Vision Health

Sant (Winn) Leelamanthep MBBS

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Vision Health

one eye at a time

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A STORY

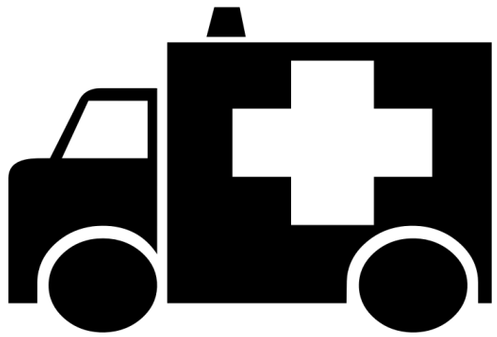
AUNTY SOM

Story
Aunty Lee 60 y/o female patient from a village in rural Thailand, brought to ER by paramedics after a witnessed fall. She hit her head and lost consciousness. O/E unresponsive to sound, touch or pain. GCS 3.
PMHx
diabetes, hypertension
DHx:
Metformin, dapaglifozin, ramipril; NKDA

DDx - hemorrhagic stroke, for transfer to tertiary care hospital for craniotomy

A STORY

AUNTY SOM



A STORY

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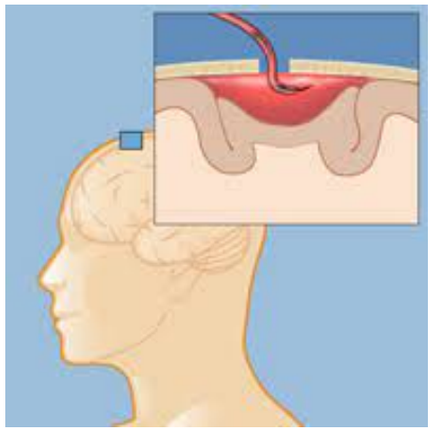

A STORY

AUNTY SOM

5 years later: despite surviving, she struggles to walk and perform activities of daily living

Diabetic Retinopathy Screening

Annual eye screening recommended

Diabetic Retinopathy Screening

- Lack of awareness and knowledge
- Travel time and distance to hospital with specialty care
- Loss of income
- Cost of diagnosis and treatment
- Limited mobility
- ‘I’m fine’

Social Determinants of health

Diabetic Retinopathy Screening

- Lack of awareness and knowledge
- Travel time and distance to hospital with specialty care
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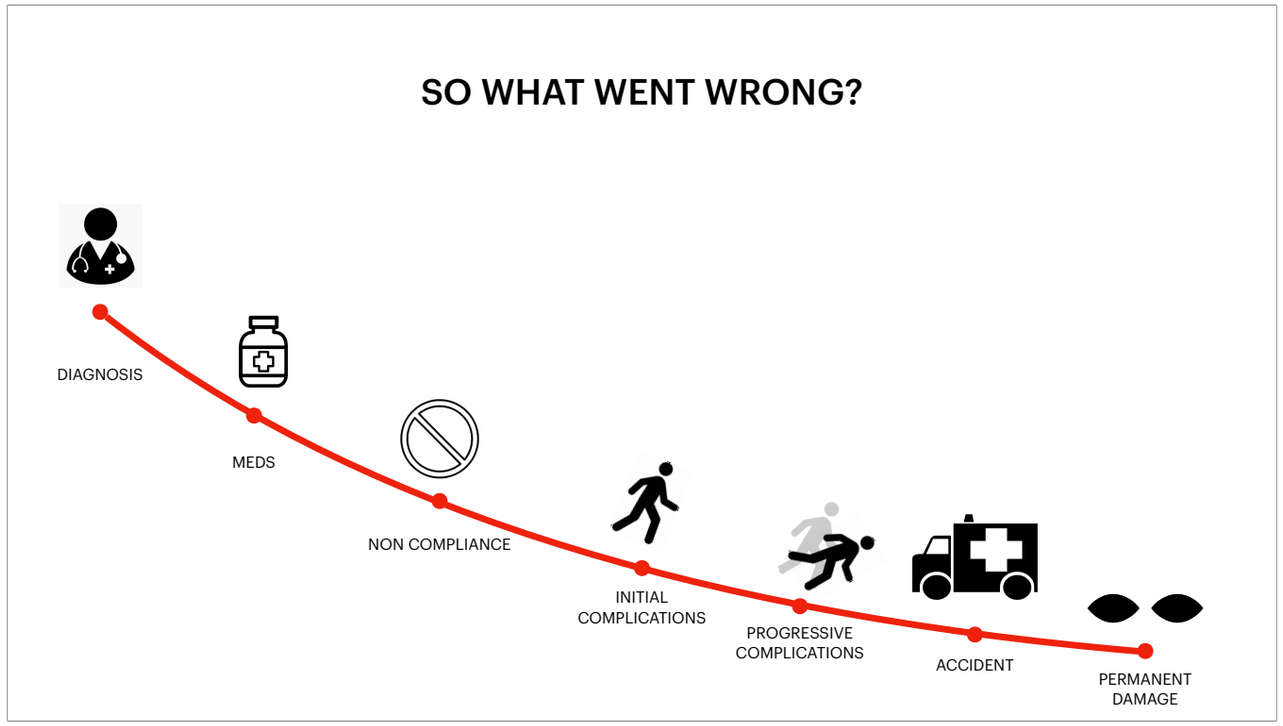
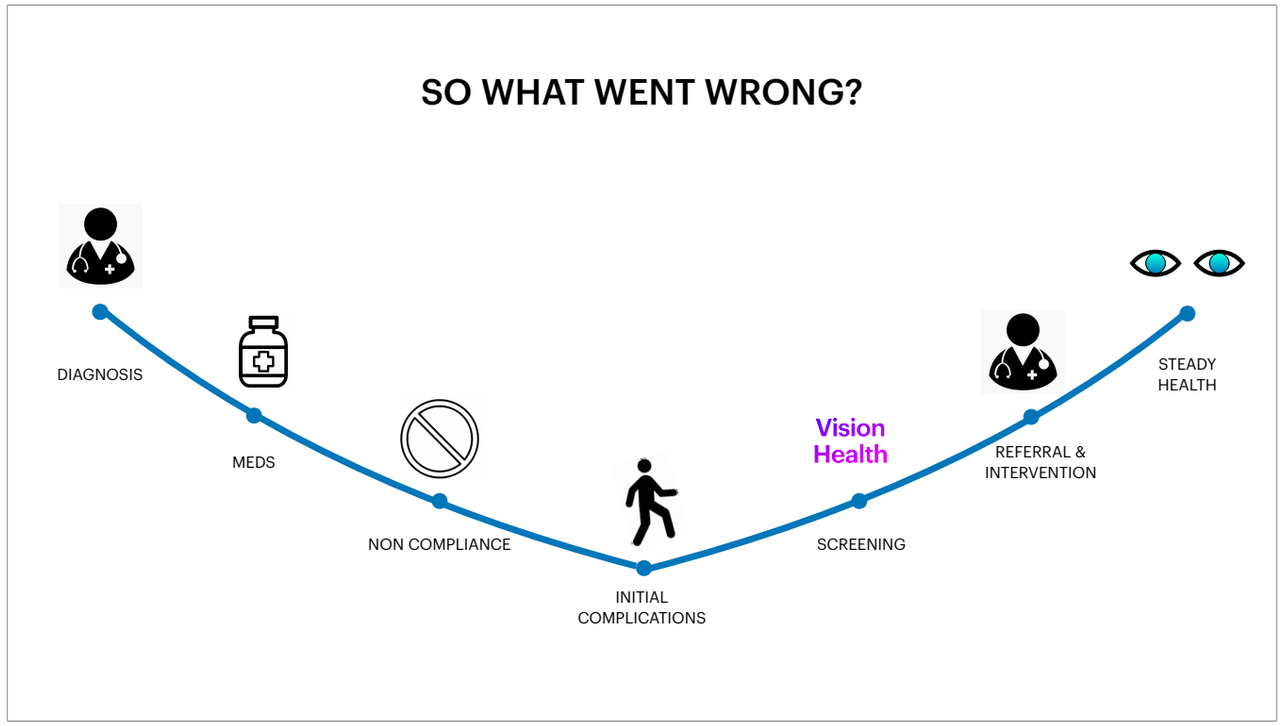
Social Determinants of health



Some blurred vision, which she believes is normal aging

1 Diabetes diagnosis
2 Meds
3 Non compliance
4 Early stage complications: peripheral neuropathy or retinopathy
5 Blurred vision and unsteady walking
6 Fall / accident
7 Total vision loss

Some blurred vision, which she believes is normal aging



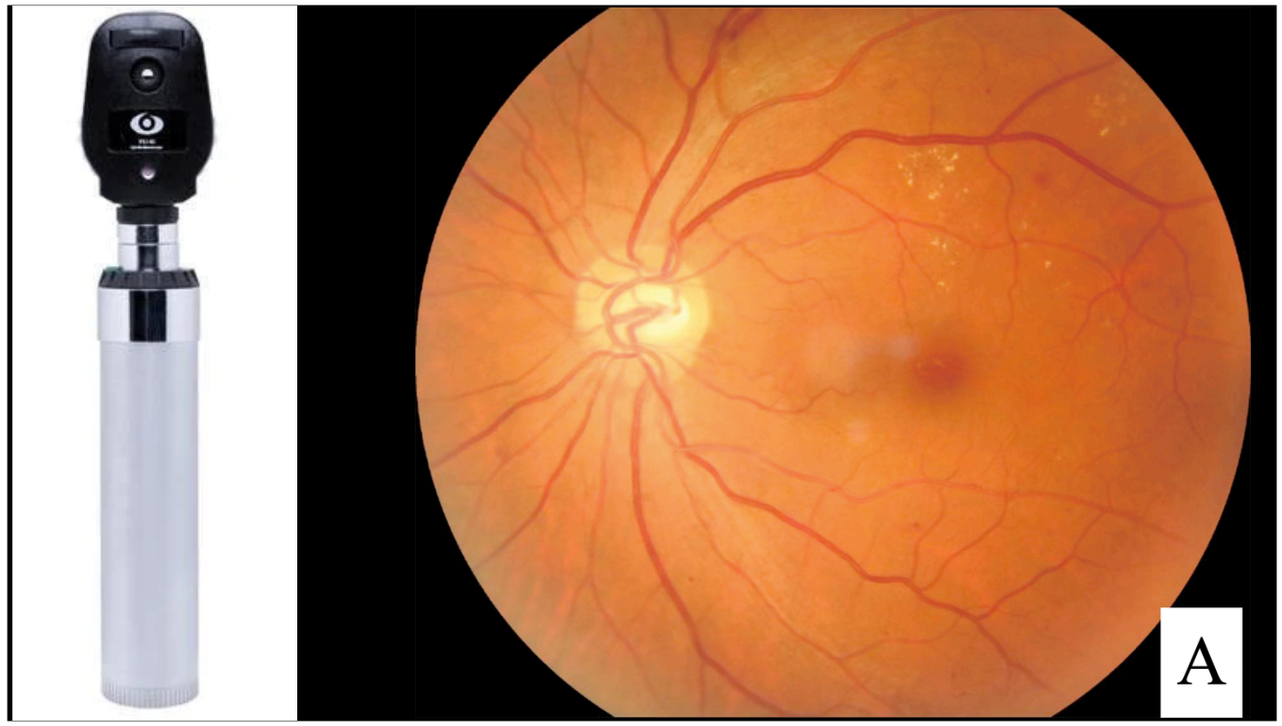
1 Diabetes diagnosis
2 Meds
3 Non compliance
4 Early stage complications: peripheral neuropathy or retinopathy
5 Retinopathy screening with vision health
6 Referral for intervention
7 Maintain steady health

Diabetes is a chronic disease that affects 11.8% of adults globally. It frequently presents without any symptoms, or with non-specific symptoms. Due to the nature of the presentation, as high as one in two diabetic patients are undiagnosed (IDF, 2021; Wichai et al., 2003). Delay in diagnosis or poor compliance to therapy after diagnosis leads to complications of different organ systems and body parts such as eyes (diabetic retinopathy), heart (stroke and cardiovascular accidents), and nerves (peripheral neuropathy, mononeuritis multiplex). (BMJ, 2023)

Early diagnosis and therapy for diabetic retinopathy (DR) reduces risk by 57% (Ting et al., 2015). Disease sequelae begins with minimal decrease in visual acuity, which progresses over time to full blindness. DR is classified into 5 grades of severity: 4 non-proliferative stages and proliferative diabetic retinopathy. DR is one of the leading causes of preventable blindness (WHO, 2022).

The WHO and many developed countries recommend annual eye screening for diabetics which usually involves a retinal imaging through fundography or OCT. Due to operational shortcomings, countries and regions with high degrees of social determinants of health have higher incidence of proliferative diabetic retinopathy due to delayed intervention. Social determinants of health include: poor health literacy, limited access to healthcare, limited number of ophthalmologists (Shukla, 2023; Ghanchi, 2012).

FrieNd-DA
Ministry of Health
5 USD / patient + additional resources
5 million diabetics in Thailand
½ diabetics in Thailand are undiagnosed



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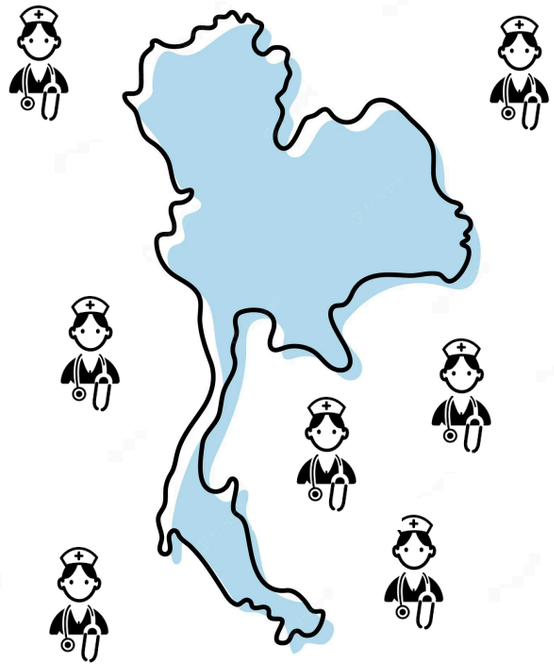
6% prevalence

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0245801#:~:text=The%20overall%20prevalence%20of%20DR%20among%20Thai,T2D%20was%205.0%20to%206.9%25.



Community-based screening tool

Early detection of diabetic retinopathy using computer vision

Augmented intelligence & referral

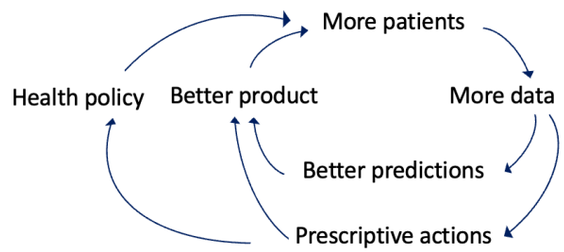
Population health engagement and education

5 million
Diagnosed diabetics

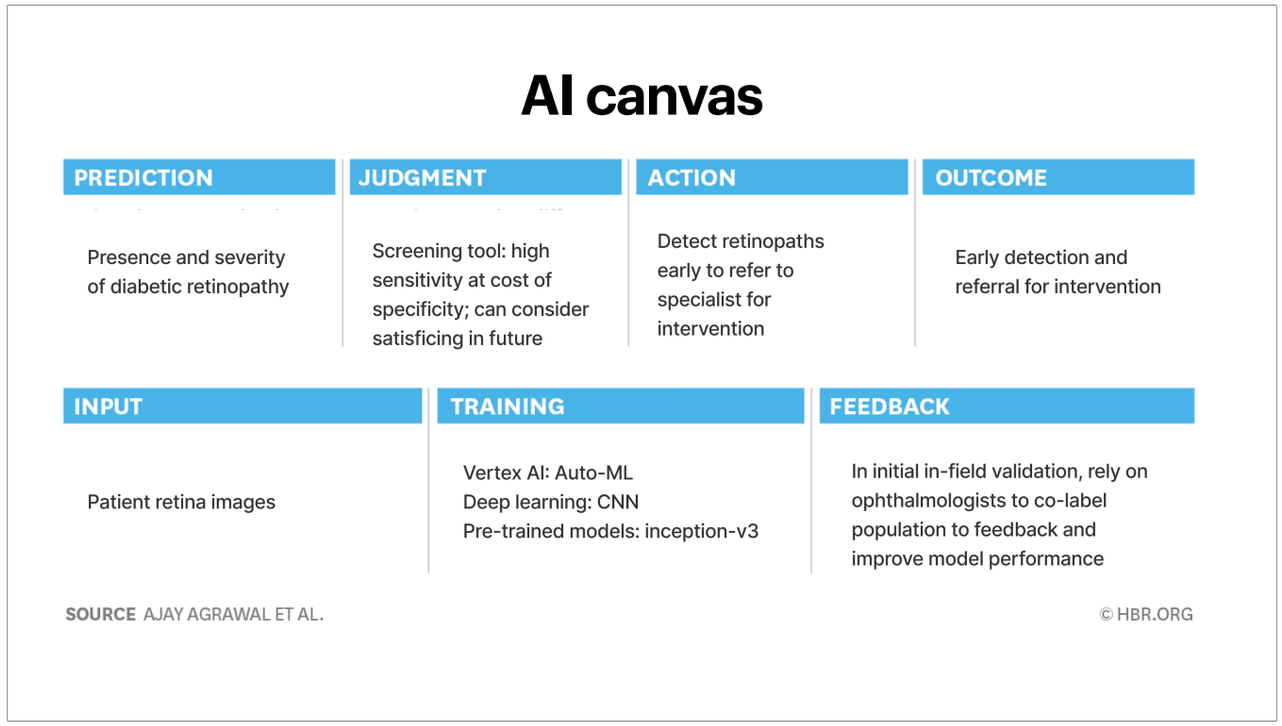
10 million
At-risk patient diabetics

$1 per eye

Data Flywheel



1 USD / eye
Policy
5 million diabetics = 10 m USD / year
Strategic partner - MoH



For our project, we binarized the data to make our task a binary classification.

For our judgment we are prioritizing sensitivity over specificity because it is better to be more cautious and conservative, so that we don't miss anyone who actually has DR.

The action that we take with our prediction is to refer patients to specialists for intervention if the prediction indicates a possibility that they have DR.

This then brings a positive outcome of early detection and intervention of people with DR.

The input of our tool would be patients retina images, which is then used to train a computer vision model, and we would get feedback from professionals to co-label the output of our model to track model performance.

Team

Product Manager: Design and product, UI, stakeholder management, timeline

Data Engineer: dataOps (manage data pipeline, storage, quality)

Data Scientist: modelOps (computer vision, experiment logging)

ML + **Software Engineer**: MLOps (deploying software at scale, UI)

Subject Matter Expert - ophthalmologist: provide subject matter input

Liaison to the Ministry of Health: coordinate with government and Ministry to on compliance, regulations, new projects

For our proposed product team, we would have a product manager that takes care of the stake holders and user experience.

A data engineer manage the data pipeline.

A data scientist to develop the model.

A software engineer to deploy the model at scale.

A specialist that provide su jet matter input on diabetic retinopathy

And a liaison to the ministry of health to coordinate with the government to ensure compliance with regulations and proper deployment of our product into the community.

Defining Value

Early Detection of DR

↘

Fewer People Become Blind

↘

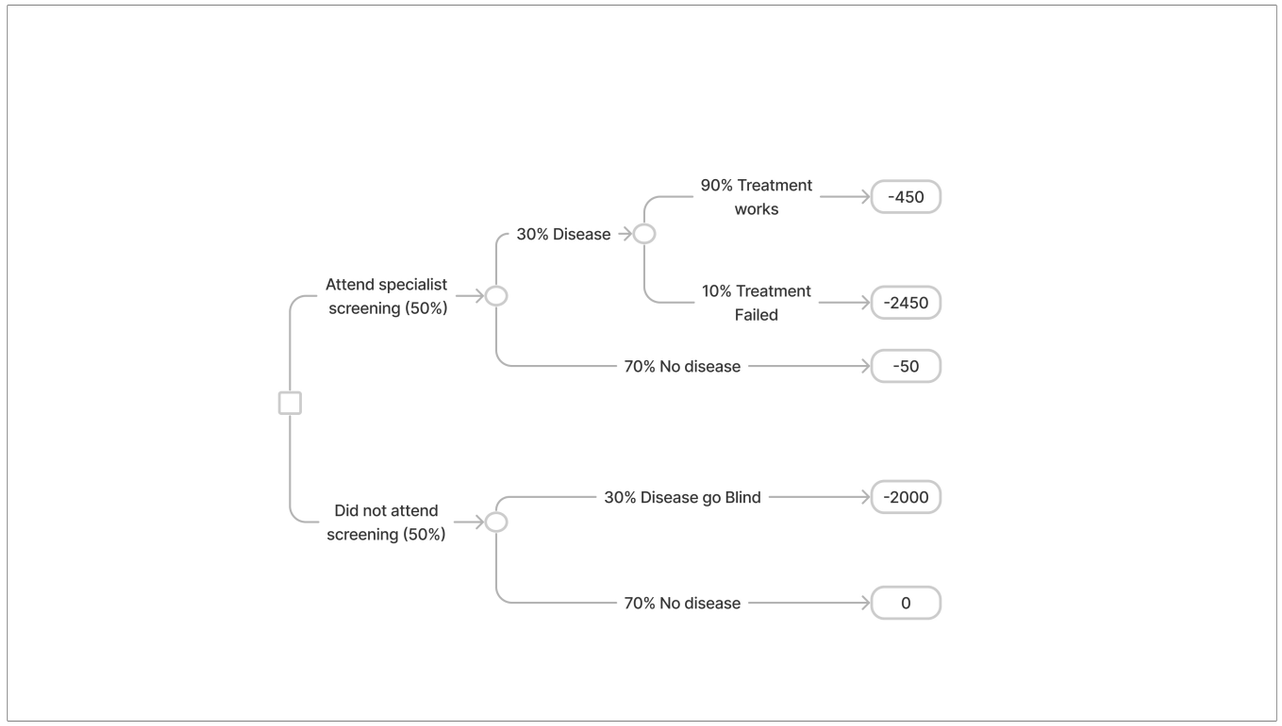
Increased Social Wellbeing!

Since the Ministry of Health’s goal in this problem is to maximize social welfare and improved population health, any cost that we can reduce for the people is value created. Therefore, our goal is to minimize the number of people who go blind due to diabetes, which translates to a creation of monetary value.

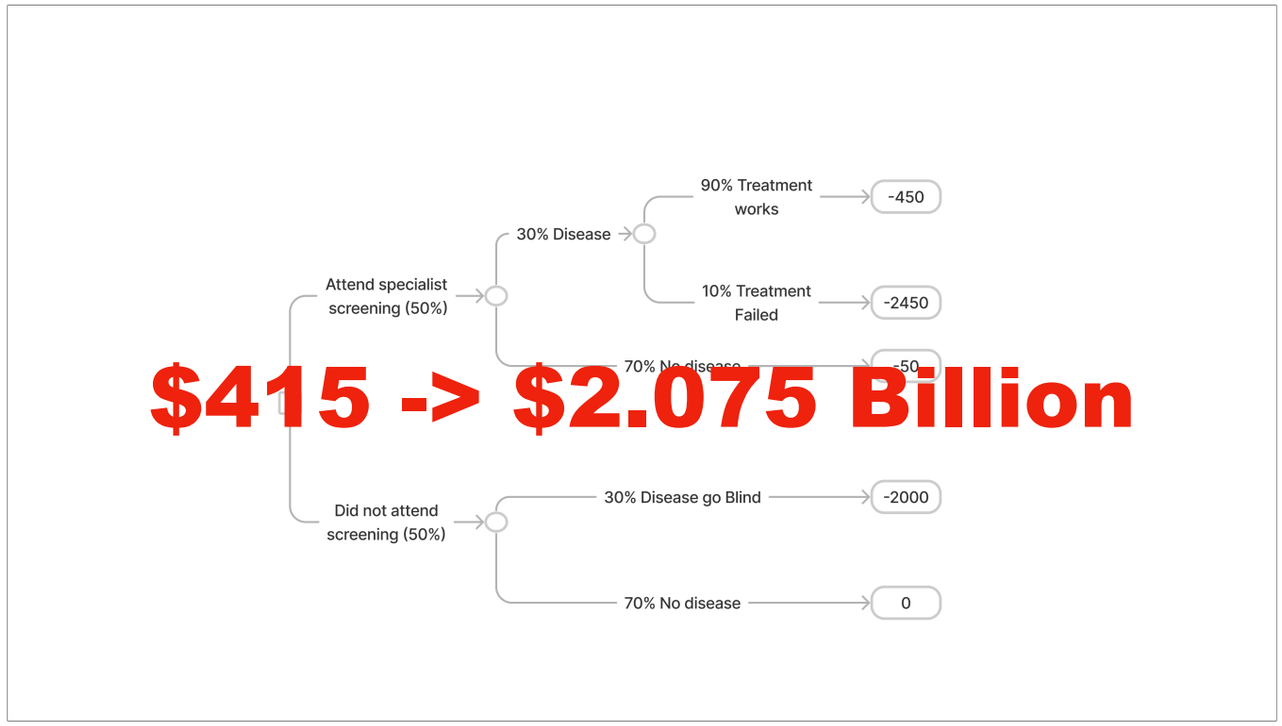
Cost Assumptions

cost of treatment: $400
cost of blindness: $2000
cost of traditional: $50
cost of our screening: $2

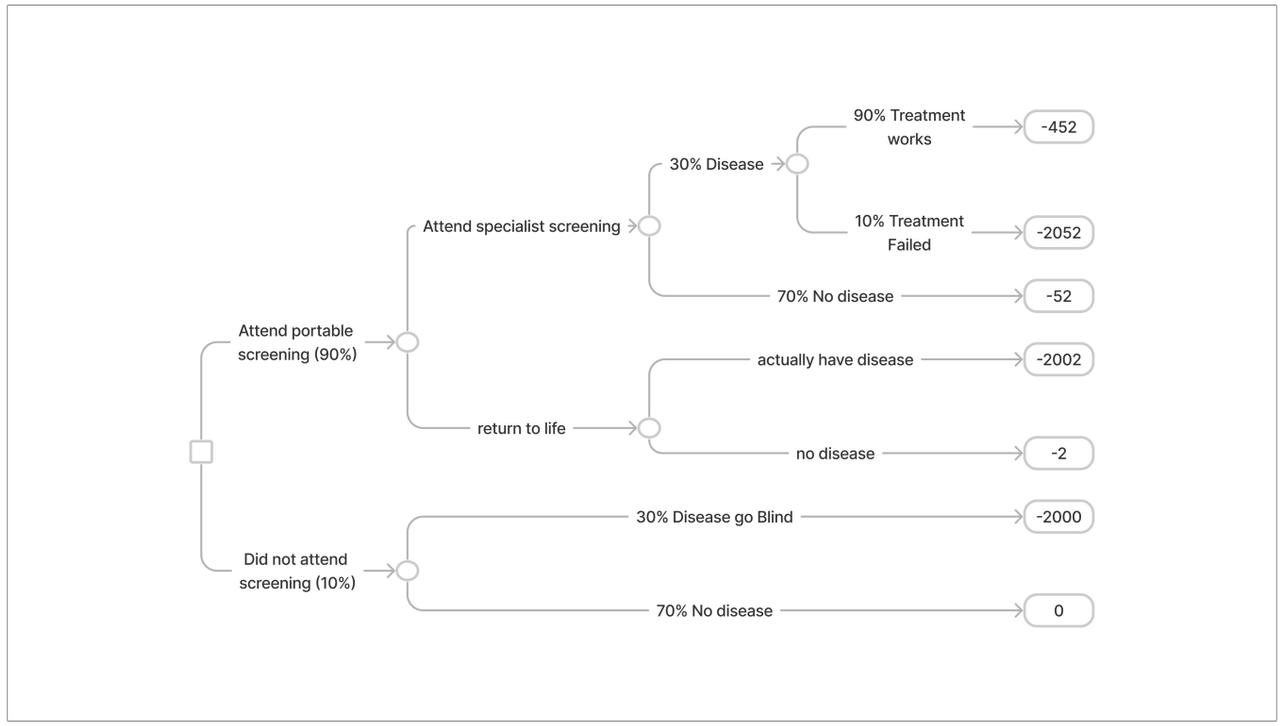
Before we dive into how we calculated the amount of value that our screening tool can provide, we have to put some monetary value on some things such as the cost of blindness treatment, and cost to screening. Note that these costs are per person costs.



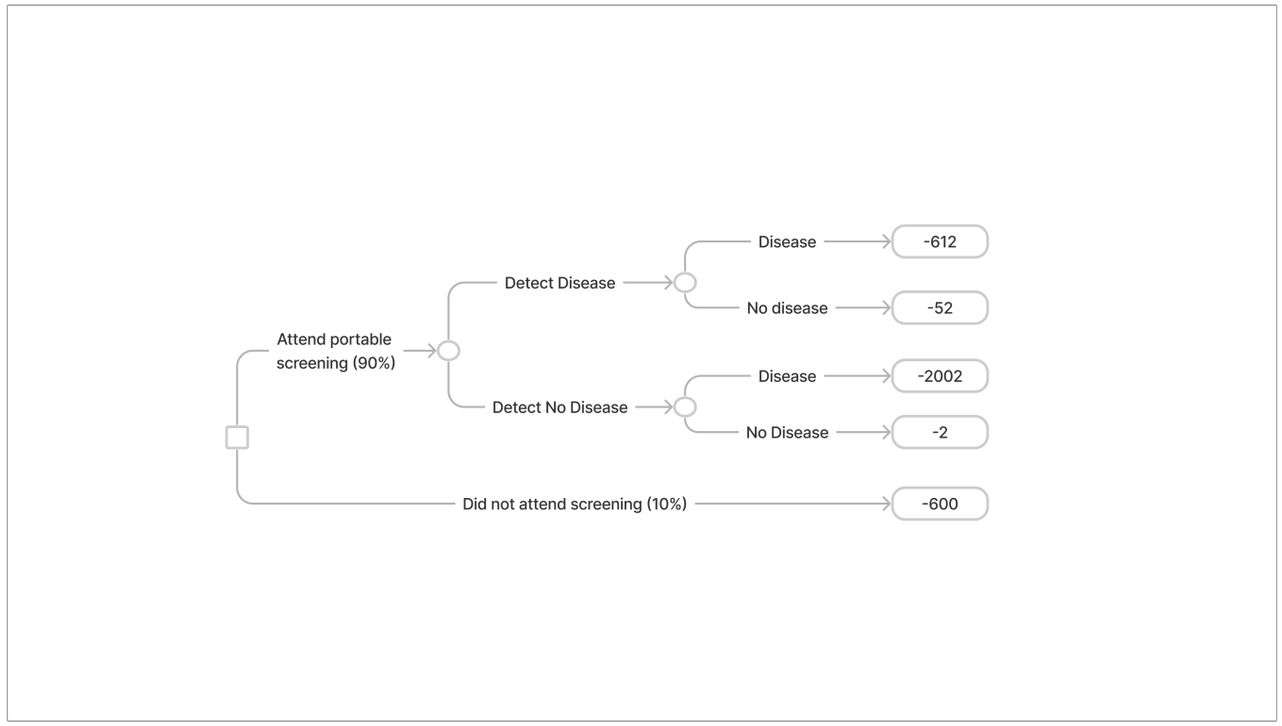
Here’s the decision tree that we made for calculating the expected cost of the disease, screening, and treatment for any person in Thailand.



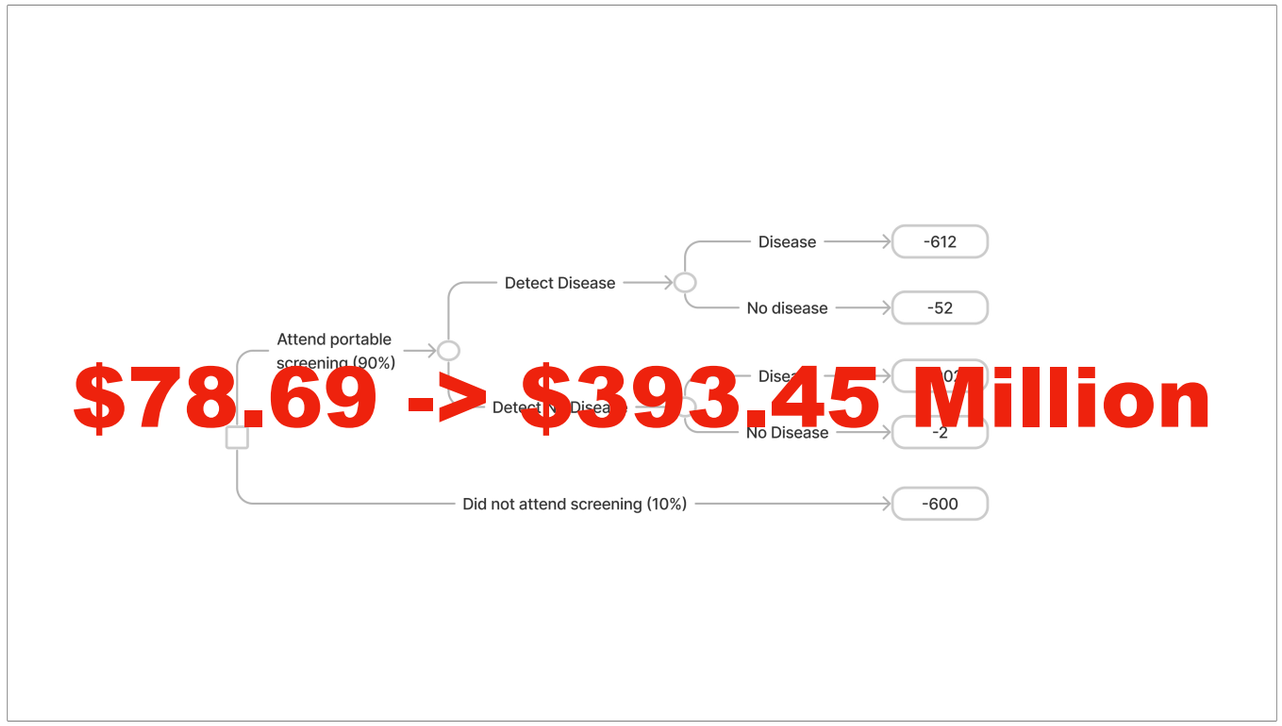
From our calculation, we concluded that there is an expected cost of 415 per person which leads to a cost of $2075Million for the whole country. There is definitely a lot of money to be saved.



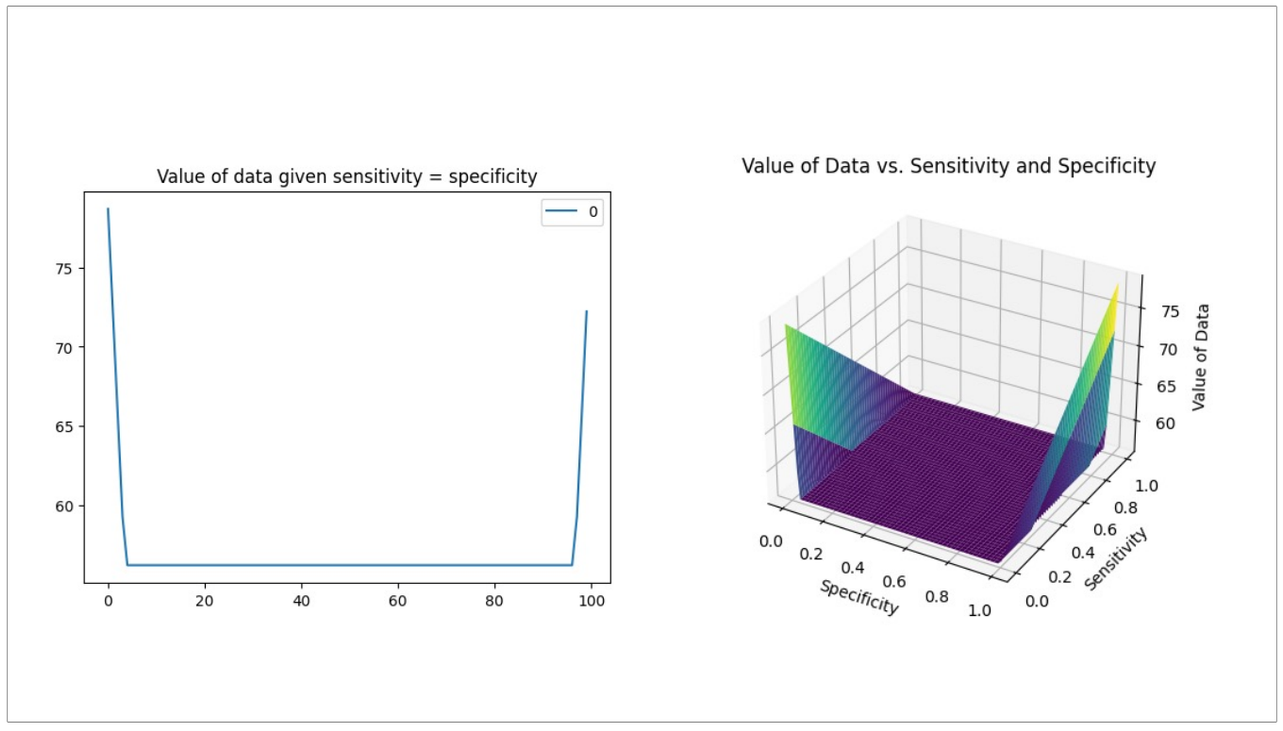
Here’s a decision tree that we created for when we introduce our portable screening device into the system.



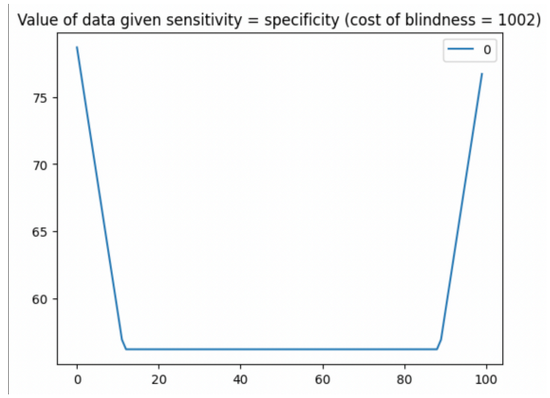
We further simplified it to filter out the uncertain nodes that do not depend on the specificity and sensitivity of our model.

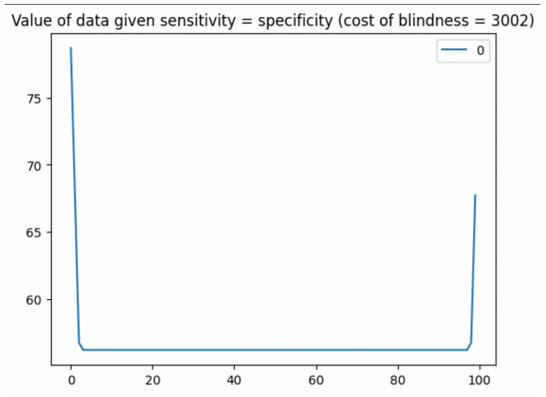


If our model were to be perfect, the value of clairvoyance would be 78.69999999999999



With the current assumptions, our model would have to be quite sensitive and specific in order for us to create value.





Something interesting to note is that for different estimations of the cost of blindness, we would have a different threshold for sensitivity and specificity in which our model creates value. In this case, the higher the cost of blindness, the more specific our model would have to be.

Model type selection, metrics

- Google's Vertex AI AutoML
- CNN (Keras)
- Inception-v3 (Tensorflow)

Mixed results...much to be improved on but performs well as an initial low-cost community-based screening tool to rule out patients before specialist screening

- 94% sensitivity
- 11% specificity

*Optimized based on f1

94%

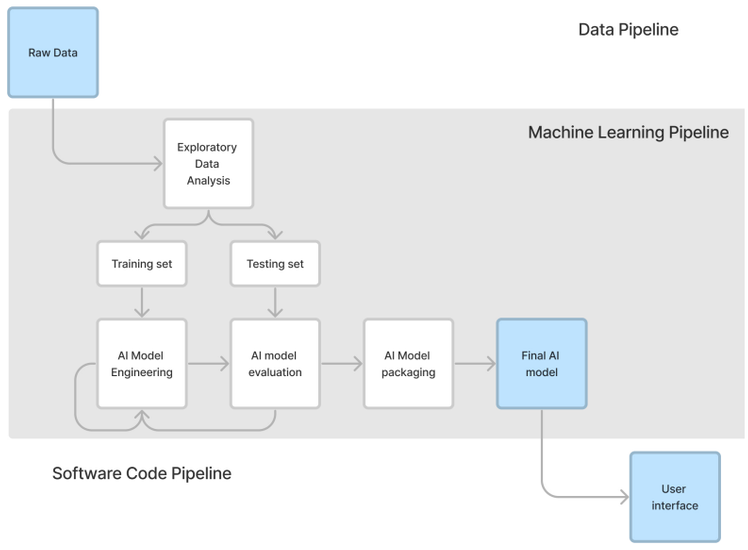
Sensitivity

```
Confusion Matrix:
 [[ 48 401]
 [ 19 158]]
```

For our MVP, we experimented with Google's vertex AI, a pre-trained model, and implemented our own CNN. We got mixed results with a 94% sensitivity and 11% specificity. Although this mode ultimately This model that we created actually creates a value of 56.19999999999999 per person.

We recognize that the assumptions about the system in real life may be overly optimistic, but in this small simulation, we can see that it is indeed possible to create value.

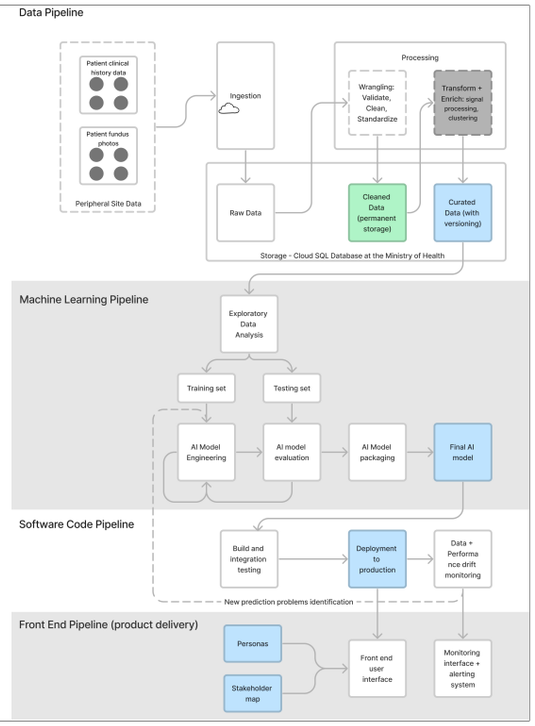
MVP development and lessons learnt



1. Improving from IPYNBs
2. Data science is exploratory...even if the problem has been solved by someone else
3. Scientific process
4. Leverage tech and capital
5. Anticipate unanticipated challenges

The Architecture of our MVP is very simple, we have a set of Raw Data, we process it and feed it into an AI model, we package it and use it to generate responses in our User interface.

Proposed Architecture (launch)



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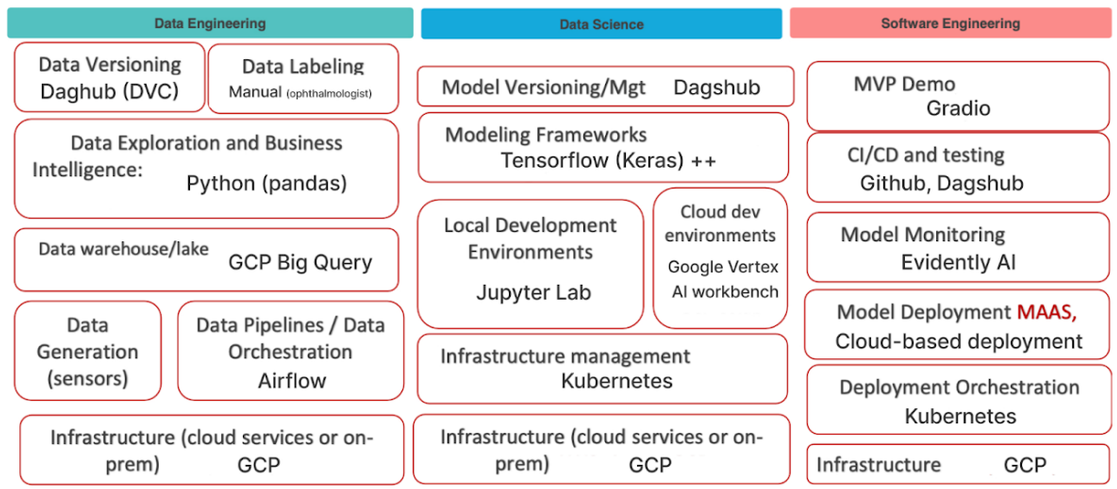
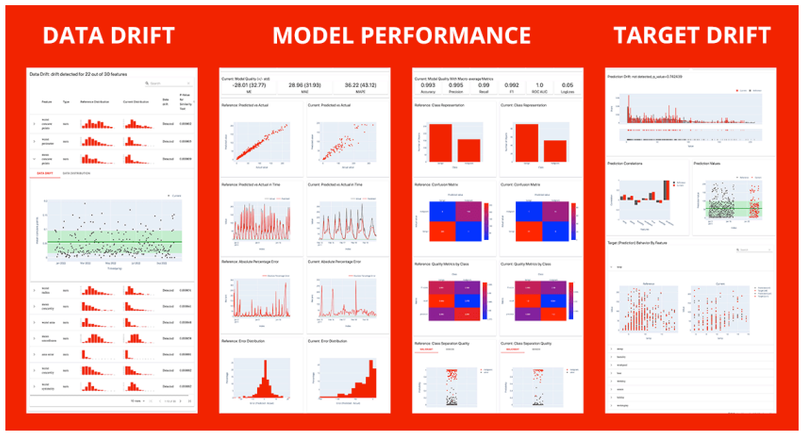


These are the tools that we thought would work for the proposed architecture. For data engineering, we'll use days hub for

Drifts Monitoring

Data, Data Quality, Performance, Target



For the launch, we would also employ drifts monitoring for data drift, model performance, and target drift so that we can retrain the model every year to maintain good results.

Vision Health

[link]