PMSA

PHARMACEUTICAL MANAGEMENT SCIENCE ASSOCIATION

Demystifying contextual messaging for AI powered field alerts with large language models

Prepared for PMSA

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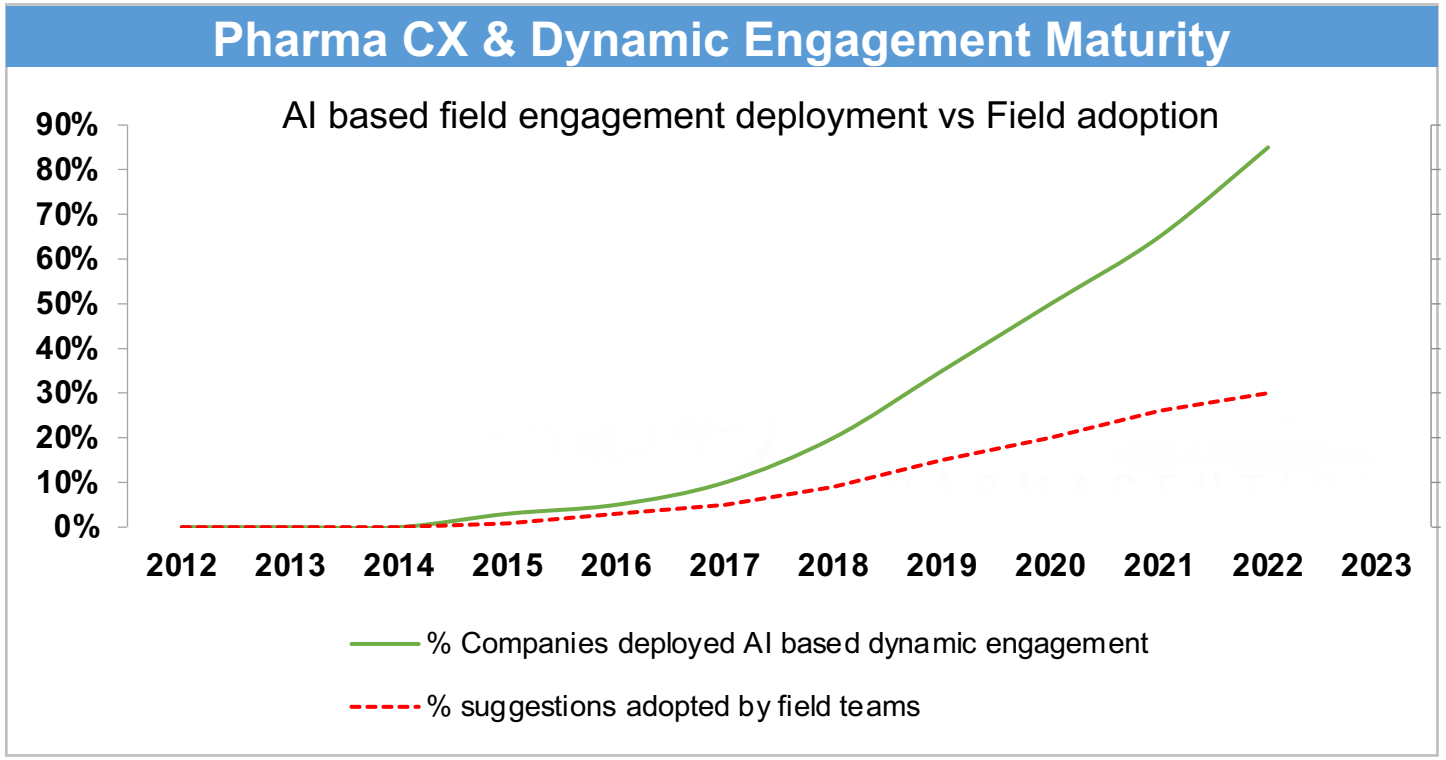
Agenda

- Background
- Role of Gen AI
- Our approach
- Results
- Future Enhancements
- Q&A

Despite the remarkable surge in AI applications for dynamic engagement in pharma, adoption of AI-driven predictive field alerts has been limited



Source: ZS Estimates 2023 (Top 30 pharma companies globally)
Percentage of pharma companies enabling capability

While most of the top pharma companies have deployed **AI-based alerts, only ~30%** of those alerts are acted upon by pharma field teams

There is a need to bridge this adoption gap to fully explore the substantial untapped potential of the AI-driven predictive alerts for enhanced customer engagement

There are some challenges that hinders the adoption of the AI-driven predictive alerts

Limited interpretability of ML-based insights

Lack of an evidence-based delivery system for predictive alerts impacts the sales' team confidence to leverage the insights & widens the adoption gap

Limited Context

Reps are unable to successfully leverage the alerts they receive as they lack context for engagement

Hence, there's a need for an **advanced solution** which can generate alerts that are

Scalable across multiple types of alerts for same or different therapeutic areas

Precise evidence-based delivery system providing automated summaries which are easy to interpret

Contextual Messaging to amplify HCP Interactions

The key to overcoming these challenges is to balance the 4Cs of customer engagement

Who are the right customers?

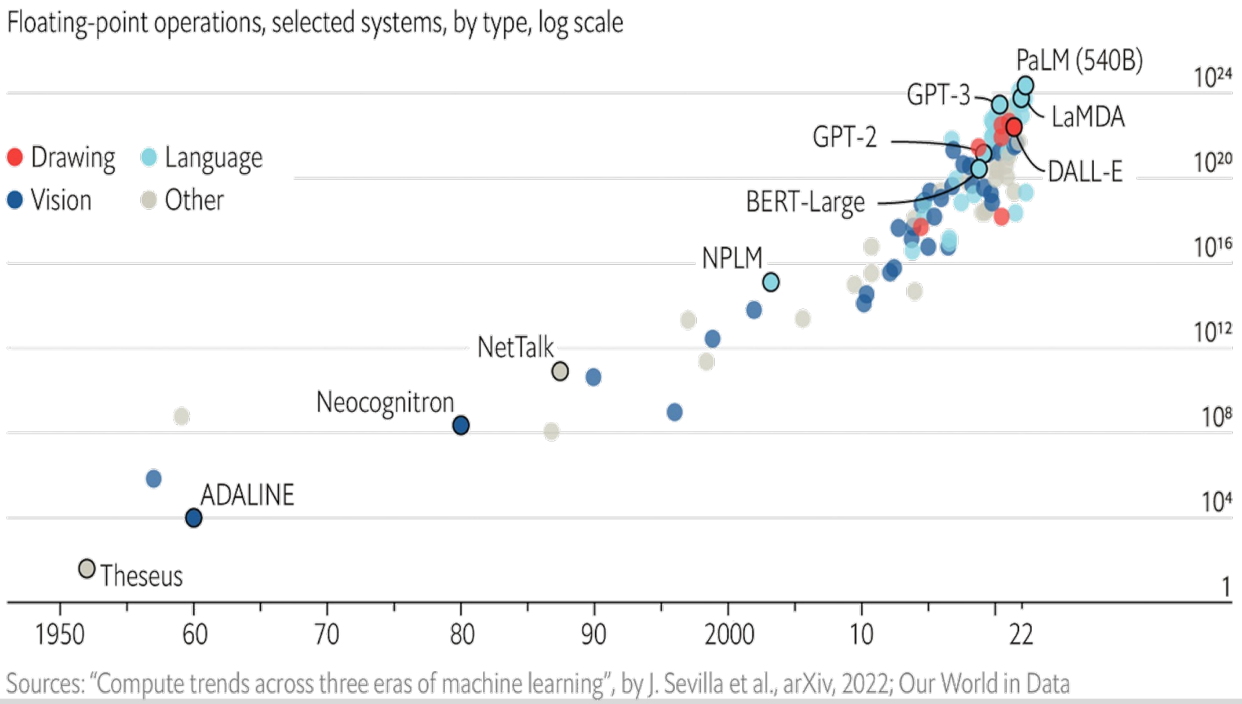
What is the best mode of engagement for the customers?

How do we contextualize messaging for field and physicians?

What is the right engagement frequency for the customers?

In recent years, companies improved customer identification, cadence, and channels, but research on content personalization continues. GenAI offers a path to achieve this

Generative AI based models such as GPT-4 is disrupting how we process data, given their wide-ranging capabilities



Since 2023, models like GPT-4 and Llama 2, Kosmos-1 have revolutionized the AI landscape

*Illustration based on Google's PALM (Pathways Language Model). Source for illustration: https://ai.googleblog.com/2022/04/pathways-language-model-palm-scaling-to.html

Recent advancements in the realm of Generative AI-based models have ushered in a profound transformation, significantly enhancing the models' interpretability and explain ability

Classical AI and Generative AI models can disrupt the dynamic engagement landscape, driving widespread adoption and impact

- Identify the most relevant HCPs for effective engagement
- Determine the opportune moments to interact with physicians for maximum impact

- Discern the rationale behind prioritizing specific HCPs
- Contextualize messaging strategy based on HCP's preferences and types of patients HCP manages

We have developed a five-step framework which can be leveraged for creating scalable, evidence based, contextual alerts for the field

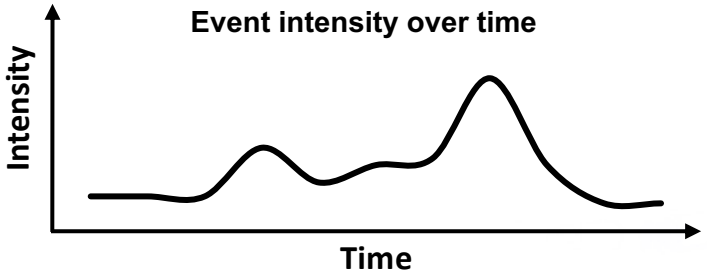
Classical AI + Gen AI	Classical AI	Classical AI	Gen AI	Pull-through
				
1	2	3	4	5
Patient Archetyping	**Event Prediction**	**Pathway Based Drivers**	**LLM based summarization**	**Contextual Messaging**
Convert the patient journey into generalized archetypes of progression	Leverage AI/ML models to generate the predictive trigger for field alerts	Identify factors driving the trigger, differentiated across patient archetypes	Leverage LLMs to summarize insights from steps 1 and 3 in context of the triggers generated in step 2	Generate blurbs for field to build confidence on triggers or engage in content generation for HCP discussion

Advanced AI lies at the heart of all these steps, helping generate effective alerts and synthesizing insights for easy consumption

The first step involves development of patient archetypes

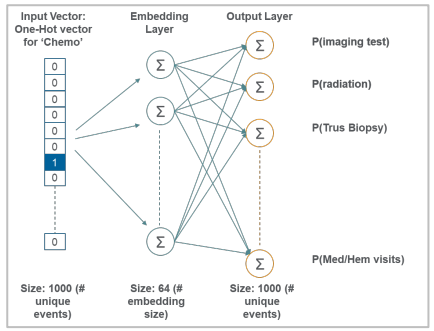
Step 1 — Generation of Event Representations

Approach 1: C-Hawkes



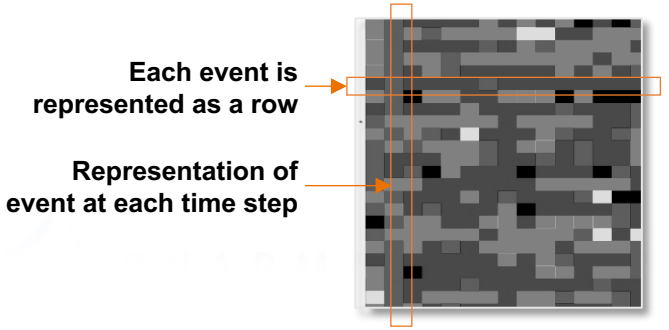
Approach 2: Word2Vec

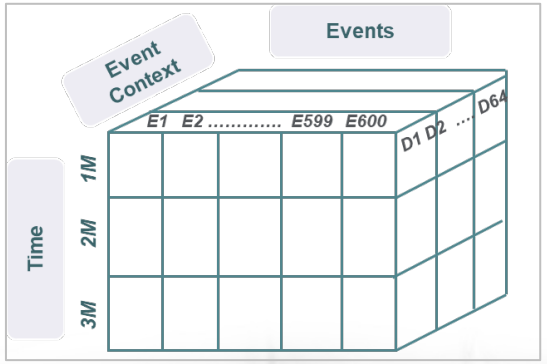
Event embeddings



Step 2 — Patient Image Generation

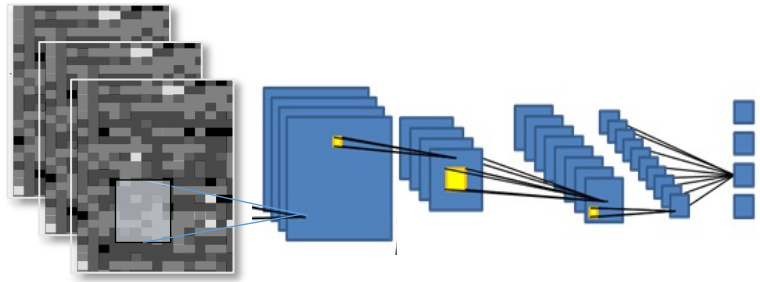
3D patient images are formed based on event embeddings/intensities and time

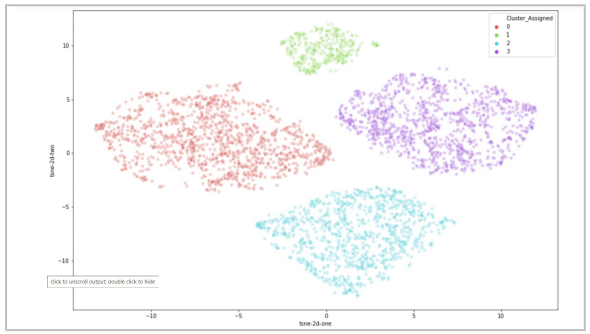




Step 3 — CNN and Clustering on latent features

CNN autoencoders are run on patient image to learn latent patient features; clusters are created based on these features





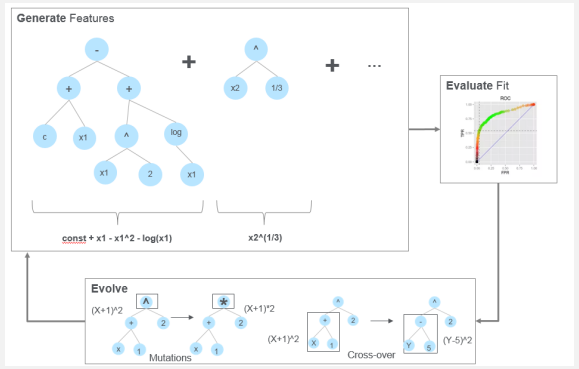
The second step involves training a predictive model to generate the alert

Illustration

Inputs 1

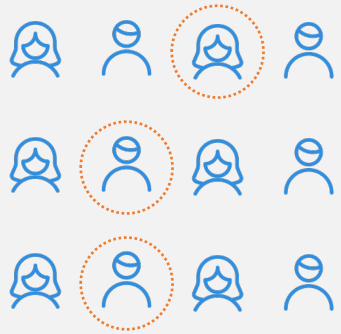
Patient Demographics	• Age, gender, etc. • Geographic distribution (state level)
Validate Disease Trends	• Distribution by comorbidities/ symptoms • Incidence/Prevalence rate • Diagnosing HCP specialty distribution
Validate Treatment Trends	• Yearly patient and claim trends by product • Treating HCP specialty distribution
Managed Care	• Yearly patient and claim trends by payer • Payer channel mix – approved and rejected counts

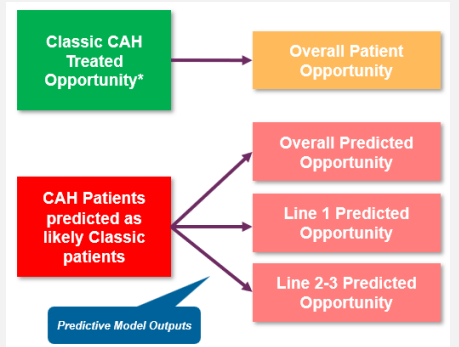
Feature Engineering 2



Modeling, Evaluation & Optimization 3

Total Patient Identification 4





The third step involves understanding the key medical events that act as drivers or barriers for each archetype

Illustration

Each archetype has a distinct profile based on medical events that the patients have gone through

Archetype A
- Less time to treatment adoption
- Long pre-existing commodity burden
- Frequent HCP interaction

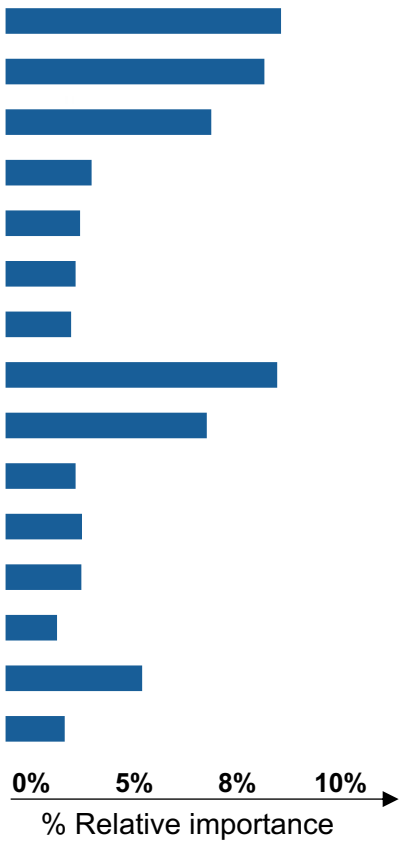
Archetype B
- Moderately heavy in comorbidity burden
- Highly comorbid

Archetype C
- High Prevalence of post diagnosis comorbidities
- High drug treatment & frequent monitoring

Drivers' analysis

Relative importance across archetypes

	Drivers & Barriers	B
Comorbidities 51%	Comorbidity 1	**35%**
	Comorbidity 2	18%
	Comorbidity 3	9%
	…	**45%**
	….	**33%**
	....	**35%**
	….	**45%**
Treatments 27%	Treatment 1	33%
	Treatment 2	**35%**
	…	23%
Procedures 12%	Biomarkers Test	**46%**
	Lab Test	16%
	…	**42%**
HCP Behavior 10%	Specialty	29%
	…	**26%**



Drivers are identified separately for each patient archetype

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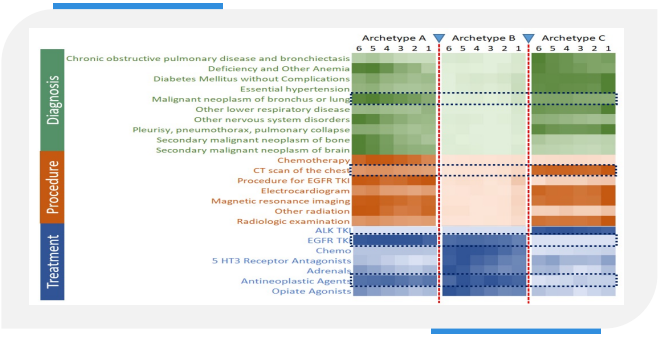
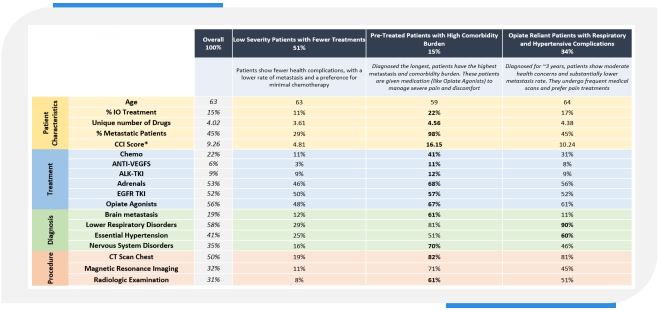
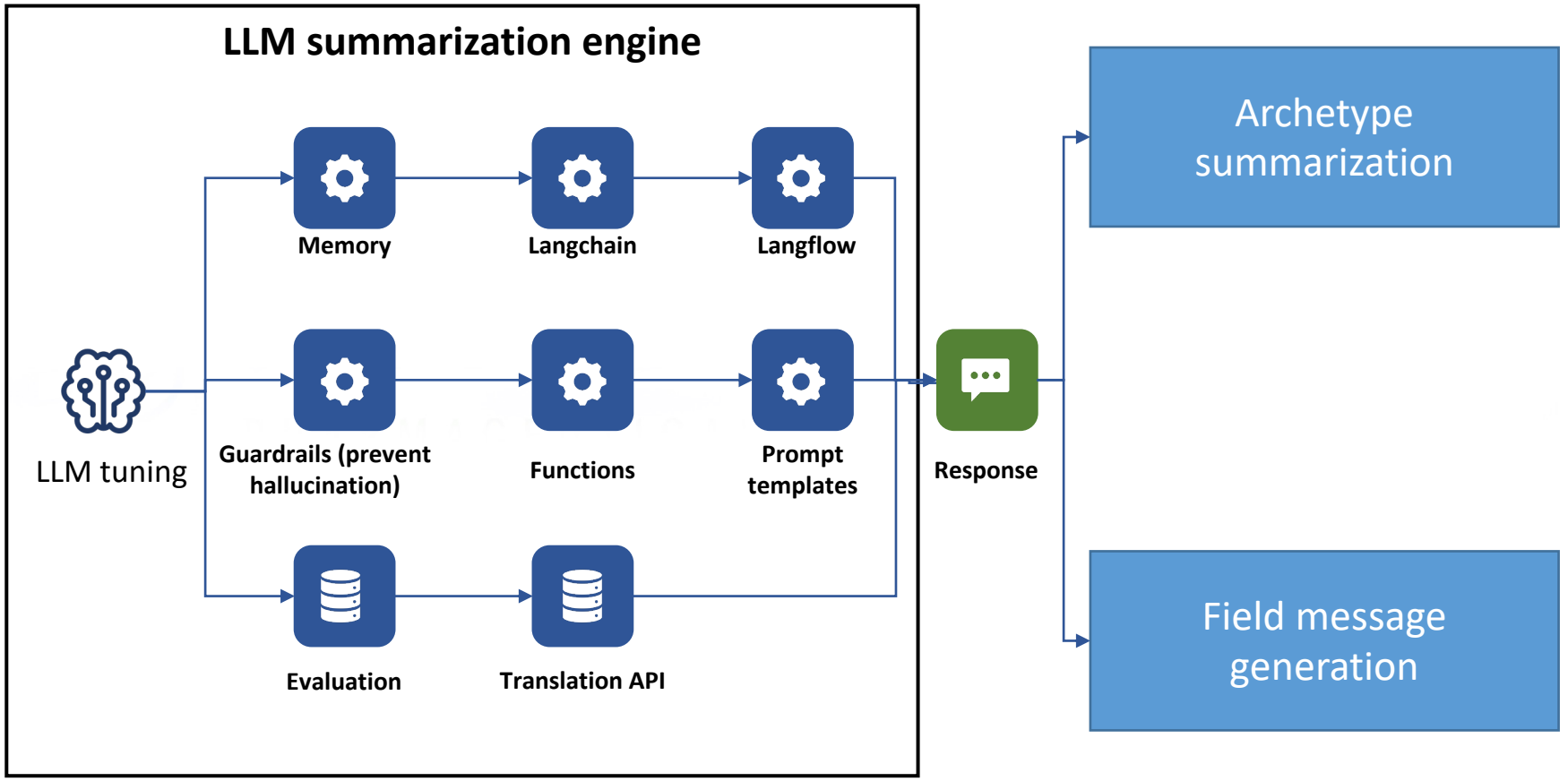
The fourth step involves leveraging LLMs to summarize the type of patients managed by the HCPs, enhancing contextual information for the field

The data is preprocessed and anonymized and converted to string format to be fed into the API



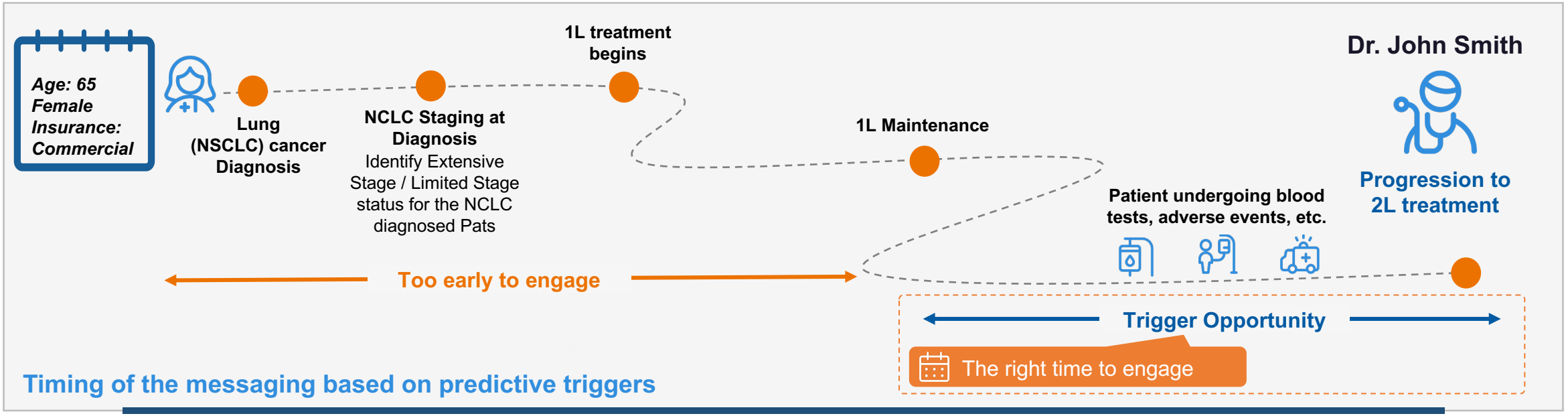


		Overall 100%	Low Severity Patients with Fewer Treatments 51%	Pre-Treated Patients with High Comorbidity Burden 15%	Opiate Reliant Patients with Respiratory and Hypertensive Complications 34%
			Patients show fewer health complications, with a lower rate of metastasis and a preference for minimal chemotherapy	Diagnosed the longest, patients have the highest metastasis and comorbidity burden. These patients are given medication (like Opiate Agonists) to manage severe pain and discomfort	Diagnosed for ~3 years, patients show moderate health concerns and substantially lower metastasis rate. They undergo frequent medical scans and prefer pain treatments
Patient Characteristics	Age	63	63	59	64
	% IO Treatment	15%	11%	22%	17%
	Unique number of Drugs	4.02	3.61	4.56	4.38
	% Metastatic Patients	45%	29%	98%	45%
	CCI Score*	9.26	4.81	16.15	10.24
Treatment	Chemo	22%	11%	41%	31%
	ANTI-VEGFS	6%	3%	11%	8%
	ALK-TKI	9%	9%	12%	9%
	Adrenals	53%	46%	68%	56%
	EGFR TKI	52%	50%	57%	52%
	Opiate Agonists	56%	48%	67%	61%
Diagnosis	Brain metastasis	19%	12%	61%	11%
	Lower Respiratory Disorders	58%	29%	81%	90%
	Essential Hypertension	41%	25%	51%	60%
	Nervous System Disorders	35%	16%	70%	46%
Procedure	CT Scan Chest	50%	19%	82%	81%
	Magnetic Resonance Imaging	32%	11%	71%	45%
	Radiologic Examination	31%	8%	61%	51%



The token limit for the GPT-4 API is 8K, we employed a token tracker to limit the prompt size to get the relevant output.
We explored various LLMs such as Llama2, Vicuna, GPT 3.5 Turbo etc. GPT4 outperformed all the LLMs.

The fifth step involves strategic rollout of alerts to field teams



Timing of the messaging based on predictive triggers

Archetype A + Drivers

Highly comorbid patients driven by diagnosis events & high treatment usage

→

HCP: Dr. John Smith

HCP mapped to patient archetype A

→

Rep 1

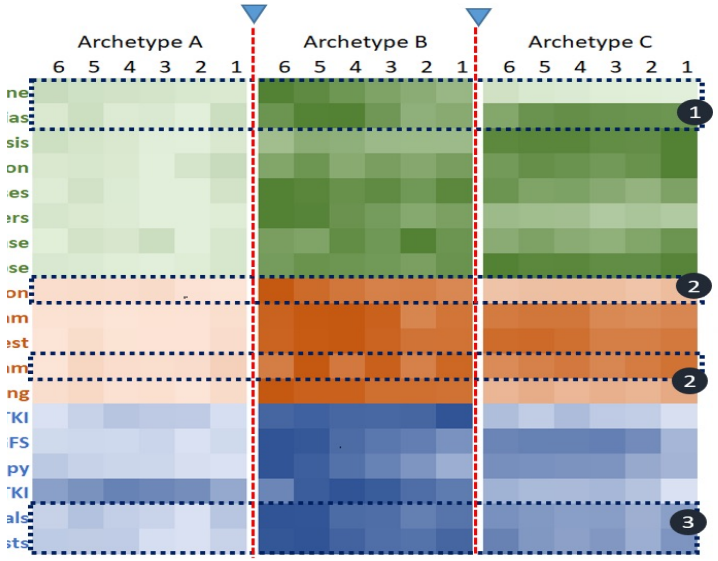
Rep assigned to HCP

Engagement strategy for rep 1 will be based on the patient archetype A & the HCP 1 mapped to these patients

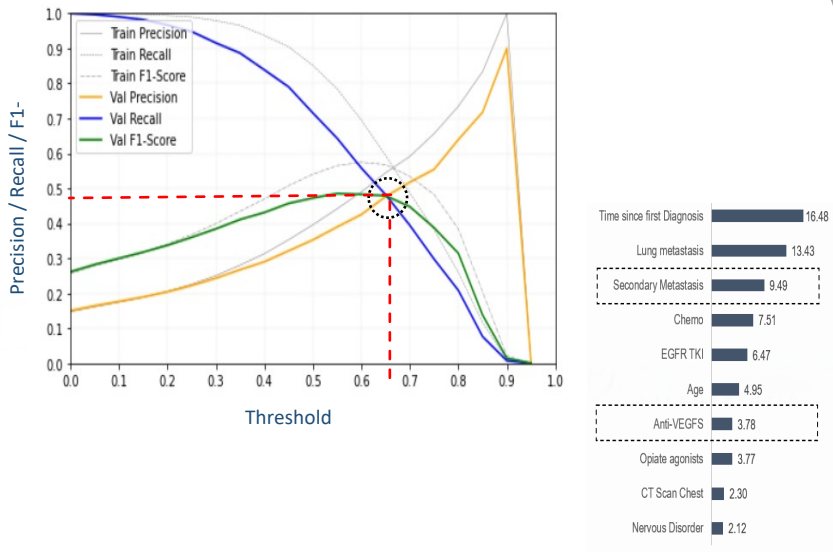
Context of the messaging based on the patient archetype and drivers

Previewing Outcomes: Identifying patients likely to initiate IO treatment in the next 3 months and generating contextual field alerts using LLM

Patient Archetyping



Patient Identification and pathway based drivers



LLM Based alert generation

Dr. XYZ's *patients are frequently diagnosed with secondary malignant neoplasms of the brain, showing a potential shift in their health challenges. Alongside, they maintain a consistent chemotherapy regimen and opiate use. Given their reliance on medical imaging, IO treatment can be a pivotal solution. It can potentially streamline their care, reducing the need for frequent scans and addressing pain management.*

Dr. ABC's *patients are displaying an increased preference for EGFR TKI treatments and adrenal agents, indicating varied therapeutic approaches. Respiratory concerns persist, and while neoplasm diagnoses fluctuate, the varied drug use underscores their evolving needs. IO treatments can provide a comprehensive solution, catering to both respiratory and diverse therapeutic requirements.*

Dr. DEF's *patients consistently show signs of secondary malignant neoplasms, emphasizing a complex health trajectory. Their frequent medical scans and preference for pain-relief treatments, paired with occasional use of adrenal agents, indicate diverse medical interventions. IO treatments can offer a holistic approach, potentially reducing their scan frequency and addressing varied health challenges.*

Identifying the variation of patient journey by creating Archetypes and finding the events that drive a patient to IO treatment

Determine the ideal threshold for achieving balanced performance in the patient identification ML Model

Leverage the patient vector and archetypes data with a finetuned LLM model to generate field alerts

To develop a scalable, evidence-based system for generating AI-driven predictive alerts for the field team

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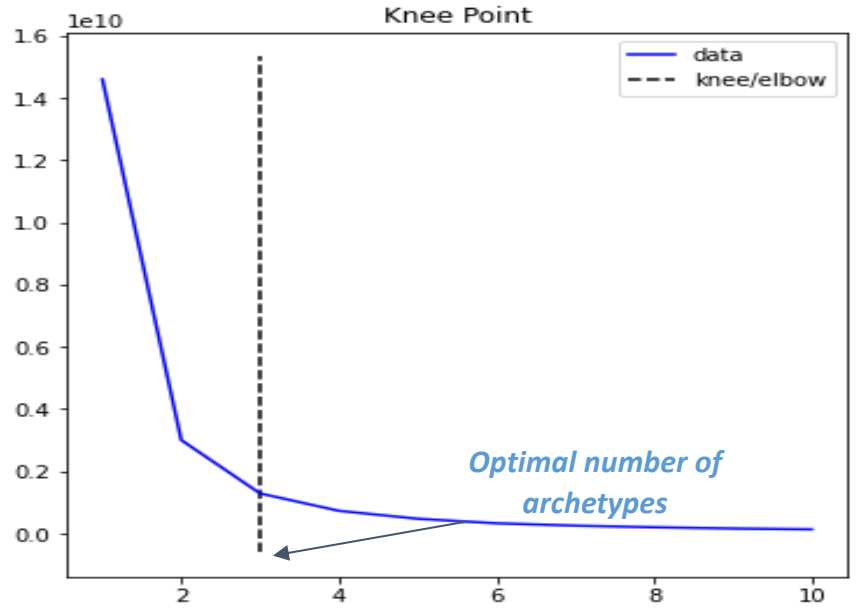
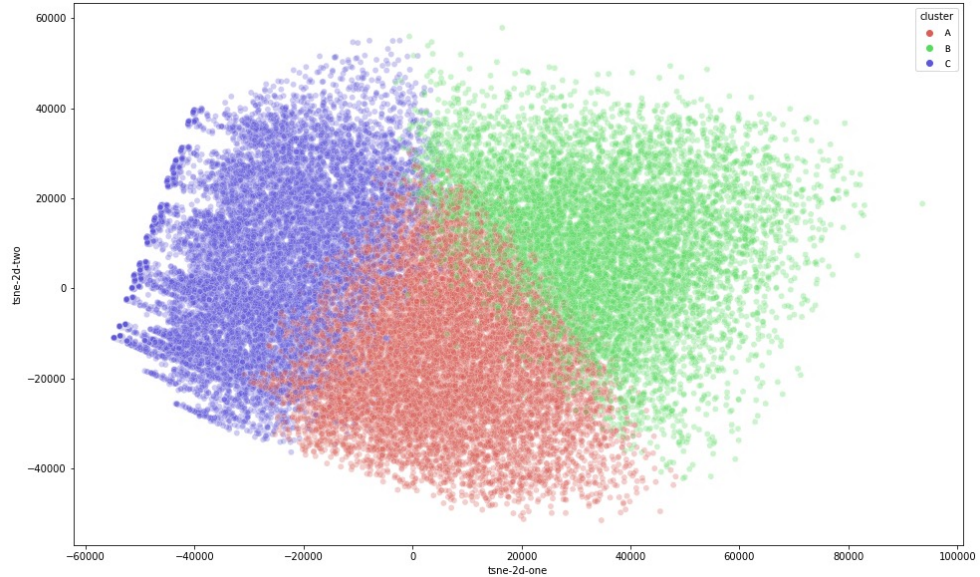
We identified three distinct archetypes of NSCLC patients, based on their journey and characteristics





Knee plot was used to identify the optimal number of patient archetypes determined using K-Means algorithm

Two-dimensional t-SNE plot helped with **visual confirmation of the clear separation of patients** into these three clusters

Data Source : SHS Claims Data

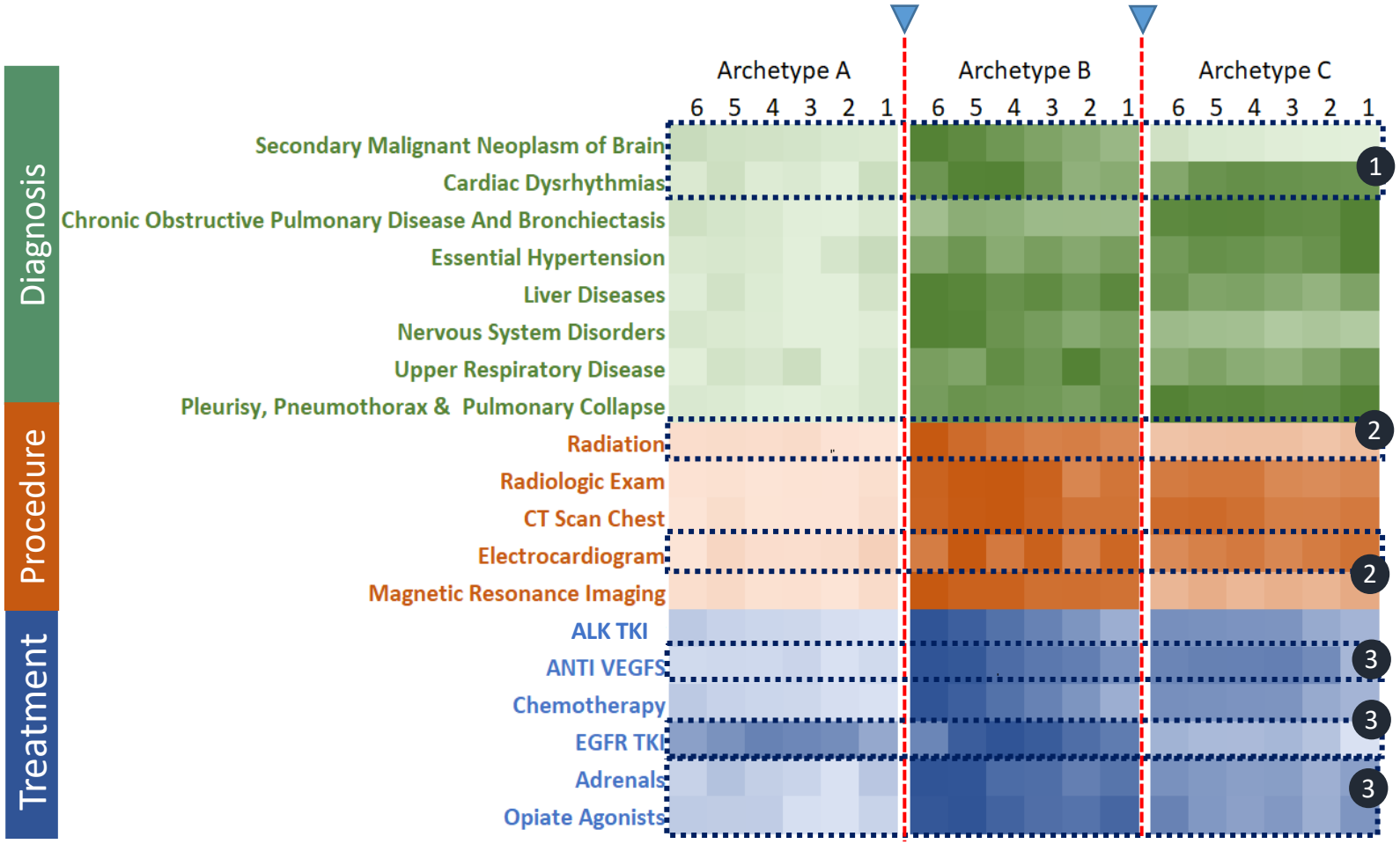
Profiling of the archetypes revealed key differences in comorbidity burden, treatment history and diagnostic tests

			Archetype A	Archetype B	Archetype C
		Overall 100%	Low severity, early-stage patients with fewer treatments 51%	Metastatic, severe, high comorbidity burden patients with multiple prior treatments 15%	Moderately severe patients with respiratory and hypertension complications 34%
			Patients are diagnosed early, show fewer health complications, and low chemo usage	*Patients diagnosed in advanced stage with high comorbidity burden and undergone multiple treatments, require strong management for pain and discomfort*	*Patients show moderate comorbidity burden and are reliant on pain medications. They suffer from high respiratory and hypertensive complications*
Patient Characteristics	Age	*63*	63	59	64
	% IO Treatment	*27%*	21%	**41%**	32%
	% Metastatic	*45%*	29%	**98%**	45%
	Unique number of Drugs	*4.01*	3.61	**4.56**	4.38
	CCI Score*	*8.36*	4.81	**16.15**	10.24
Treatment	Chemo	*34%*	22%	**56%**	42%
	ANTI-VEGFS	*6%*	3%	**11%**	8%
	ALK-TKI	*3%*	4%	**2%**	3%
	Adrenals	*53%*	46%	**68%**	56%
	EGFR TKI	*16%*	16%	**18%**	17%
	Opiate Agonists	*55%*	48%	**67%**	61%
Diagnosis	Brain metastasis	*19%*	12%	**61%**	11%
	Lower Respiratory Disorders	*58%*	29%	81%	**90%**
	Essential Hypertension	*41%*	25%	51%	**60%**
	Nervous System Disorders	*34%*	16%	**70%**	46%
Procedure	CT Scan Chest	*50%*	19%	**82%**	81%
	Magnetic Resonance Imaging	*32%*	11%	71%	45%
	Radiologic Examination	*31%*	8%	**61%**	51%

Data Source : SHS Claims Data

* CCI: The Charlson Comorbidity Index (CCI) score is a quantitative measure that assesses the burden of comorbid medical conditions in a patient

Longitudinal Analysis showed some interesting patterns in journeys across the archetypes



1 As patients approach IO treatment, Archetype C sees an increase in Pulmonary and Cardiac severities; While there's a decline in bone metastasis over time across all archetypes, with a higher prevalence observed in Archetype B

2 Archetype B sees a decline in use of radiation, while the trend remains constant in Archetypes A and C. Electrocardiograms are conducted periodically across all clusters with a higher prevalence in archetypes B and C

3 Usage of Anti-VEGFS is high initially in archetypes B and C and declines prior to IO usage. While archetypes B & C have high usage of pain medications, there's a decline in usage over time. Archetype A shows a slight increase in EGFR usage prior to IO

▼ Anchor date: 3 months before the first IO treatment
Each time bucket represents 60 days

Data Source : SHS Claims Data

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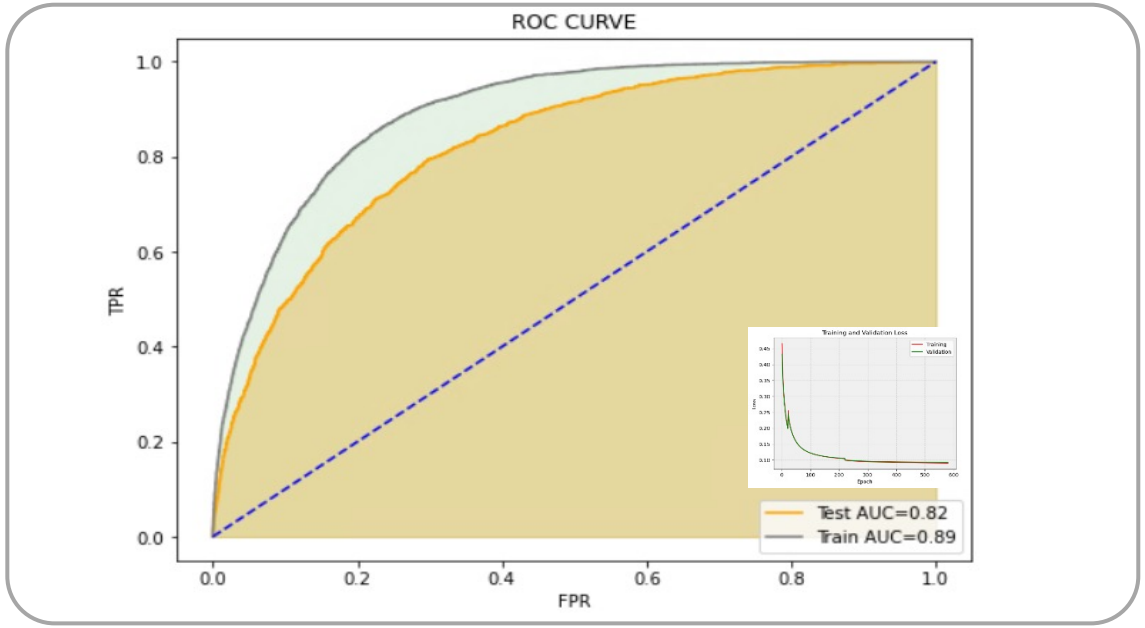
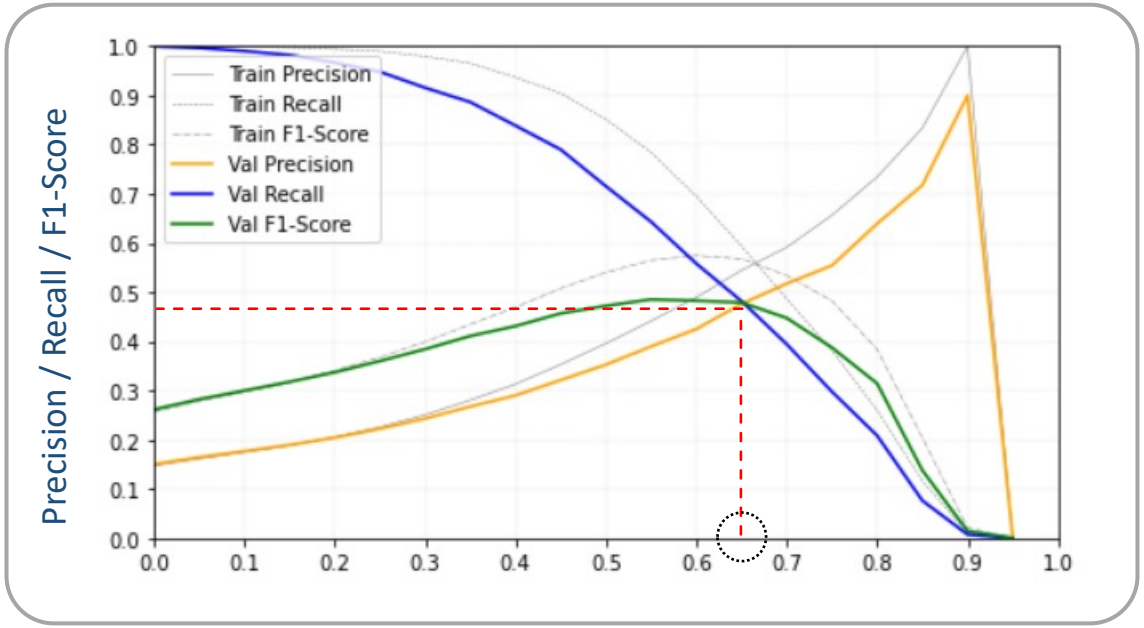
We trained a prediction model for identifying patients likely to initiate IO treatments in next 3 months. The Model had an AUC score of ~89%



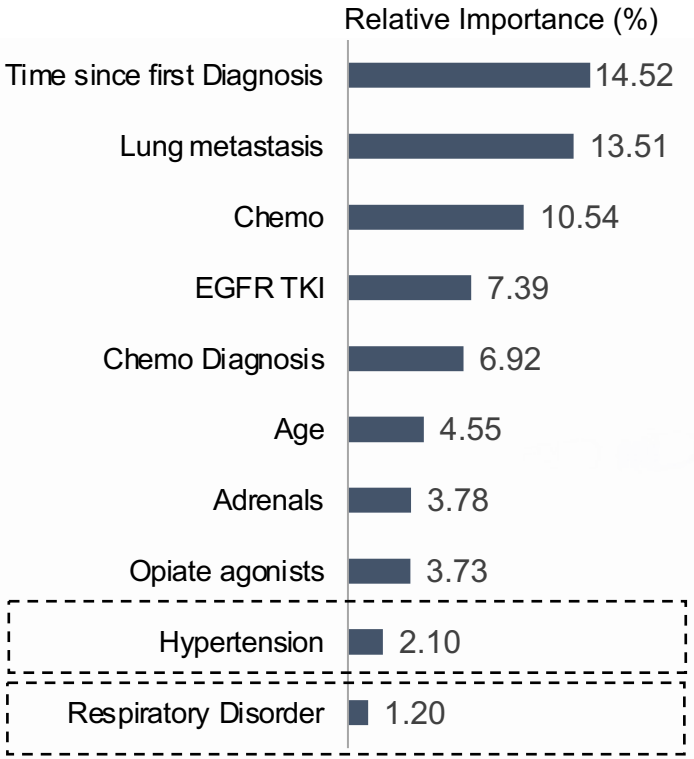


- A high **AUC score of 89%** across training and validation sets indicated that the model is robust
- Identified **4.9k patients** who are likely to initiate IO treatment in next 3 months
- Threshold was set at 0.65 to maintain a balance between recall (85%) and precision (40%)
- Generated triggers for **3.3k HCPs** managing these patients

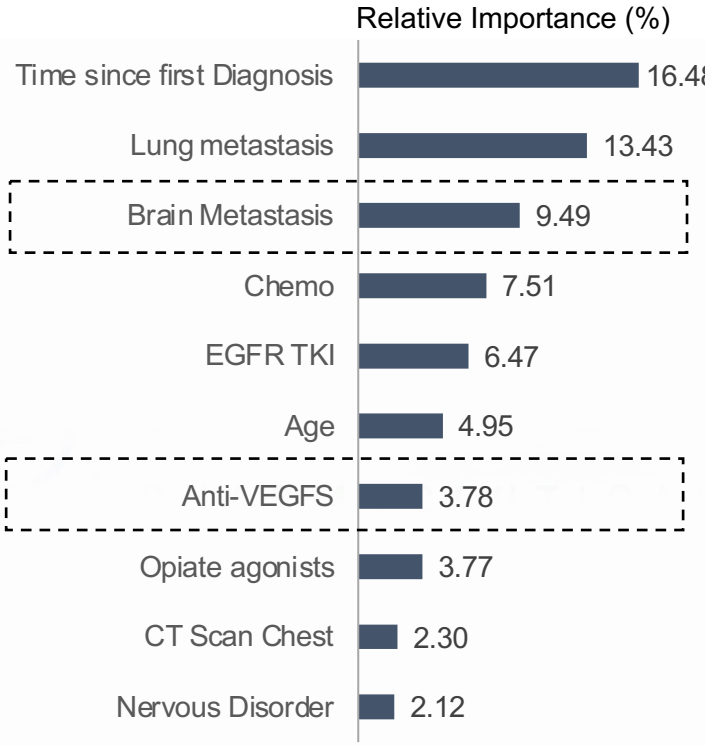
Data Source : SHS Claims Data

Factors driving IO initiation were analyzed across the patient archetypes

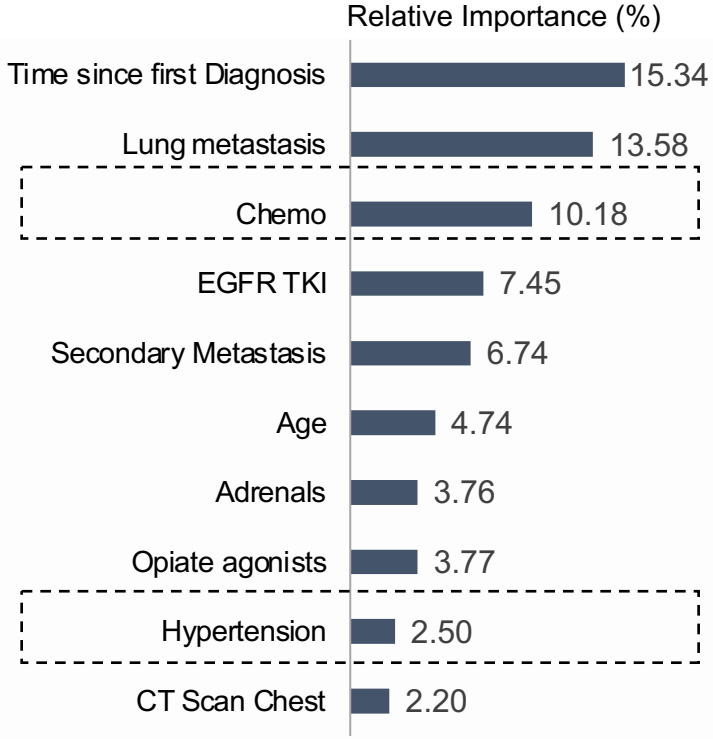
Archetype A



Archetype B



Archetype C

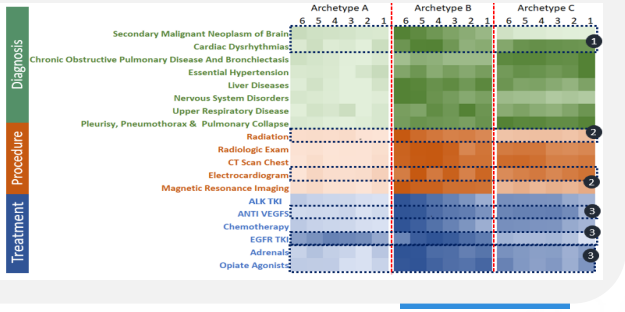


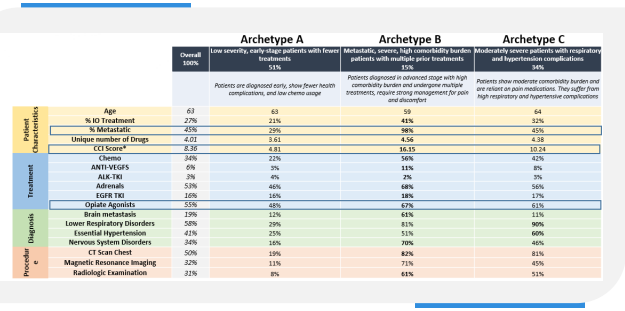
- Brain metastasis and prior utilization of Anti VEGFs exhibit increased significance in Archetype B, suggesting a higher likelihood of severe patients opting for IO treatments
- Presence of comorbidities emerged as an influencing factor for IO treatment within archetype A patients
- In the case of Archetype C, patients who initially received chemotherapy and demonstrated reduced reliance on chemotherapy over time are more likely to opt for IO treatments

Data Source : SHS Claims Data

The message below was not generated by medical experts, but GPT-4!

The data is preprocessed and anonymized and converted to string format to be fed into the API





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	Magnetic Resonance Imaging	32%	11%	71%	45%
	Radiologic Examination	31%	8%	61%	51%

OpenAI GPT-4 API

Dr. XYZ** is managing patients who are likely to switch to IO therapies. These patients are usually **non-metastatic, managing well with fewer comorbidities, pain management medications and monitoring**, as seen with the lower use of opiate agonists and procedures like electrocardiograms and echocardiograms. **There has been an increase in hypertension and respiratory complications recently.

These messages to field improves adoption and confidence in the alerts significantly

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Rep Alerts were tailored using LLM to contextualize the alerts for HCPs, based on the type of patient these HCPs were managing

HCP: XYZ

- Med-Onc
- Primarily managing archetype A patients

***Dr. XYZ** is managing patients who are likely to switch to IO therapies. These patients are usually non-metastatic, managing well with fewer comorbidities, pain management medications and monitoring, as seen with the lower use of opiate agonists and procedures like electrocardiograms and echocardiograms. There has been an increase in hypertension and respiratory complications recently*

HCP: ABC

- Med-Onc
- Primarily managing archetype C patients

***Dr. ABC** is managing patients who are likely to switch to IO therapies. These patients are metastatic, have high comorbidity burden, frequently encountering brain metastasis. Frequent diagnostic interventions like electrocardiogram, CT scans are common, along with a heavy reliance on Chemotherapy, opiate agonists, and anti-VEGFs.*

HCP: DEF

- Specialist
- Primarily managing archetype B patients

***Dr. DEF** is managing patients who are likely to switch to IO therapies. These patients with moderate medical complexity, are showing signs of hypertension and respiratory disorders. They engage moderately with procedures such as CT scans and have observed a decrease in chemo usage recently*

Future Enhancements

The current approach needs refinement for consistent, insightful results. LLMs can hallucinate; more research is needed to prevent this

We have tried using tabular information as inputs to LLM; Further research can be conducted to explore generating insights using multi-modal data (e.g., images of the bit plots and SHAP plots, instead of the tabular data)

Given limitations of the volume of inputs that can be fed to LLMs (i.e., # tokens), further investigation can be made towards pre-processing the input data to optimize the prompts

We still need some initial assessment of the alerts by a human expert to ensure stability of the system, further research can focus towards making the systems self-validating

Additional information about the HCP (e.g., papers published, recent conferences attended, social media, websites, etc.) can be layered on to add additional context and provide an exhaustive view for the rep

Q&A