing sudden patchy hair loss, commonly seen as localized bald spots on the scalp, and what could be the possible causes behind it?
- **Response:** Sudden patchy hair loss, also known as **alopecia areata**, is an autoimmune disorder that results in the sudden loss of hair in small patches on the scalp or other areas of the body. The exact cause of alopecia areata is not fully understood, but it's believed to be related to a problem with the immune system. Effective treatments for addressing sudden patchy hair loss include. Corticosteroids: Topical or injected corticosteroids are often used to treat alopecia areata. They help reduce inflamm
- **Observations:**
  1. **Accurate Condition Identification:** Correctly recognizes **alopecia areata** as an autoimmune disorder responsible for **patchy hair loss**.
  2. **Acknowledgment of Uncertain Causes:** States that the **exact cause is not fully understood**, aligning with current medical consensus.
  3. **Introduction to Treatment Options:** Mentions **corticosteroids** as a primary intervention for managing inflammation.

# Question Answering using LLM with Prompt Engineering

- **Question:** What treatments are recommended for a person who has sustained a physical injury to brain tissue, resulting in temporary or permanent impairment of brain function?
- **Response:** According to the American Association of Neurological Surgeons (AANS), treatment for a brain injury depends on the severity and location of the injury. For mild traumatic brain injuries, also known as concussions, rest, hydration, and avoiding activities that worsen symptoms are recommended. More severe injuries may require surgical intervention to remove hematomas or repair skull fractures. Rehabilitation therapies such as physical therapy, occupational therapy, speech therapy, and cognitive rehabilitation may be necessary for individuals with impairments in motor function, communication, memory, or other
- **Observations**
  1. **Accurate Classification of Injuries:** Clearly differentiates between **mild traumatic brain injuries (TBIs, concussions)** and **severe TBIs requiring surgical intervention**.
  2. **Reference to a Trusted Source:** Cites the **American Association of Neurological Surgeons (AANS)**, enhancing credibility.
  3. **Includes Rehabilitation Strategies:** Mentions **physical, occupational, speech, and cognitive therapy**, which are crucial for long-term recovery

# Question Answering using LLM with Prompt Engineering

- **Question:** What are the necessary precautions and treatment steps for a person who has fractured their leg during a hiking trip, and what should be considered for their care and recovery?
- **Response:** According to the American Academy of **Orthopaedic Surgeons (AAOS)**, a fractured leg, also known as a femur or tibia fracture, is a common injury that occurs during hiking due to falls or accidents. The necessary precautions and treatment steps for a person with a fractured leg are as follows. Assess the severity of the injury: If you suspect a fracture, do not move the person unless it is necessary to prevent further harm or ensure their safety. Call emergency medical services immediately if there are signs of severe bleeding, unconsciousness, or in
- **Observations**
  1. **Reference to a Trusted Source:** Cites the **American Academy of Orthopaedic Surgeons (AAOS)**, reinforcing credibility.
  2. **Correctly Identifies Cause & Risk:** Recognizes **falls and accidents** as common contributors to fractures during hiking.

# Data Preparation for RAG

- **Efficient tokenization** for large text processing. **Prepares text for AI embeddings or model input** (e.g., **Retrieval-Augmented Generation**). The **parameters** below were used to create the **RAG**
- **Recursive Characters Text Splitter** → Splits text recursively by characters while preserving structure (e.g., paragraphs & sentences).
- Specifies the **token encoding** format. **c1100k\_base** which is optimized for **OpenAI models**
- Sets the **maximum size** **chunk\_size 512** for each text chunk
- Determines **how much overlap** **chunk\_overlap 16** exists between consecutive chunks
- **Sentence Embedding Model all-MiniLM-L6-v2**, transforms sentences and paragraphs into a **384-dimensional dense vector space**, **Lightweight and optimize for speed**

# Data Preparation for RAG

- **Number of Pages** → **4114** in the **Merck Manual**
- **Vector Store** is Created with Chroma, it takes the embedding model, document chunks and directory name to help organize and reference store embeddings in Chroma
- Once the vector store is defined, we use a **retriever** from the vector store to perform a similarity search type that returns only the **top 2 similarities**. The retriever query is performed in a method that returns the specific request based on the question.

# Question Answering using RAG

- **Question and Answer System Prompt Message:** You are a medical AI assistant providing expert-level insights based on trusted sources, primarily referencing the Merck Manuals. Your responses should be accurate, concise, and formatted for easy comprehension.
- **Question and Answer User Message Prompt:** Here is relevant medical information sourced from the Merck Manuals:  
{context}  
  
Based on this authoritative knowledge, please provide an answer to the following medical query:  
{question}
- **Observations:** The response generated using Retrieval-Augmented Generation (RAG) was very accurate and did directly address the question posed. The retrieved information provided relevance, that align with the intended query, resulting in an effective answer.



# Question Answering using RAG

- **Question:** What is the protocol for managing sepsis in a critical care unit?
  
- **Response:** The management of sepsis in a critical care unit involves several key steps:  
Early recognition and evaluation: Sepsis should be suspected based on clinical signs such as fever, chills, rapid heart rate, rapid breathing, confusion, or low blood pressure. Patients with suspected sepsis should undergo a thorough examination, including assessment for infection sources. Laboratory tests, such as urinalysis, urine culture, serial blood cultures, and measurement of procalcitonin and C-reactive protein levels, may be helpful in confirming the diagnosis. Supportive care: This
  
- **Observations:**
  1. Emphasizes **early detection**, which is critical for reducing mortality.
  2. Includes **key clinical signs** to look for in suspected sepsis cases.
  3. Mentions **important laboratory tests** (e.g., blood cultures, procalcitonin) to confirm the diagnosis.

# Question Answering using RAG

- **Question:** What are the common symptoms for appendicitis, and can it be cured via medicine? If not, what surgical procedure should be followed to treat it?
- **Response:** The common symptoms of appendicitis include epigastric or periumbilical pain that shifts to the right lower quadrant after a few hours. This pain increases with coughing and motion. Nausea, vomiting, and loss of appetite may also occur. Appendicitis is typically treated through surgical removal of the appendix due to the risk of necrosis, gangrene, perforation, or appendiceal abscess if left untreated. There are no known cures for appendicitis via medicine alone.
- **Observations:**
  - **Accurate Symptom Description:** The response correctly identifies the **progression of pain**, starting in the **epigastric/periumbilical region** and shifting to the **right lower quadrant**, which aligns with clinical observations.
  - **Additional Detail on Pain Characteristics:** Mentioning that the pain **worsens with coughing and motion** is a solid inclusion, as it reflects **peritoneal irritation**, a key diagnostic factor.
  - **Comprehensive Understanding of Surgical Necessity:** The explanation correctly highlights the **risks**

# Question Answering using RAG

- **Question:** What are the effective treatments or solutions for addressing sudden patchy hair loss, commonly seen as localized bald spots on the scalp, and what could be the possible causes behind it?
- **Response:** Sudden patchy hair loss, also known as alopecia areata, is characterized by round or oval bald patches on the scalp. The exact cause of this condition is unknown but it's believed to be an autoimmune disorder where the body attacks its own hair follicles. There are several treatment options for addressing alopecia areata:
  1. Topical treatments: Minoxidil (Rogaine) and corticosteroid creams or ointments can help stimulate hair growth in affected areas.
  2. Intralesional
- **Observations:**
  - **Accurate identification of condition:** The response correctly defines **sudden patchy hair loss** as **alopecia areata**, describing its **typical round or oval bald patches**.
  - **Recognition of autoimmune cause:** It correctly states that alopecia areata is believed to be **an autoimmune disorder**, where the body mistakenly attacks **its own hair follicles**.

# Question Answering using RAG

- **Question:** What treatments are recommended for a person who has sustained a physical injury to brain tissue, resulting in temporary or permanent impairment of brain function?
- **Response:** For individuals with neurologic deficits due to brain injuries, rehabilitation is essential.  
Rehabilitation involves a team approach that includes physical therapy, occupational therapy, speech therapy, skill-building activities, and counseling to address social and emotional needs. The Merck Manuals recommend early intervention by rehabilitation specialists for maximal functional recovery. Depending on the severity of the injury, cognitive and emotional areas may require prolonged periods of rehabilitation. Rehabilitation services should be planned as soon as possible.
- **Observations:**
  - **Correct emphasis on rehabilitation:** The response appropriately highlights **rehabilitation** as a critical intervention for **neurologic deficits** following a brain injury.
  - **Multidisciplinary approach:** It effectively acknowledges the **team-based nature** of treatment, including **physical therapy, occupational therapy, speech therapy, skill-building activities, and counseling**—which are key components of recovery.

# Question Answering using RAG

- **Question:** What are the necessary precautions and treatment steps for a person who has fractured their leg during a hiking trip, and what should be considered for their care and recovery?
- **Response:** A fractured leg requires prompt medical attention. The initial steps before reaching a healthcare facility include ensuring the safety of the individual and immobilizing the affected limb using a splint or sling to prevent further injury and provide comfort. Once at the hospital, definitive treatment such as reduction (alignment) of the bone may be necessary.

During recovery, it is essential to follow specific precautions:

1. Elevate the leg above heart level for the first 48 hours after suturing or immobilization to promote proper healing and reduce swelling. A sl

- **Observations:**
  - **Emphasizes immediate action:** The response correctly states the **importance of prompt medical attention** and outlines **initial safety measures**, including **immobilization with a splint or sling** to prevent further injury.
  - **Recognizes hospital treatment:** The mention of **bone reduction (alignment)** is accurate

# Question Answering using RAG Fine Tuning

- **Question and Answer System Prompt Message:** You are a medical AI assistant providing expert-level insights based on trusted sources, primarily referencing the Merck Manuals. Your responses should be accurate, concise, and formatted for easy comprehension.
- **Question and Answer User Message Prompt:** Here is relevant medical information sourced from the Merck Manuals:  
{context}  
  
Based on this authoritative knowledge, please provide an answer to the following medical query:  
{question}
- **Parameter.** On each Question the **temperature parameter was used to change** the randomness of the response from RAG. **Observation:** The **response where more accurate** changing the **temperature parameter** with more detail information listed in a sequence.

# Question Answering using RAG Fine Tuning

○ **Question:** What is the protocol for managing sepsis in a critical care unit?

○ **Response:** The management of sepsis in a critical care unit involves several key steps:

1. Early recognition and evaluation: Sepsis should be suspected based on clinical signs such as fever, chills, rapid heart rate, rapid breathing, confusion, or low blood pressure. Diagnosis is ultimately clinical, but laboratory tests including urinalysis, urine culture, serial blood cultures, and cultures of other suspect body fluids can help identify the source of infection.
2. Supportive care: This includes providing adequate nutrition, preventing infection (through strict hand hygiene practices, use of sterile equipment, and monitoring

○ **Observation: Temperature: 0.3**

**Correct emphasis on early recognition:** The response appropriately highlights the **key clinical signs** of sepsis, including **fever, chills, tachycardia, tachypnea, confusion, and hypotension**, which align with clinical diagnostic criteria.

**Acknowledgment of diagnostic testing:** It correctly mentions **urinalysis, urine culture, and blood cultures** as tools for **identifying the source of infection**, reinforcing standard clinical practice.

# Question Answering using RAG Fine Tuning

- **Question:** What are the common symptoms for appendicitis, and can it be cured via medicine? If not, what surgical procedure should be followed to treat it?
- **Response:** The classic symptoms of appendicitis include epigastric or periumbilical pain followed by brief nausea, vomiting, anorexia; after a few hours, the pain shifts to the right lower quadrant. The pain increases with cough and motion. Right lower quadrant direct and rebound tenderness are common signs. Acute appendicitis is the most common cause of acute abdominal pain requiring surgery in the US, affecting over 5% of the population at some point, primarily in the teens and 20s.

Appendicitis cannot

- **Observation: Temperature: 0.7**

**Accurate symptom description:** The response correctly highlights **epigastric or periumbilical pain** that shifts to the **right lower quadrant** over time, which is a hallmark of appendicitis.

**Additional pain characteristics:** Including **increased pain with coughing and motion** is important, as it suggests **peritoneal irritation**, a key diagnostic factor.

**Clinical signs:** The mention of **right lower quadrant direct and rebound tenderness** aligns with **physical exam findings** for appendicitis.



# Question Answering using RAG Fine Tuning

- **Question:** What are the effective treatments or solutions for addressing sudden patchy hair loss, commonly seen as localized bald spots on the scalp, and what could be the possible causes behind it?
- **Response:** Sudden patchy hair loss, also known as alopecia areata, is characterized by round or oval bald patches that may appear anywhere on the body but most commonly affect the scalp and beard. Alopecia areata is an autoimmune disorder where the immune system mistakenly attacks hair follicles, leading to hair loss.

Effective treatments for alopecia areata include:

1. Topical treatments: Minoxidil (Rogaine) can stimulate hair growth and slow down hair loss in some cases. Other topical treatments like

- **Observation: Temperature: 0.5**

**Accurate definition of alopecia areata:** The response correctly describes **round or oval bald patches**, most commonly affecting the **scalp and beard**, which aligns with clinical presentations. **Clear identification of autoimmune cause**

# Question Answering using RAG Fine Tuning

- **Question:** What treatments are recommended for a person who has sustained a physical injury to brain tissue, resulting in temporary or permanent impairment of brain function?
- **Response:** For individuals with traumatic brain injuries (TBIs) and persistent neurologic deficits, rehabilitation is essential. Rehabilitation typically involves a team approach that includes physical therapy, occupational therapy, speech therapy, skill-building activities, and counseling to address social and emotional needs. The goal of rehabilitation is to maximize functional recovery and improve quality of life. Early intervention by rehabilitation specialists is crucial for optimal outcomes, particularly in cognitive and emotional areas where a prolonged period of treatment may be required. Brain injury support groups can also provide assistance to the families
- **Observation: Temperature: 0.6**  
**Emphasizes Rehabilitation:** The response correctly identifies **rehabilitation as a key component** in managing traumatic brain injuries (TBIs) with **neurologic deficits**.

# Question Answering using RAG Fine Tuning

- **Question:** What are the necessary precautions and treatment steps for a person who has fractured their leg during a hiking trip, and what should be considered for their care and recovery?
- **Response:** A fractured leg requires immediate attention. The first priority is to ensure the person's safety and prevent any further injury. If there are signs of an open or compound fracture (bone protruding through the skin), do not move them unless it is necessary for their safety. Call emergency medical services if available, or have someone transport them to a hospital as soon as possible.

Once at the hospital, the healthcare team will assess the extent and location of the fracture and provide appropriate treatment. Depending on the severity of the fracture, this may include: splinting or setting

- **Observation: Temperature: 0.5**
  - **Immediate attention to safety:** The response correctly prioritizes **ensuring the person's safety**, which is crucial in emergency scenarios. **Recognizes open/compound fractures:** It appropriately highlights the need to **avoid movement unless absolutely necessary**, preventing further injury or complications.

# Output Evaluation Groundness Rater System Message

- O Groundness Rater System Message:** You will be presented a **Question**, **Context** used by the AI system and AI generated **Answer**.

**Your task is to judge the extent to which the Answer is derived from Context.**

**Rate it 1** - if The **Answer** is not derived from the **Context** at all

**Rate it 2** - if The **Answer** is derived from the **Context** only to a limited extent

**Rate it 3** - if The **Answer** is derived from **Context** to a good extent

**Rate it 4** - if The **Answer** is derived from **Context** mostly

**Rate it 5** - if The **Answer** is is derived from **Context** completely

**Please note:** Make sure you give a single overall rating in the **range of 1 to 5** along with an overall explanation.

# Output Evaluation Relevance Rater System Message

- O Relevance Rater System Message:** You will be presented with a **Question**, the **Context** used by the AI system to generate a response, and the **AI-generated Answer**.

**Your task is to judge** the extent to which the **Answer** is relevant to the **Question**, considering whether it directly addresses the key aspects of the **Question** based on the provided **Context**.

Rate the relevance as follows:

**Rate 1** – The **Answer** is not relevant to the **Question** at all.

**Rate 2** – The **Answer** is only slightly relevant to the **Question**, missing key aspects.

**Rate 3** – The **Answer** is moderately relevant, addressing some parts of the **Question** but leaving out important details.

**Rate 4** – The **Answer** is mostly relevant, covering key aspects but with minor gaps.

**Rate 5** – The **Answer** is fully relevant, directly answering all important aspects of the **Question** with appropriate details from the **Context**.

Note: Provide a single overall rating in the range of 1 to 5, along with a brief explanation of why you assigned that **score**.

# Output Evaluation

- **Groundness Rater System Message:** Assess the factual accuracy and reliability of the response. Ensure claims are well-supported by trusted sources, align with established knowledge, and avoid misinformation or speculation.
- **Relevance Rater System Message:** Assess whether the response directly addresses the given prompt. Ensure the information is contextually appropriate, focused on the inquiry, and avoids unnecessary details or tangents
- **Default Parameters**
  - Max Tokens: 128** - Maximum number of tokens the model should generate
  - Temperature: 0** - Control the randomness of generated response
  - Top p : 0.95** - Control the diversity of generated response
  - Top k: 50** - Control the maximum number of most likely tokens to considered when generating token

# Output Evaluation Managing Sepsis

- **Question:** What is the protocol for managing sepsis in a critical care unit?
- **Relevance Score Rating: 5** - The Answer is derived from the Context completely.
- **Explanation:** The Context provides detailed information about the management of critically ill patients in an ICU setting, including the general approach to managing shock and sepsis. The Answer summarizes these steps accurately and specifically mentions the protocol for managing sepsis as outlined in the Merck Manuals, which is referenced in the Context.

# Output Evaluation Managing Sepsis

- **Brief Explanation on Score Rating :** The provided answer directly addresses all important aspects of the question regarding the protocol for managing sepsis in a critical care unit. It covers first aid measures, initial assessment, fluid resuscitation, airway and ventilation management, intravenous access, and medications and monitoring. The information is derived from the context, specifically the section on "Prognosis and Treatment" of sepsis.
- .
- **Observation:** The Judgement from the LLM is accurate and describes the protocol to manage sepsis



# Output Evaluation for Appendicitis

- **Question:** What are the common symptoms for appendicitis, and can it be cured via medicine? If not, what surgical procedure should be followed to treat it?
- **Relevance Score Rating: 5**
- **Explanation:** The AI generated answer is completely derived from the context. The context provides detailed information about the symptoms, signs, diagnosis, etiology, and treatment of appendicitis. The AI answer accurately summarizes this information and includes all the key points mentioned in the context. Additionally, the AI answer also mentions that the standard treatment for appendicitis is surgical removal, which is explicitly stated in the context. Therefore, the AI generated answer is a comprehensive and accurate reflection of the information provided in the context

# Output Evaluation for Appendicitis

- **Brief Explanation on Score Rating:** The AI-generated answer directly addresses all important aspects of the question by providing a detailed explanation of the common symptoms of appendicitis and stating that it cannot be cured via medicine alone, but requires surgical removal (appendectomy). The answer also mentions the standard treatment procedure for appendicitis and the potential complications if diagnosis is delayed. **Therefore, the relevance score is 5**
- **Observation:** The LLM judgement on appendicitis was very accurate with the context and the relevance rating score is indicated correctly

# Output Evaluation Sudden Patchy Hair Loss

- **Question:** What are the effective treatments or solutions for addressing **sudden patchy hair loss**, commonly seen as localized bald spots on the scalp, and what could be the possible causes behind it?
- **Relevance Score Rating: 5**
- **Explanation:** The context provides detailed information about various types of alopecia, including alopecia areata, which is described as a sudden patchy hair loss disorder. The text also mentions that alopecia areata is an autoimmune disorder and discusses possible treatments for this condition, such as corticosteroids, minoxidil, and DPCP. The Answer summarizes these points and provides additional details about the effectiveness of each treatment option.

# Output Evaluation Sudden Patchy Hair Loss

- **Brief Explanation on Score Rating:** The AI-generated answer directly addresses both parts of the question. It explains that sudden patchy hair loss, also known as alopecia areata, is a common autoimmune disorder causing hair loss from the scalp or other areas of the body. Additionally, it provides a list of effective treatments for addressing this condition, including topical and injected corticosteroids, minoxidil, DPCP, systemic corticosteroids, and JAK inhibitors. The answer also briefly touches upon the possible cause of alopecia areata being an autoimmune response where the immune system attacks the hair follicles, which aligns with the context provided
- **Observation:** The explanation and brief explanation provided detail information on patch hair loss and the reason for a relevance score of 5. The explanation provided a list on effective treatment plans for patchy hair loss while the brief explanation provides concrete information on the cause alopecia areata.

# Output Evaluation Physical Injury to Brain Tissue

- **Question:** What treatments are recommended for a person who has sustained a physical injury to brain tissue, resulting in temporary or permanent impairment of brain function?
- **Relevance Score Rating: 5**
- **Explanation:** The Context provides detailed information about the treatments and prognosis for a person with a brain injury, including supportive care measures to prevent complications and the importance of early rehabilitation planning. The Answer accurately summarizes this information and adds that consulting healthcare professionals is necessary for personalized medical advice and treatment options.

# Output Evaluation Physical Injury to Brain Tissue

- **Brief Explanation on Score Rating:** The AI-generated answer directly addresses the key aspects of the question by summarizing the recommended treatments for brain injury patients from the provided context, which includes supportive care measures to prevent complications and ensure proper nutrition and pressure ulcer prevention. It also acknowledges that there is no specific treatment to restore brain function but emphasizes the importance of early rehabilitation planning. The answer also provides some insight into the varying prognosis for brain injury patients based on the severity of their injuries, making it a fully relevant response to the question
- **Observation:** The relevance score of 5 indicates that the LLM correctly judge the response that is related to the question. The explanation provide detail information on the treatment of brain tissue damage while stressing the importance of preventative care

# Output Evaluation Fractured Leg

- **Question:** What are the necessary precautions and treatment steps for a person who has fractured their leg during a hiking trip, and what should be considered for their care and recovery?
- **Relevance Score Rating: 5**
- **Explanation:** I would rate the answer a 5. The context provided in the Merck Manuals was extensive and covered various aspects of treating injuries, including fractures. The answer accurately summarized the recommended precautions and treatment steps for someone who has fractured their leg during hiking, which were directly derived from the context. The answer also referenced specific information from the context, such as the use of splinting, pain management with opioids, and rehabilitation exercises.

# Output Evaluation Fractured Leg

- **Brief Explanation on Score Rating:** The AI-generated answer directly addresses all important aspects of the question based on the provided context. It covers the necessary precautions and treatment steps for a person who has fractured their leg during a hiking trip, including assessing the severity of the injury, immobilizing the injured leg, treating pain, resting and elevating the injured leg, applying ice and compression, and considering rehabilitation. The answer also provides specific recommendations based on the context, such as using a splint with a nonrigid or noncircumferential device and seeking definitive treatment depending on the type and severity of the fracture.
- **Observations:** The LLM judged the context correctly. In the brief explanation on why the **relevance score rating was a 5**. It clearly state the precautions and treatment steps for a person who has a fractured leg. The explanation also provides the specific recommendation such as using a splint that is non rigid or non circumferential. The LLM judging the response made the correct decision.



# Data Background and Contents

- The **Merck Manuals** are medical references published by the American pharmaceutical company Merck & Co., that cover a wide range of medical topics, including disorders, tests, diagnoses, and drugs. The manuals have been published since 1899, when Merck & Co. was still a subsidiary of the German company Merck. The manual has over **4,000 pages** **divided** into **23 sections**

# Data Background and Contents

Nutritional Disorders	Ear, Nose, and Throat Disorders	Infectious Diseases
Gastrointestinal Disorders	Dental Disorders	Psychiatric Disorders
Hepatic and Biliary Disorders	Eye Disorders	Neurologic Disorders
Musculoskeletal and Connective	Dermatologic Disorders	Genitourinary Disorders
Pulmonary Disorders	Hematology and Oncology	Gynecology and Obstetrics
Critical Care Medicine	Endocrine and Metabolic Disorders	Pediatrics
Cardiovascular Disorders	Immunology & Allergic Disorders	Geriatrics
Clinical Pharmacology	Injuries & Poisoning	<b>Special Subjects</b>



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