CAPSTONE DESIGN EXPO | Computer Science | CS 25-334

Synthetic Medical Notes: Bridging the Gap in Healthcare Data

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Background

Advancements in technology have introduced the possibility of medical analysis of patient data, however, extracting discrete data values from real clinical notes is a time-consuming process prone to errors and data leaks. Our project addresses this challenge by creating a tool that generates synthetic medical notes – realistic but entirely artificial patient records.

These synthetic notes mimic the structure and content of real medical documents, particularly focusing on radiation oncology consults for prostate cancer patients. By providing a source of "fake" but medically accurate data, our tool enables:

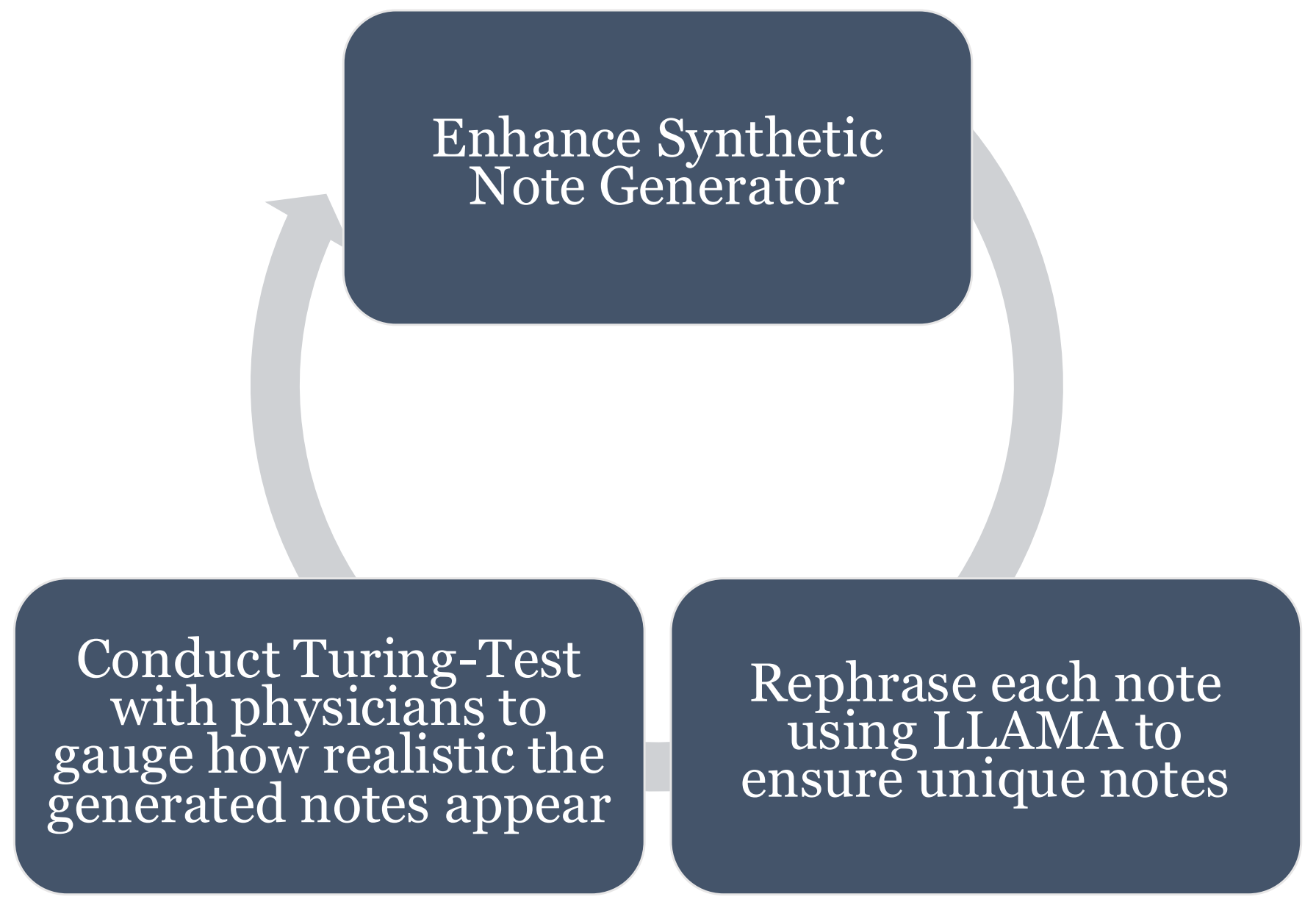
- Training of medical professionals without risking patient privacy
- Development and testing of healthcare software systems
- Medical research studies that require large datasets

Our innovative approach combines large language models with carefully crafted templates to produce notes that are indistinguishable from real ones yet contain no actual patient information. This project aims to accelerate medical research and improve healthcare practices while maintaining the highest standards of patient confidentiality.

Objective

Our primary objective is to work with the pre-existing Synthetic Note Generator code to create a functional web-tool capable of generating realistic notes. Our note-generator will be able to rephrase sections of text and offer a wider variety of generated notes by utilizing *Meta's Llama 3-7b* chatbot. After achieving consistently realistic and varied notes, our team has completed a clinical Turing-test to gauge how comparable our generated notes are to physician notes.

By enhancing the generated notes to be as believable and realistic as possible, we were able to later fine-tune a Large Language Model (LLM) to extract data from generated clinical notes on a large scale while not compromising fake patient data.



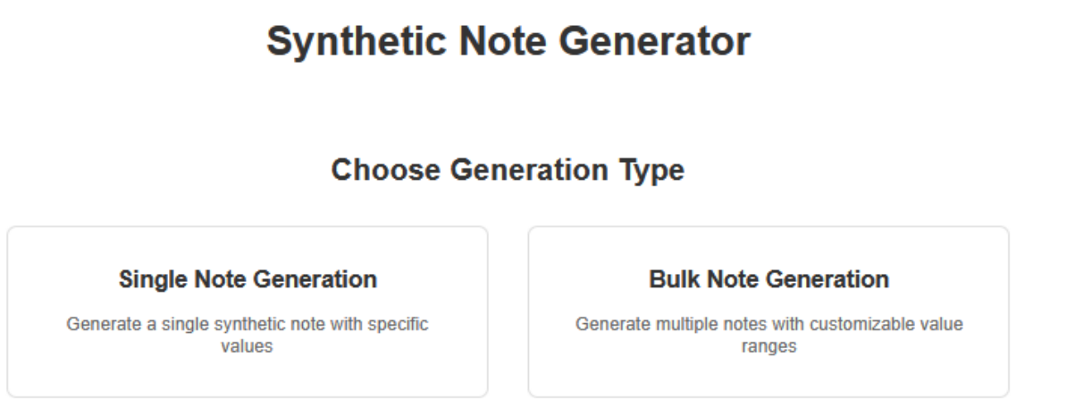
Enhance Synthetic Note Generator

Rephrase each note using LLAMA to ensure unique notes

Conduct Turing-Test with physicians to gauge how realistic the generated notes appear

Note Generator & Web Tool

- **Web tool**: Developed and refined the web-based interface, ensuring usability and easy data entry for users.
  - ○ Landing Page
  - ○ Single Note Generation
  - ○ Bulk Note Generation
    - ▪ Export functionality, LLM Rephrasing, Note Display, and Section inclusion/exclusion.
- **Note Types**: Implemented four new note types, incorporated internal feedback, and ensured seamless functionality throughout the app.
  - ○ Initial Consultation, Follow Up, On-Treatment Visit, & Treatment Summary

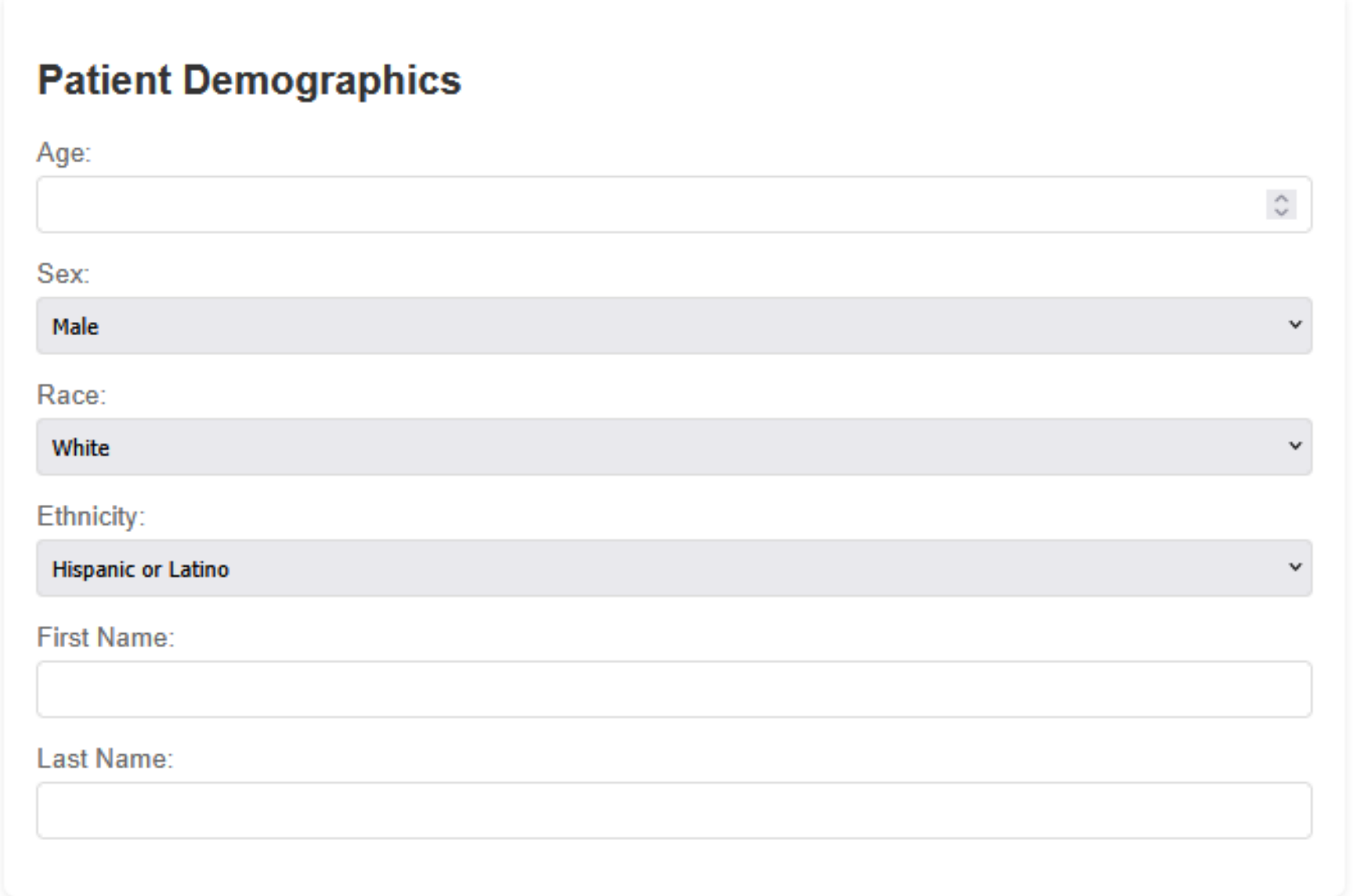


Synthetic Note Generator

Choose Generation Type

Single Note Generation
Generate a single synthetic note with specific values
Bulk Note Generation
Generate multiple notes with customizable value ranges

Landing Page with Single or Bulk note Generation



Patient Demographics

Age:

Sex: Male

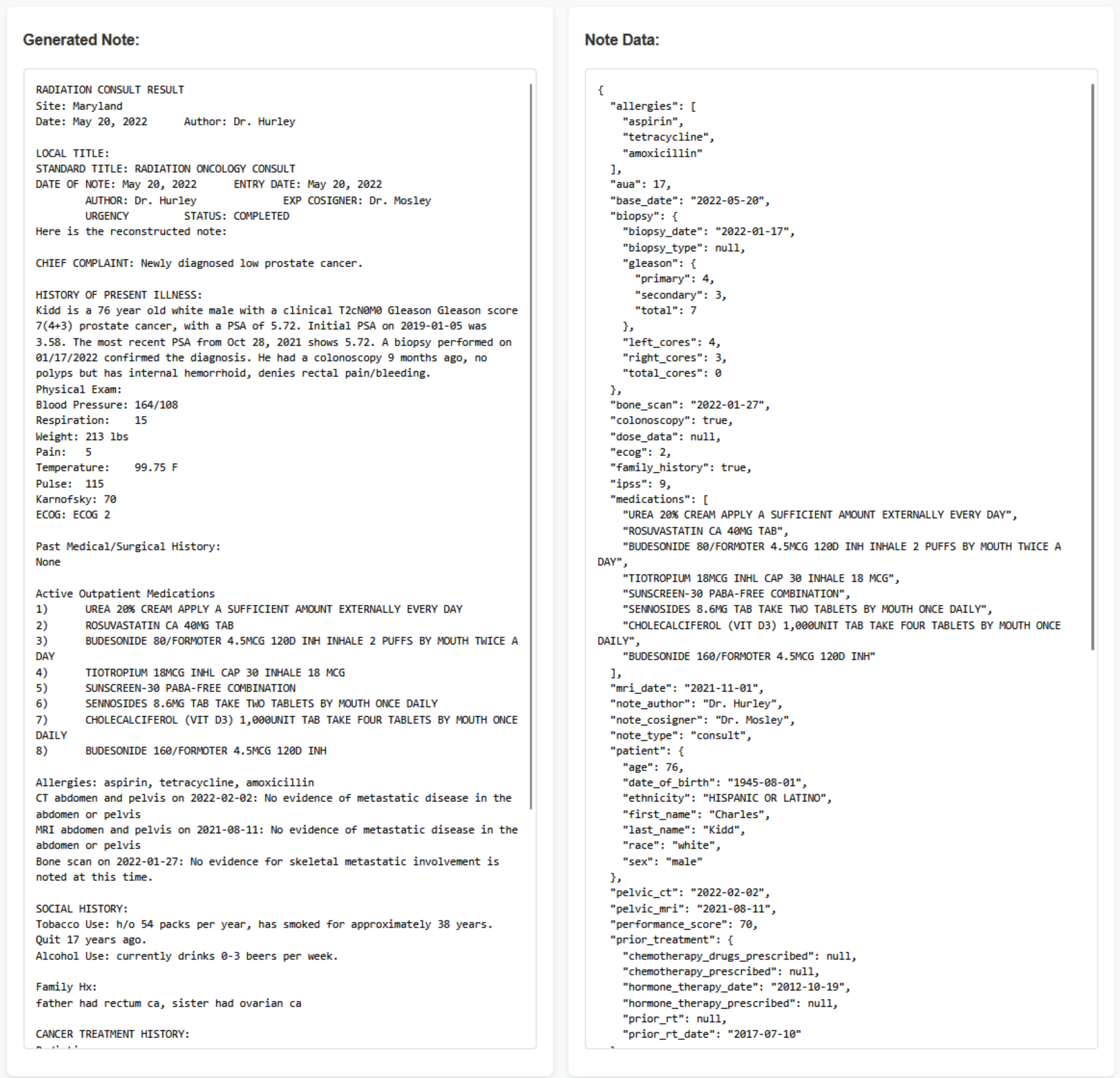
Race: White

Ethnicity: Hispanic or Latino

First Name:

Last Name:

Sample fields on Web Tool. Allows user to input specific values to be in the note.



Generated Note:

```
RADIATION CONSULT RESULT
Site: Maryland
Date: May 20, 2022      Author: Dr. Hurley

LOCAL TITLE:
STANDARD TITLE: RADIATION ONCOLOGY CONSULT
DATE OF NOTE: May 20, 2022      ENTRY DATE: May 20, 2022
        AUTHOR: Dr. Hurley              EXP COSIGNER: Dr. Mosley
        URGENCY         STATUS: COMPLETED
Here is the reconstructed note:

CHIEF COMPLAINT: Newly diagnosed low prostate cancer.

HISTORY OF PRESENT ILLNESS:
Kidd is a 76 year old white male with a clinical T2cN0M0 Gleason Gleason score
7(4+3) prostate cancer, with a PSA of 5.72. Initial PSA on 2019-01-05 was
3.58. The most recent PSA from Oct 28, 2021 shows 5.72. A biopsy performed on
01/17/2022 confirmed the diagnosis. He had a colonoscopy 9 months ago, no
polyps but has internal hemorrhoid, denies rectal pain/bleeding.
Physical Exam:
Blood Pressure: 164/108
Respiration:    15
Weight: 213 lbs
Pain:   5
Temperature:    99.75 F
Pulse:  115
Karnofsky: 70
ECOG: ECOG 2

Past Medical/Surgical History:
None

Active Outpatient Medications
1)      UREA 20% CREAM APPLY A SUFFICIENT AMOUNT EXTERNALLY EVERY DAY
2)      ROSUVASTATIN CA 40MG TAB
3)      BUDESONIDE 80/FORMOTER 4.5MCG 120D INH INHALE 2 PUFFS BY MOUTH TWICE A
DAY
4)      TIOTROPIUM 18MCG INHL CAP 30 INHALE 18 MCG
5)      SUNSCREEN-30 PABA-FREE COMBINATION
6)      SENNOSIDES 8.6MG TAB TAKE TWO TABLETS BY MOUTH ONCE DAILY
7)      CHOLECALCIFEROL (VIT D3) 1,000UNIT TAB TAKE FOUR TABLETS BY MOUTH ONCE
DAILY
8)      BUDESONIDE 160/FORMOTER 4.5MCG 120D INH

Allergies: aspirin, tetracycline, amoxicillin
CT abdomen and pelvis on 2022-02-02: No evidence of metastatic disease in the
abdomen or pelvis
MRI abdomen and pelvis on 2021-08-11: No evidence of metastatic disease in the
abdomen or pelvis
Bone scan on 2022-01-27: No evidence for skeletal metastatic involvement is
noted at this time.

SOCIAL HISTORY:
Tobacco Use: h/o 54 packs per year, has smoked for approximately 38 years.
Quit 17 years ago.
Alcohol Use: currently drinks 0-3 beers per week.

Family Hx:
father had rectum ca, sister had ovarian ca

CANCER TREATMENT HISTORY:
```

Note Data:

```
{
  "allergies": [
    "aspirin",
    "tetracycline",
    "amoxicillin"
  ],
  "aua": 17,
  "base_date": "2022-05-20",
  "biopsy": {
    "biopsy_date": "2022-01-17",
    "biopsy_type": null,
    "gleason": {
      "primary": 4,
      "secondary": 3,
      "total": 7
    },
    "left_cores": 4,
    "right_cores": 3,
    "total_cores": 0
  },
  "bone_scan": "2022-01-27",
  "colonoscopy": true,
  "dose_data": null,
  "ecog": 2,
  "family_history": true,
  "ipss": 9,
  "medications": [
    "UREA 20% CREAM APPLY A SUFFICIENT AMOUNT EXTERNALLY EVERY DAY",
    "ROSUVASTATIN CA 40MG TAB",
    "BUDESONIDE 80/FORMOTER 4.5MCG 120D INH INHALE 2 PUFFS BY MOUTH TWICE A
DAY",
    "TIOTROPIUM 18MCG INHL CAP 30 INHALE 18 MCG",
    "SUNSCREEN-30 PABA-FREE COMBINATION",
    "SENNOSIDES 8.6MG TAB TAKE TWO TABLETS BY MOUTH ONCE DAILY",
    "CHOLECALCIFEROL (VIT D3) 1,000UNIT TAB TAKE FOUR TABLETS BY MOUTH ONCE
DAILY",
    "BUDESONIDE 160/FORMOTER 4.5MCG 120D INH"
  ],
  "mri_date": "2021-11-01",
  "note_author": "Dr. Hurley",
  "note_cosigner": "Dr. Mosley",
  "note_type": "consult",
  "patient": {
    "age": 76,
    "date_of_birth": "1945-08-01",
    "ethnicity": "HISPANIC OR LATINO",
    "first_name": "Charles",
    "last_name": "Kidd",
    "race": "white",
    "sex": "male"
  },
  "pelvic_ct": "2022-02-02",
  "pelvic_mri": "2021-08-11",
  "performance_score": 70,
  "prior_treatment": {
    "chemotherapy_drugs_prescribed": null,
    "chemotherapy_prescribed": null,
    "hormone_therapy_date": "2012-10-19",
    "hormone_therapy_prescribed": null,
    "prior_rt": null,
    "prior_rt_date": "2017-07-10"
```

LLM Rephrasing

- **LLM integration**: Focused on smooth integration with *Groq* API, creating a mapping system, and implementing validation tests to ensure that original note variables haven't been altered. This validation system promises that *Llama* keeps original "patient" information while increasing note variability.

Original Text:
Mr. {11} is a {1} year old {13} {2} with {18} risk prostate cancer, stage {17}. Initial PSA was {28} on {19}, most recently {3} on {14}. Biopsy on {16} showed Gleason {5}. {10}

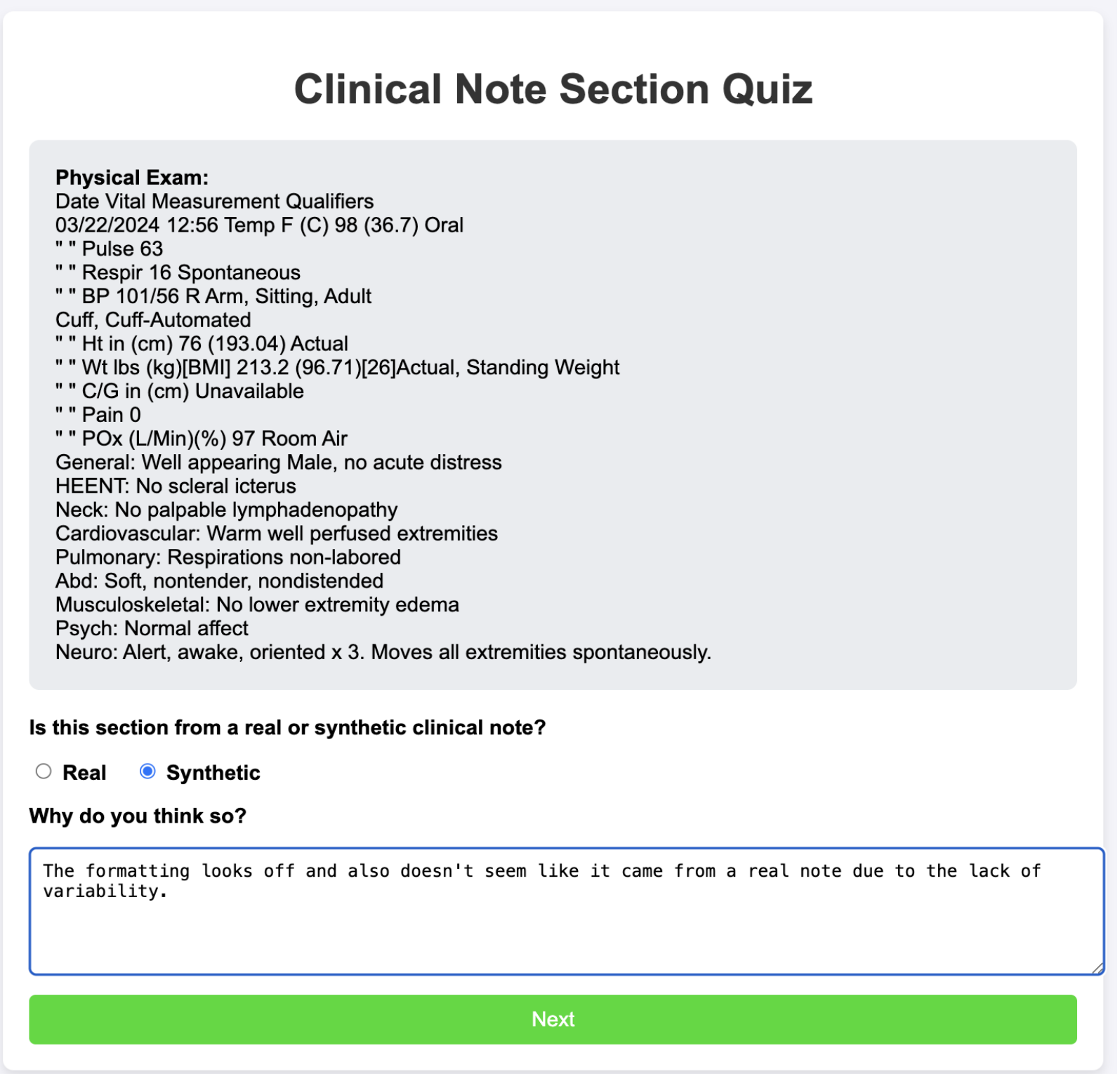
AI Rephrased Text:
Patient {11} is a {1} year old {13} {2} with high-risk prostate cancer, stage {17}.

Initial PSA: {28} on {19}.
Latest PSA: {3} on {14}.
Biopsy on {16} revealed Gleason {5}.
{10}

Turing Test

Turing Test: Implemented updates and testing cycles to enhance the tool's ability to pass a clinical Turing Test by generating realistic and coherent notes.

Test Screen with user selection and reason text box



Clinical Note Section Quiz

Physical Exam:
Date Vital Measurement Qualifiers
03/22/2024 12:56 Temp F (C) 98 (36.7) Oral
" " Pulse 63
" " Respir 16 Spontaneous
" " BP 101/56 R Arm, Sitting, Adult
Cuff, Cuff-Automated
" " Ht in (cm) 76 (193.04) Actual
" " Wt lbs (kg)[BMI] 213.2 (96.71)[26]Actual, Standing Weight
" " C/G in (cm) Unavailable
" " Pain 0
" " POx (L/Min)(%) 97 Room Air
General: Well appearing Male, no acute distress
HEENT: No scleral icterus
Neck: No palpable lymphadenopathy
Cardiovascular: Warm well perfused extremities
Pulmonary: Respirations non-labored
Abd: Soft, nontender, nondistended
Musculoskeletal: No lower extremity edema
Psych: Normal affect
Neuro: Alert, awake, oriented x 3. Moves all extremities spontaneously.

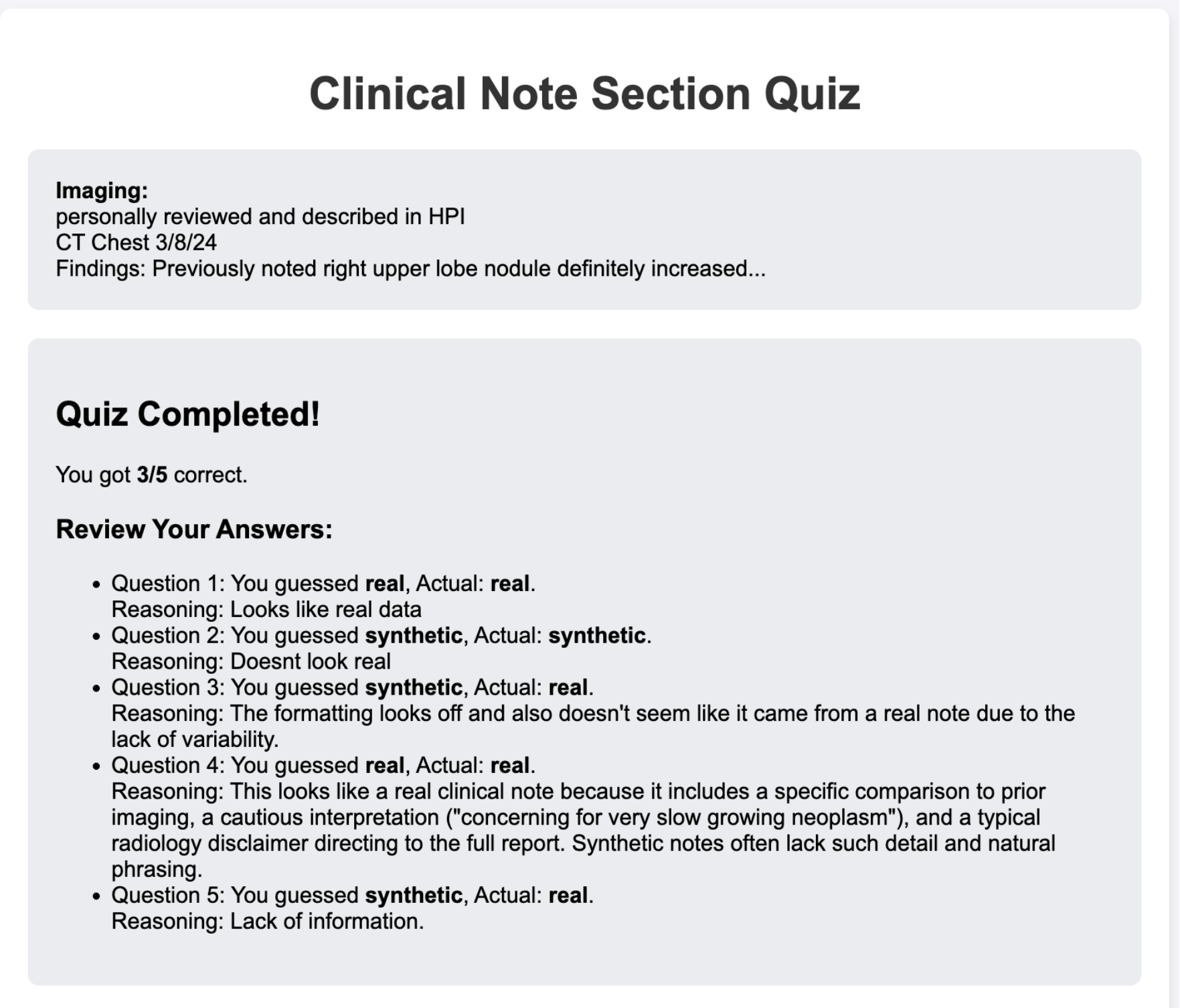
Is this section from a real or synthetic clinical note?

○ **Real** ● **Synthetic**

Why do you think so?

The formatting looks off and also doesn't seem like it came from a real note due to the lack of variability.

User sees the results of their quiz at the end



Clinical Note Section Quiz

Imaging:
personally reviewed and described in HPI
CT Chest 3/8/24
Findings: Previously noted right upper lobe nodule definitely increased...

Quiz Completed!

You got **3/5** correct.

Review Your Answers:

- Question 1: You guessed **real**, Actual: **real**.
  Reasoning: Looks like real data
- Question 2: You guessed **synthetic**, Actual: **synthetic**.
  Reasoning: Doesnt look real
- Question 3: You guessed **synthetic**, Actual: **real**.
  Reasoning: The formatting looks off and also doesn't seem like it came from a real note due to the lack of variability.
- Question 4: You guessed **real**, Actual: **real**.
  Reasoning: This looks like a real clinical note because it includes a specific comparison to prior imaging, a cautious interpretation ("concerning for very slow growing neoplasm"), and a typical radiology disclaimer directing to the full report. Synthetic notes often lack such detail and natural phrasing.
- Question 5: You guessed **synthetic**, Actual: **real**.
  Reasoning: Lack of information.

Future Direction

In the future our team plans to share our code with physicians, request them to return Turing Test surveys, and analyze the results. Gaining direct feedback from physicians will allow us to reach our goal of creating clinical notes that are accurate, contextually relevant, and indistinguishable from both AI-generated and physician-authored notes. Additionally, our project will focus on expanding the synthetic note generator to support a broader range of cancer types, allowing for more comprehensive use across medical scenarios.

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