



EpiGPT: Prompting LLMs for Epidemiology





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Introduction

Large Language Models (LLMs):

A language model notable for its ability to achieve general-purpose language understanding and generation.

Prompting:

A prompt is the starting question that is asked to a large language model

Why is it important?

Focus on zero-shot output, without any training.



Introduction

Large Language Models have been shown to work excellently for many time-series tasks:

- Forecasting
- Summarization

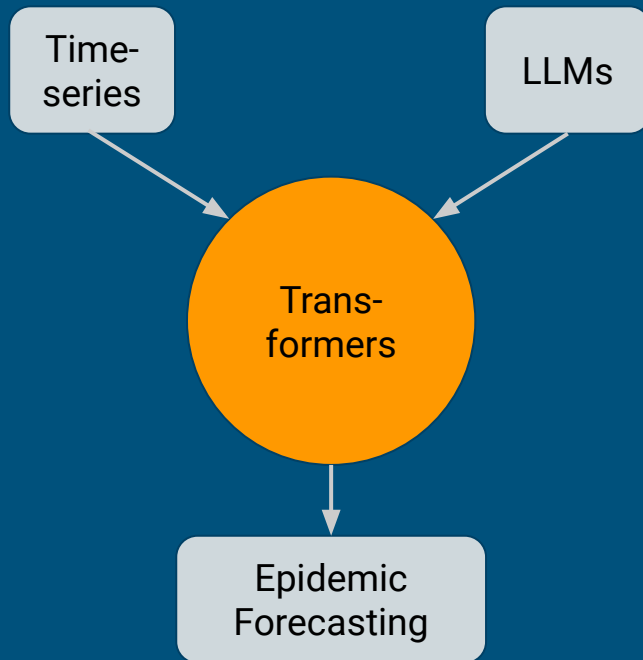
This project aims to extend these capabilities towards epidemiology.



Introduction

Intuition

- Time-series is well-analyzed using sequence models like RNNs and transformers.
- Transformers provide state-of-the-art results on forecasting.
- LLMs use transformers very effectively.



Introduction

Intuition

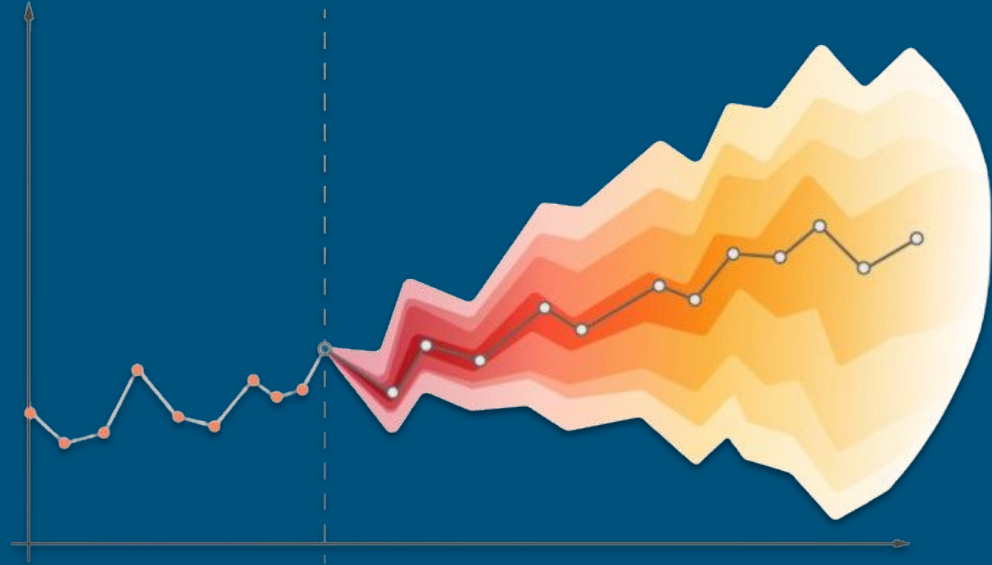
- Time-series is well-analyzed using sequence models like RNNs and transformers.
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- LLMs use transformers very effectively.

Related works

- LLMTIME ([NeurIPS '23](#)):
First work towards forecasting using LLMs.
- LLM4TS ([preprint](#)):
Incorporates time series patching and binning.
- TIMELLM ([preprint](#)):
Evaluates more prompt engineering.

Epidemic Forecasting

- Predicting the next few time steps of data with a focus on epidemiology.
- Helps predict outbreak of a disease, or effect of various intervention policies.
- Here, we focus on zero-shot forecasting using LLMs.



Epidemic Forecasting - Datasets

1) CDC-Flu

2) CDC-Covid

3) Google Symptom's Search

4) Monash-Covid

5) Monash-Hospitalization

Training points: 51

Average length of series: 167

Size on disk: 72 KB

Epidemic Forecasting - Datasets

- 1) CDC-Flu
- 2) CDC-Covid
- 3) **Google Symptom's Search**
- 4) Monash-Covid
- 5) Monash-Hospitalization

Length of dataset: 780

Average length of series: 221

Size on disk: 1.5 MB

Epidemic Forecasting - Datasets

- 1) CDC-Flu
- 2) CDC-Covid
- 3) Google Symptom's Search
- 4) **Monash-Covid**
- 5) Monash-Hospitalization

Length of dataset: 266

Average length of series: 212

Size on disk: 458 KB

Epidemic Forecasting - Datasets

- 1) CDC-Flu
- 2) CDC-Covid
- 3) Google Symptom's Search
- 4) Monash-Covid
- 5) **Monash-Hospitalization**

Length of dataset: 767

Average length of series: 84

Size on disk: 553 KB

Epidemic Forecasting – Types

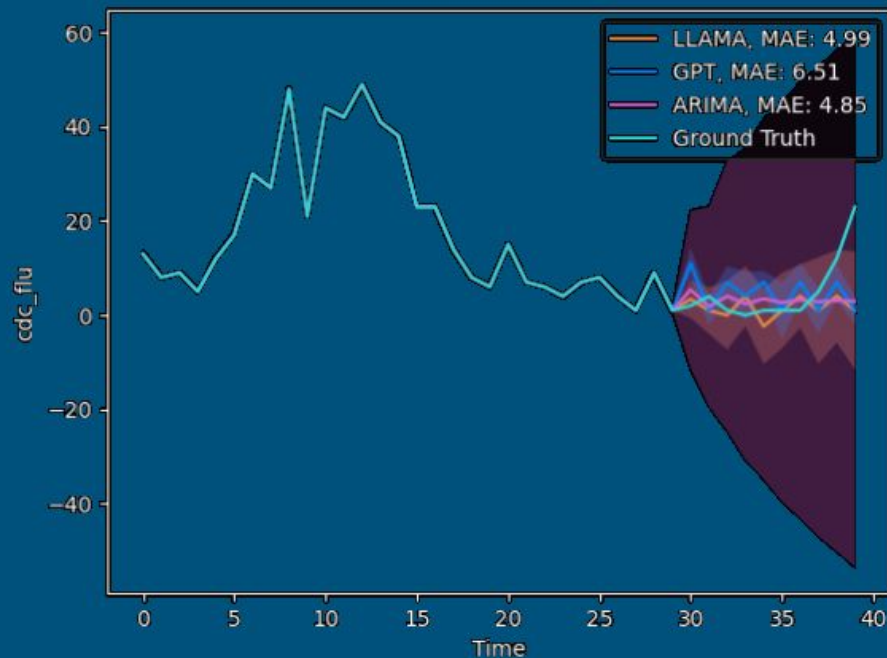
- TYPE A: We prompt the LLM with instructions for generic forecasting.

“You are a helpful assistant that performs time series predictions. The user will provide a sequence and you will predict the remaining sequence. The sequence is represented by decimal strings separated by commas. Please continue the following sequence without producing any additional text. Do not say anything like ‘the next terms in the sequence are’, just return the numbers.”

Epidemic Forecasting – Types

- TYPE A: We prompt the LLM with instructions for generic forecasting.

Dataset	LLAMA	GPT4ALL	ARIMA
CDC-Flu	8.32	9.23	7.96
CDC-Covid	22.15	19.76	25.89
Symptoms search	0.28	0.49	0.32
Monash-Covid	2.22	1.61	1.09
Monash-Hospitalization	7.89	8.46	6.73



Epidemic Forecasting – Types

- TYPE A: We prompt the LLM with instructions for generic forecasting.
- TYPE B: We prompt the LLM with some generic context.

“The user is trying to predict the number of flu cases in the US.”

Epidemic Forecasting – Types

- TYPE A: We prompt the LLM with instructions for generic forecasting.
- TYPE B: We prompt the LLM with some generic context.
- TYPE C: We prompt the LLM with specific context.

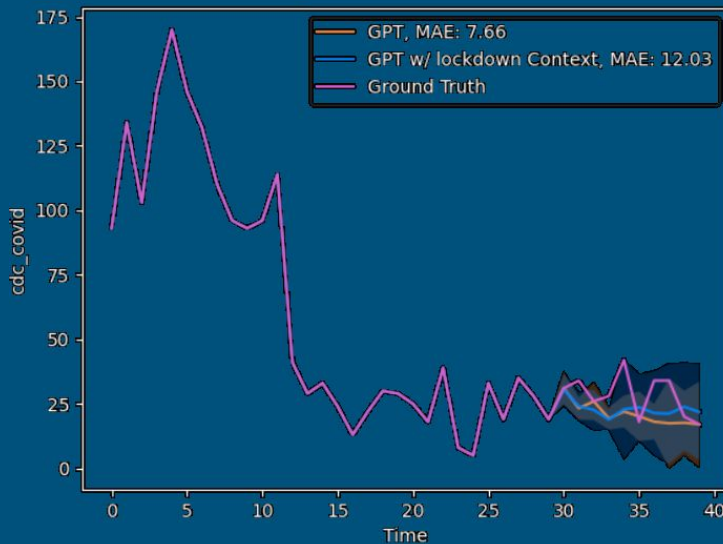
“The user is trying to predict the number of flu cases in the US. It usually rises every year in the winter and falls in the summer. It had one wave in the past year.”

Dataset	GPT4ALL	w/ context	more context
CDC-Flu	9.23	8.92	8.65
CDC-Covid	19.76	18.73	26.31
Symptoms search	0.49	0.46	0.48
Monash-Covid	1.61	2.36	2.39
Monash-Hospitalization	8.46	7.72	8.41

Epidemic Forecasting – Types

- TYPE A: We prompt the LLM with instructions for generic forecasting.
- TYPE B: We prompt the LLM with some generic context.
- TYPE C: We prompt the LLM with specific context.
- TYPE D: We prompt the LLM about a hypothetical situation (counterfactual prediction)

“The user is trying to predict the number of covid cases in the US if a lockdown was declared starting now.”



Epidemic Forecasting - Discussion

Conclusion

- The zero-shot performance of LLM forecasting is really impressive.
- Adding context helps, but there needs to be a balance in the amount of context. Overwhelming the LLM does more harm than good.
- LLMs do not seem like a good fit for counterfactual predictions. Other methods, like ABMs, might be more suitable.

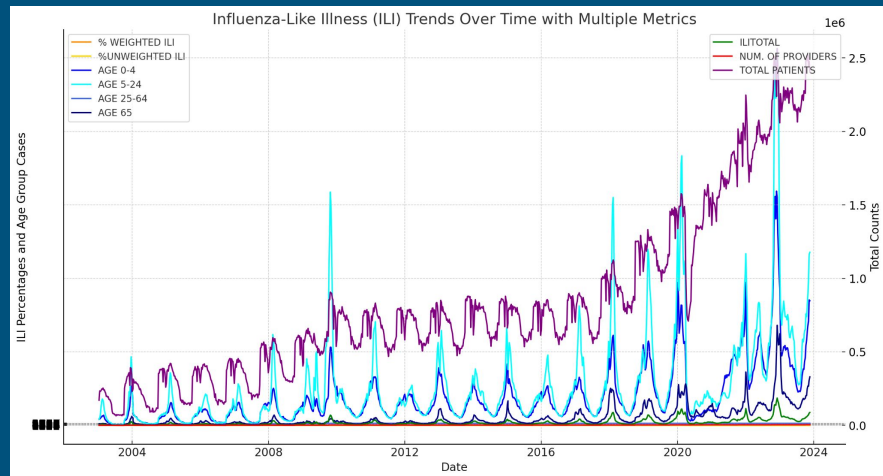
Challenges

- Using ChatGPT API has a subscription cost, but we aimed to make our system free and open source.
- Hence, we used GPT4ALL and LLAMA for all the experiments.

Epidemic Series Summarization

Why Time2Text ?

- Complexity of Epidemic Data
 - Dynamic and high-dimensional
 - Need for Domain Knowledge
- Text as The Most Accessible Format



Epidemic Series Summarization

Evaluation of Standard Prompt

- Task
 - Summarize the ILINet of 2023
- Chosen LLM
 - GPT3.5
 - BARD
 - GPT4

- Prompt

[BEGIN DATA]

[Domain]: Description of the role of a Public Health Communication Specialist, with a focus on the U.S. Outpatient Influenza-like Illness Surveillance Network (ILINet) data from 2023.

[Instruction]: A directive to summarize the ILINet data concerning outpatient visits for ILI from the 1st to the 46th week of 2023.

[Input Data]: Specific patient visit numbers for the given time frame (data omitted for brevity).

[END DATA]

Epidemic Series Summarization

Evaluation of Standard Prompt

- Output of GPT4

In the U.S. Outpatient Influenza-like Illness Surveillance Network (ILINet) for the year 2023, the number of outpatient visits for influenza-like illness (ILI) from week 1 to week 46 showed significant variations. The data is as follows:

- Weeks 1-10: 2,257,219, 2,214,718, 2,134,322, 2,179,097, 2,208,786, 2,301,891, 2,262,519, 2,212,367, 2,278,801, 2,274,369
- Weeks 11-20: 2,228,243, 2,295,244, 2,270,922, 2,191,695, 2,254,413, 2,277,306, 2,270,577, 2,259,439, 2,295,923, 2,201,318
- Weeks 21-30: 2,168,837, 2,145,458, 2,181,818, 2,151,354, 2,138,841, 2,151,567, 2,064,071, 2,155,163, 2,163,061, 2,145,981
- Weeks 31-40: 2,132,141, 2,155,733, 2,185,559, 2,243,104, 2,248,034, 2,210,702, 2,276,390, 2,263,734, 2,259,450, 2,490,050
- Weeks 41-46: 2,483,009, 2,481,845, 2,520,958, 2,446,527, 2,477,218, 2,403,384

Epidemic Series Summarization

Evaluation of Standard Prompt

- Output of GPT4

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- Weeks 11-20: 2,228,243, 2,196,243, 2,240,912, 2,291,695, 2,244,713, 2,177,316, 2,170,571, 2,250,439, 2,297,915, 2,211,187

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Direct Data Copying

Epidemic Series Summarization

Evaluation of Standard Prompt

- Output of BARD

Here is a summary of the ILI data for the 1st to the 46th week of 2023:

- The average number of ILI visits per week was 2,252,460.
- The minimum number of ILI visits per week was 2,064,071.
- The maximum number of ILI visits per week was 2,520,958.
- The 25th percentile of ILI visits was 2,171,402.
- The 50th percentile (median) of ILI visits was 2,245,569.
- The 75th percentile of ILI visits was 2,277,077.

Epidemic Series Summarization

Evaluation of Standard Prompt

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- The 50th percentile (median) of ILI visits was 2,245,569.
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Simple Quantile Statistics

Epidemic Series Summarization

Evaluation of Standard Prompt

- Output of GPT3.5

In 2023, the U.S. Outpatient Influenza-like Illness Surveillance Network (ILINet) collected data on outpatient visits for Influenza-like Illness (ILI) from the 1st to the 46th week. Here's a summary of the key data points:

- The number of outpatient visits for ILI varied throughout the 46 weeks.
- The lowest number of visits occurred in the 26th week with 206,4071 visits.
- The highest number of visits occurred in the 45th week with 2,520,958 visits.
- Overall, there appears to be a noticeable increase in ILI outpatient visits towards the later weeks of the year, which might be indicative of the flu season intensifying.
- The data suggests that ILI activity may have peaked in the 45th week.

Epidemic Series Summarization

Evaluation of Standard Prompt

- Output of GPT3.5

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Min Max Peak

Epidemic Series Summarization

Evaluation of Standard Prompt

- Observations:
 - Standard prompts often result in low-quality summarizations
 - Standard prompt cannot constrain variability across different LLMs

Epidemic Series Summarization

Evaluation of Standard Prompt

- Observations:
 - Standard prompts often result in low-quality outputs
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Prompt Engineering is required

Epidemic Series Summarization

Evaluation of Standard Prompt

- Observations:
 - Standard prompts often result in low-quality outputs
 - Standard prompt cannot constrain variability across different LLMs

Improve quality consistently
Reduce randomness and variability

Epidemic Series Summarization

Proposed Prompt

[Domain]: As a Public Health Communication Specialist, you have a crucial role in interpreting and translating health data for public understanding. You're currently focusing on the U.S. Weekly-Reported Outpatient Influenza-like Illness Surveillance Network (ILINet) of the 2021-2022 season collected through outpatient visits to health care providers.

[Instruction]:

- Need a conversion of weekly data to the corresponding month and week (e.g., 'Week 3 of January') for a clearer timeline.
- Output as follows:
 - **Title**
 - **Key Findings**
 - * Overall summary with Statistics.
 - * Identify and Report influenza outbreaks.
 - * Identify and Report non-influenza time periods (e.g., a “non-influenza week”) defined as two or more consecutive weeks in which each week accounted for less than 2% of the season’s total number of specimens that tested positive.
 - **Detailed Summary**
 - * Summarize the ILINet data concerning outpatient visits for ILI from the 1st to the 46th week of 2023.
 - * Discuss and analyze significant increases and decreases, peaks and valleys, and other characteristics in the number of visits.
 - **Public Health Implications**
 - * Give suggestions about the public health landscape, specifically focusing on ILI spread and intensity based on input data and your analysis.
 - **Conclusion**

[Statistics need to be calculated]: Minimum weekly visits; Maximum weekly visits; Median weekly visits; Average weekly visits; Total patient visits;

[Expected Output]:

- A precise text.
- Keep the summary factual and data-focused.
- Avoid technical jargon and provide context where necessary to explain what the data indicates about ILI trends and public health implications.
- Do not include any self-references or introductory remarks.

[INPUT DATA]

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[INPUT DATA]

Standardized output template
with domain knowledge

Tailor content and style
by targeting audiences

Epidemic Series Summarization

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Epidemic Series Summarization

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- Detailed Summary

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[INPUT DATA]

Specific tasks

Epidemic Series Summarization

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[INPUT DATA]

Open-ended tasks

Epidemic Series Summarization

Evaluation of Standard Prompt

- Output of GPT4

Key Findings

Overall Summary with Statistics:

- Minimum weekly visits for ILI: 1,655,407
- Maximum weekly visits for ILI: 2,564,503
- Median weekly visits for ILI: 1,965,791
- Average weekly visits for ILI: 2,031,366
- Total patient visits for ILI during this period: 15,631,018

Influenza Outbreaks and Non-Influenza Periods:

- Influenza outbreaks were identified by spikes in outpatient visits, identified by spikes in outpatient visits.
- Non-influenza weeks, defined as those with less than 2% of the season's total positive specimens, were observed intermittently, reflecting periods of lower ILI activity.

Detailed Summary

- The ILINet data from the 1st to the 46th week of 2023 reveals a dynamic pattern in outpatient visits for ILI.
- Variations in weekly reporting were marked, highlighting the seasonality and monthly trends in ILI occurrences.
- Significant increases and decreases in the number of visits were noted, with peaks suggesting heightened ILI activity and valleys indicating relatively quiet periods.
- The data also pointed to notable peaks during certain weeks, suggesting potential regional or nationwide influenza outbreaks.

Public Health Implications

- The observed trends in ILI visits suggest an active influenza season with periodic spikes in case numbers.
- Public health strategies should focus on heightened surveillance during peak periods and community awareness during lower activity phases.
- These trends underscore the importance of ongoing ILI monitoring and vaccination efforts, especially during anticipated peak times.

Specific tasks

correct statistics

skipped event detection

Open-ended tasks

Useless

Epidemic Series Summarization

Evaluation of Standard Prompt

- Output of BARD

Key Findings

The 2023 ILI season was characterized by a moderate peak in activity during the winter months, with a gradual decline from March to May. A total of 46,812,420 patient visits for ILI were reported during the 2023 season. The minimum weekly visits for ILI was 1,655,407 (Week 5), and the maximum weekly visits was 2,564,503 (Week 47). The median weekly visits for ILI was 1,927,606. The average weekly visits for ILI was 2,035,133.

Influenza Outbreaks

There were two significant influenza outbreaks during the 2023 season. The first outbreak occurred in Week 7, with 2,033,467 patient visits for ILI reported. The second outbreak occurred in Week 47, with 2,564,503 patient visits for ILI reported.

There were two non-influenza time periods during the 2023 season. The first non-influenza time period occurred in Weeks 23 and 24, with less than 2% of the season's total number of specimens that tested positive for ILI reported each week. The second non-influenza time period occurred in Weeks 39 and 40, with less than 2% of the season's total number of specimens that tested positive for ILI reported each week.

Detailed Summary

ILI activity began to increase in Week 5 of the 2023 season, reaching a peak in Week 7. ILI activity then gradually declined from Week 8 to Week 22. There was a slight increase in ILI activity in Week 23, but activity then declined again for the remainder of the season.

ILI activity was highest in the winter months (December, January, and February), with an average of 2,218,417 patient visits for ILI reported each week. ILI activity was lowest in the summer months (June, July, and August), with an average of 1,687,349 patient visits for ILI reported each week.

Public Health Implications

The 2023 ILI season was characterized by a moderate peak in activity, with two significant influenza outbreaks. The first outbreak occurred in Week 7, and the second outbreak occurred in Week 47. Public health officials should continue to monitor ILI activity and promote influenza vaccination to help protect the public from influenza.

Specific tasks

Complete & Right

Open-ended tasks

Useful

Time Series Summarization

Evaluation of Standard Prompt

- Output of GPT3.5

Key Findings

The 2021-2022 season of the U.S. Weekly-Reported Outpatient Influenza-like Illness Surveillance Network (ILINet) revealed significant trends in influenza-like illness (ILI) outpatient visits. Here are the key findings:

- Median weekly visits for ILI: 1,655,401 (Week 5 of January)
- Maximum weekly visits for ILI: 2,564,503 (Week 10 of December)
- Median weekly visits for ILI: 1,978,336

Average weekly visits for ILI: 2,031,291

Outpatient visits for ILI in this season: 130,367,777

We identified influenza outbreaks and non-influenza time periods. Influenza outbreaks were observed during the peak months of December 2022 and January 2023, while non-influenza time periods occurred primarily during the summer and early fall months.

Detailed Summary

From the 1st to the 46th week of 2023, the ILINet data showed variations in weekly reporting and provided insights into the seasonality and monthly trends of ILI occurrences.

- In the early months of the year, ILI visits were relatively low, but they started increasing from late October, peaking in December with 2,564,503 visits.
- January continued to have a high number of ILI visits, suggesting a prolonged influenza outbreak.
- February saw a gradual decline in ILI visits, indicating the end of the peak influenza season.
- March and April showed further decreases in ILI visits, returning to lower baseline levels.
- Summer months (May to August) witnessed the lowest number of visits with fewer than 2% of the season's total specimens testing positive for influenza.
- The fall season began with a slight increase in ILI visits in September, which continued into October.

Significant increases and decreases in weekly ILI visits were observed throughout the season. The peak months of December and January marked the height of influenza activity, while the summer months represented non-influenza time periods.

Public Health Implications

Based on the ILINet data analysis, the public health landscape can be summarized as follows:

- Influenza outbreaks during the winter months pose a significant public health challenge, requiring enhanced surveillance efforts and public awareness campaigns to reduce the spread of the virus.
- Non-influenza time periods in the summer and early fall provide an opportunity for healthcare systems to allocate resources to other health concerns.
- The seasonality of ILI occurrences emphasizes the importance of timely vaccination campaigns and preparedness for the peak months of December and January.
- Continued monitoring of ILINet data is essential for detecting early signs of influenza outbreaks and guiding public health interventions.

Open-ended tasks
Beyond instructions!
specific
insightful

Epidemic Series Summarization

Conclusions

-
- LLM is a Time2Text translator.
 - Our prompt consistently enhances the generation quality of summarization
 - Our prompt significantly enhances the generation quality of summarization
 - More powerful AGI model does not equate to better Time2Text capabilities

Future Works

- Incorporate multivariate forecasting and support for exogenous variables.
- Get more samples to more reliably compute confidence scores.
- Evaluate multi-language summary generation capabilities
-
- Metrics and Benchmarks for Time2Text



THANK YOU



Questions?

