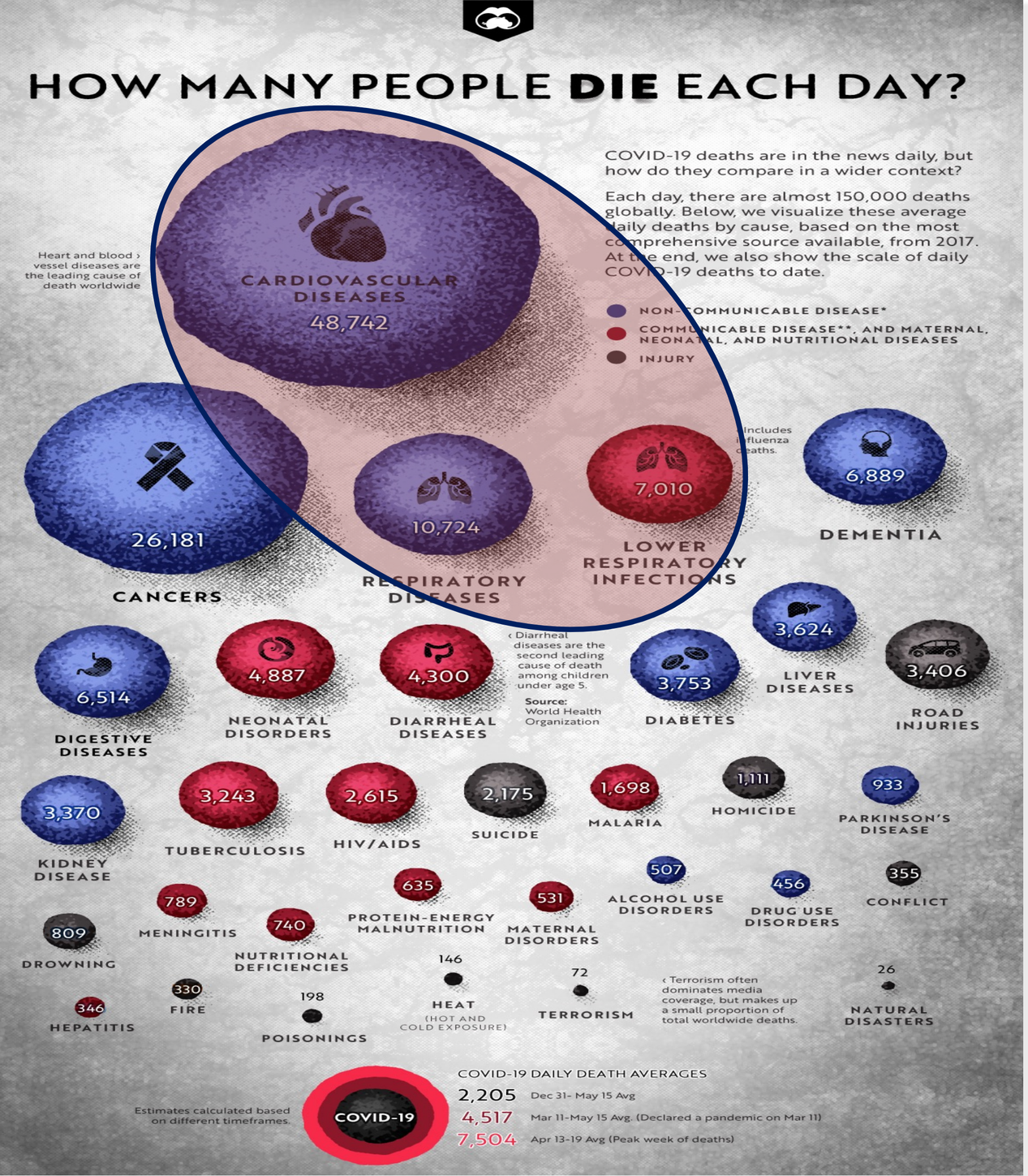


VIRONIX

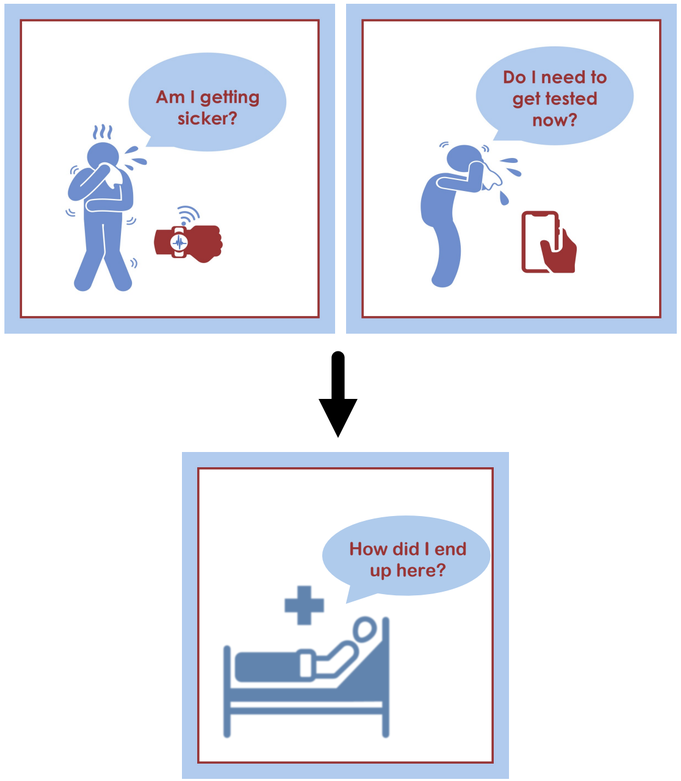
Machine-Learned APIs

Early Detection, Monitoring & Wellness Software for Chronic & Infectious Lung & Heart Diseases

https://vironix.ai

THE PROBLEM

There are no solutions for early detection of at-home exacerbations and infections resulting from infectious and chronic lung & heart disease (COPD, Asthma, Covid-19, Influenza, Heart Failure).



Individuals

The Employer

~$300B in

Office Closures, Lost Productivity, Absenteeism, Workers Comp, Liability, and Direct Spending

The Health Insurer

~$100B in

Avoidable Hospitalization, Healthcare Utilization, and Lost Membership

Monitoring Device

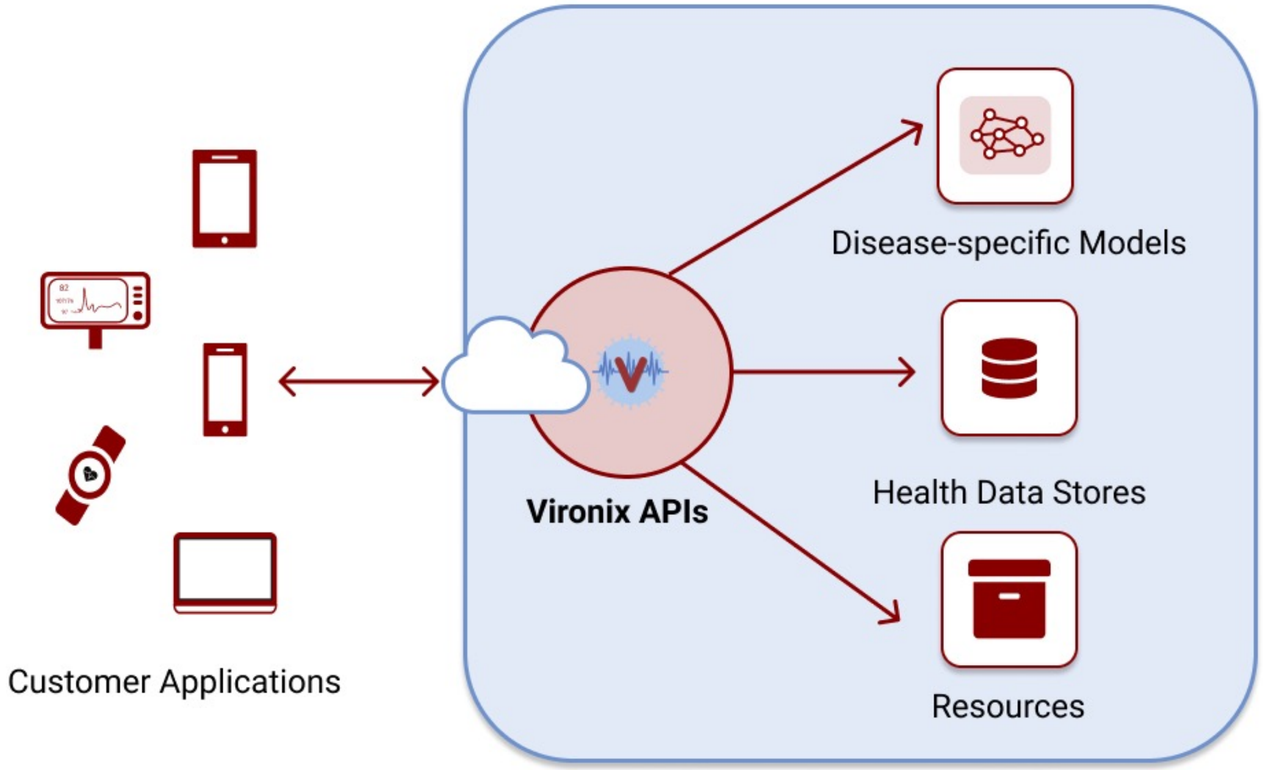
~$25B in

Unrealized Health Monitoring & Analytics Revenue

THE SOLUTION: VIRONIX MANAGED APIs

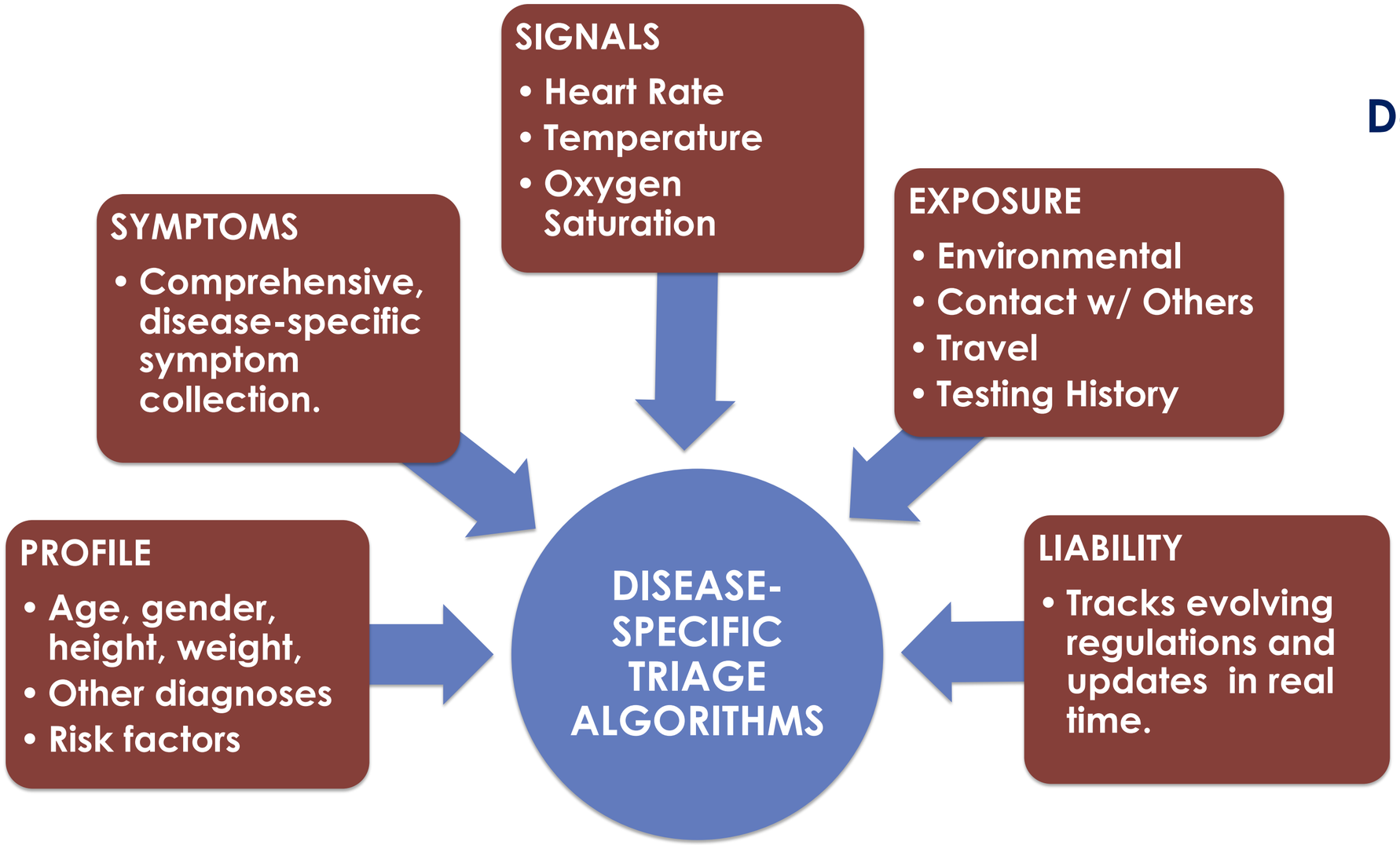
Hardware Agnostic Machine Learned Algorithms & Disease Management Workflows That Provide At-Home:

- **Early Detection** of Health Deterioration
- Proactive Personalized Decision Support for **Early Intervention**
- Interpreted Continuous Monitoring for **Ongoing Disease Management**



- ✔ Personalized
- ✔ Accessible
- ✔ Therapeutic
- ✔ Compliant
- ✔ Scalable
- ✔ Low-Cost
- ✔ Clinically Tested
- ✔ Secured Databases

HOW DOES VIRONIX WORK?



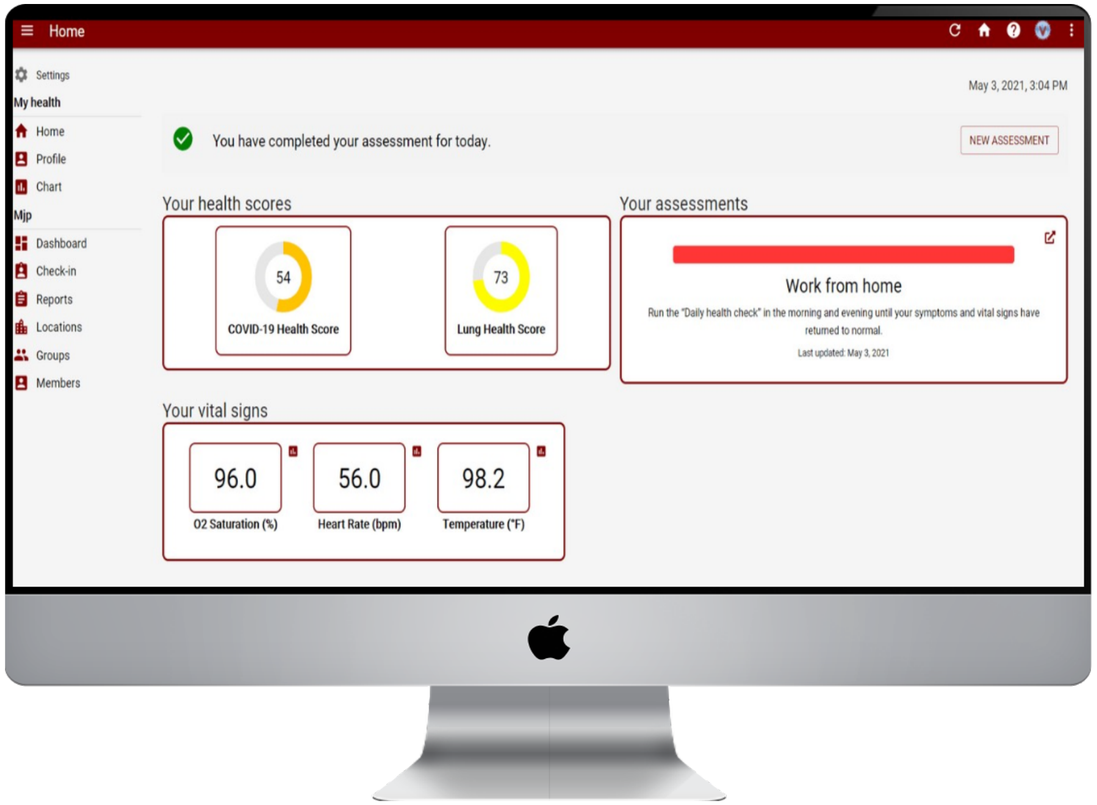
Data used by Vironix is:

- ✔ Accessible to Consumers
- ✔ Comprehensive
- ✔ Optimally Gathered

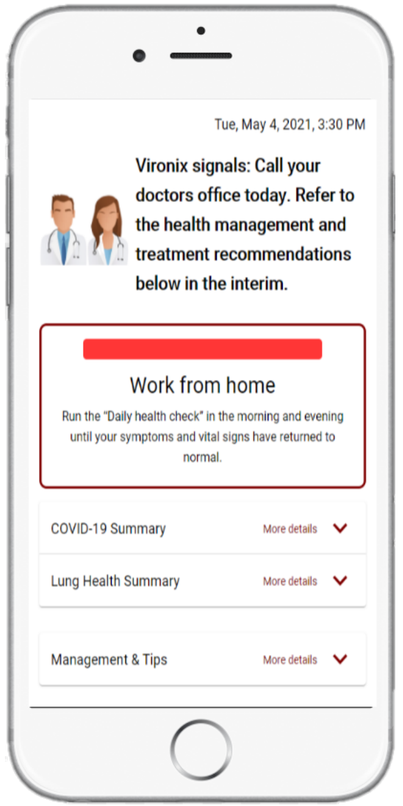
HOW DOES VIRONIX WORK?

Vironix Managed APIs take in basic consumer health data and return health assessments and decision support to individuals and institutions through numerous potential hardware and software systems.

Health Tracking and Work-From Home Recommendations



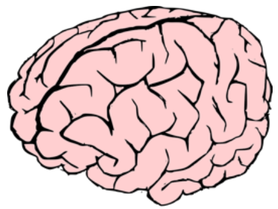
Personalized, On-Demand ML Flare-up & Infection Assessments



Continuous Interpreted Monitoring

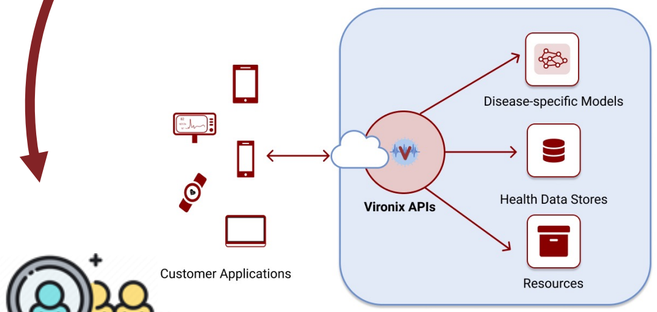
- Rapid Health Assessment
- Continuous Monitoring
- Vitals At A Glance
- WFH Recommendation
- Health Scores
- Prevention Guidelines

VIRONIX INNOVATION & PRODUCT ROADMAP



Concept &
MVP Development

Active Prototyping



Customer Validation

Clinical Evaluation

SAAS SOFTWARE

B2B

Per member per month licensing revenue

API SUBSCRIPTION

B2B/B2B2C

Per member per month or per API call reimbursement

Lean Iterative Product Optimization & Clinical Efficacy/User Testing

THE VIRONIX TEAM

Sumanth Swaminathan, PhD
Founder, Director, and CEO

Botros Toro, PhD
Founder & Product Specialist

Mahesh Visvanathan, MS/MBA
Chief Bus Dev & Operations Officer

Sriram Ramanathan, MS
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Samir Parekh, MD Oncology

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Trial enrolment & management

Mary Madura
Trial strategy, enrolment & management

Nicole Gentes
Trial Enrolment & management

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Data Science

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Grants Lead

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Full Stack Development

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M&A & Investing

Govind Shantharam, MD
Medical Resident

Jeffrey Hanson, MPH
Healthcare Strategy

Operations

HTFL, LLC
General Council

Kavita Rajput
Design

Michael Nilo
Regulatory

PULMONARY ILLNESS

CHRONIC LUNG DISEASE: COPD

What is COPD?

Chronic Obstructive Pulmonary Disease refers to a group of diseases that cause airflow blockage & breathing related problems. Chronic bronchitis and emphysema are included in this group.

COPD Triggers?

- Tobacco smoke (most common).
- Air pollutants.
- Respiratory infections

Extent of Problem

- 3rd leading cause of death (2011)
- 15 million people report that they have COPD
- 16.4 million days of work lost annually.
- 822,500 annual hospitalizations (2008)
- 6.1 billion spent on hospitalization alone in 2008.

Symptoms of COPD?

- Coughing
- Shortness of Breath
- Wheezing
- Sputum color/volume

Cost of COPD?

- $32 billion annual spending on COPD treatment (2010)
- Estimated increase to $49 billion by 2020

(Information Acquired From the Center For Disease Control and NIH)

CHRONIC LUNG DISEASE: ASTHMA

What is Asthma?

Asthma is a chronic disease that affects the airways in the lungs. During an asthma attack, airways become inflamed making it hard to breathe.

Asthma Triggers?

- Environmental Allergens
- Tobacco smoke
- Air Pollution
- Airway Infections
- Occupational Hazards

Extent of Problem

- 1 in 12 adults have asthma (2010)
- 1 in 11 children have asthma (2010)
- 10.5 million missed school days (2008)
- 14.2 millions missed work days (2008)
- ~ 9 people die from asthma per day
- 479,300 hospitalizations (2009)
- 1.9 million ER visits
- 8.9 million doctor visits

Symptoms of Asthma?

- Coughing
- Shortness of Breath
- Wheezing
- Pain or Tightness in the Chest

Cost of Asthma?

- Costs the USA 56 Billion per year
- Annual Cost Per Child in 2009 : $1039

(Information Acquired From the Center For Disease Control)

Disease Specific Early Detection & Triage Algorithms

Method 1: Modeling Disease Severity on Clinical Characteristic Data

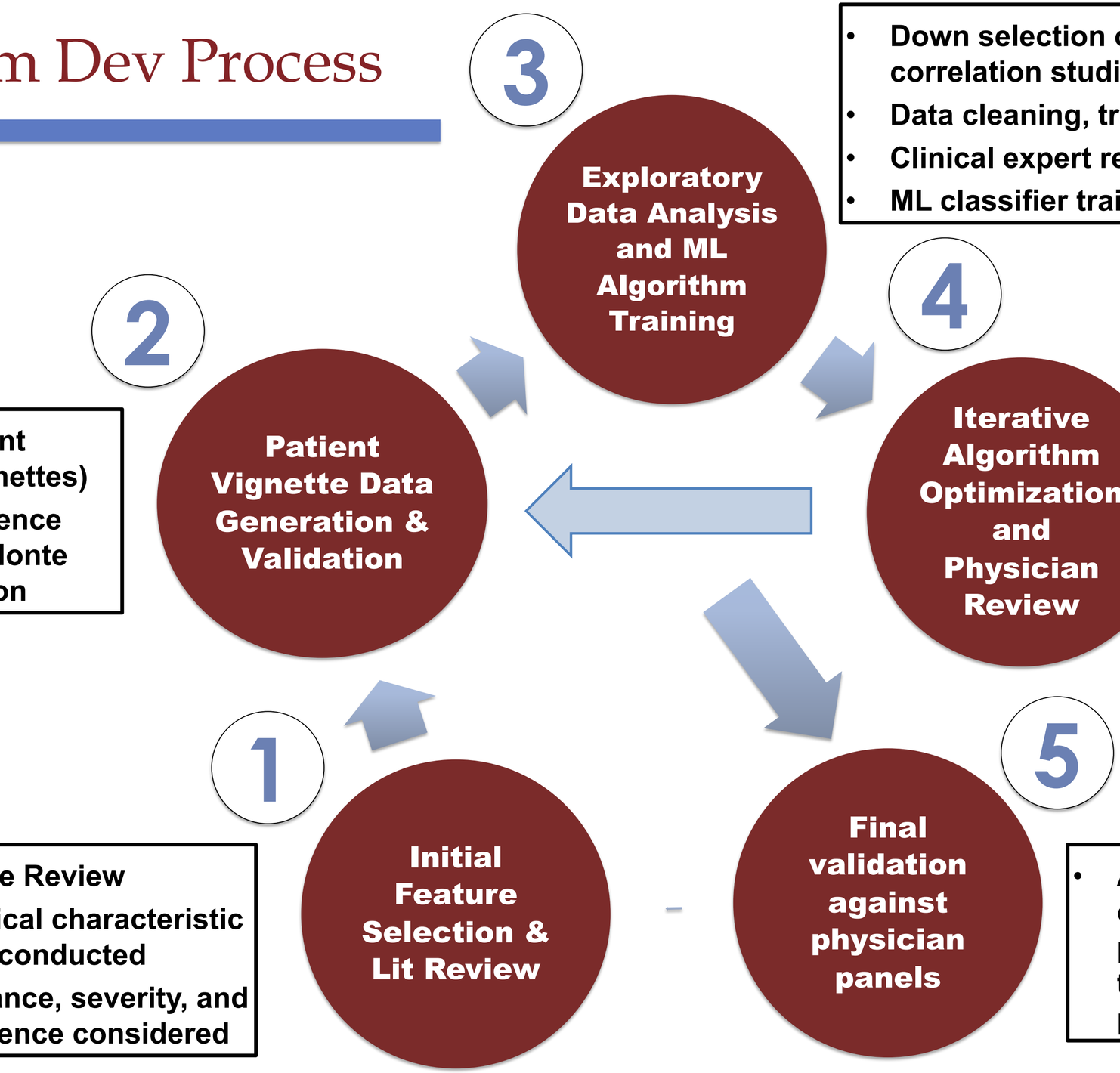
Characteristic	All Patients (N=1099)	Disease Severity	
		Nonsevere (N=926)	Severe (N=173)
Age			
Median (IQR) — yr	47.0 (35.0–58.0)	45.0 (34.0–57.0)	52.0 (40.0–65.0)
Distribution — no./total no. (%)			
0–14 yr	9/1011 (0.9)	8/848 (0.9)	1/163 (0.6)
15–49 yr	557/1011 (55.1)	490/848 (57.8)	67/163 (41.1)
50–64 yr	292/1011 (28.9)	241/848 (28.4)	51/163 (31.3)
≥65 yr	153/1011 (15.1)	109/848 (12.9)	44/163 (27.0)
Female sex — no./total no. (%)	459/1096 (41.9)	386/923 (41.8)	73/173 (42.2)
Smoking history — no./total no. (%)			
Never smoked	927/1085 (85.4)	793/913 (86.9)	134/172 (77.9)
Former smoker	21/1085 (1.9)	12/913 (1.3)	9/172 (5.2)
Current smoker	137/1085 (12.6)	108/913 (11.8)	29/172 (16.9)

1. Acquire Covid-19 clinical characteristic data from evolving human trials literature and software users
2. Use Bayesian inference to convert characteristic data into vignettes for a training/validating prediction algorithm
3. Build ML classification models for predicting health severity from a patient state
4. Deploy behind a product and analyze

$$\boldsymbol{P(feature|severity) = \frac{P(severity|feature)}{P(severity)} \cdot P(feature)}$$

S. Swaminathan, et al., CovidX: Remote Screening, Surveillance, Triage, and Management of Novel Coronavirus https://covidx.vironix.ai/CovidX_CoronaVirus_WhitePaper04052020.pdf

Algorithm Dev Process



- Global Literature Review
- Exhaustive clinical characteristic data extraction conducted
- Temporal relevance, severity, and linear independence considered

- Generate patient scenarios (vignettes)
- Bayesian inference coupled with Monte Carlo Simulation

- Down selection of features, PCA, and feature correlation studies
- Data cleaning, transforming, and visualization
- Clinical expert review
- ML classifier training and cross validation.

- Feature importance studies
- Algorithm stacking
- Clinical expert review
- Comprehensive optimization for accuracy, sensitivity, specificity, ppv, and npv

- Algorithm validated against panel opinion of internists, triage nurses, pulmonologists and ID specialists triaging 100 statistically diverse patient scenarios (vignettes)

Performance and Trends

Accuracy	87.6%
Sensitivity	85.5%
Specificity	87.8%
PPV	41.2%
NPV	98.4%

Table 3: *CovidX* model performance when classifying characteristics of COVID-19 patients who are likely to need significant care.

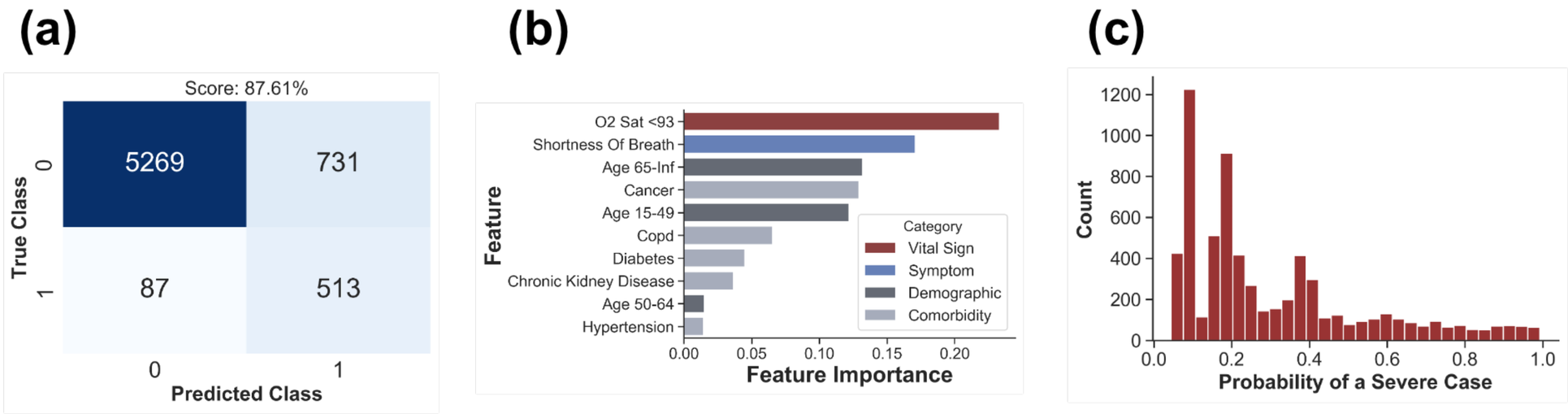
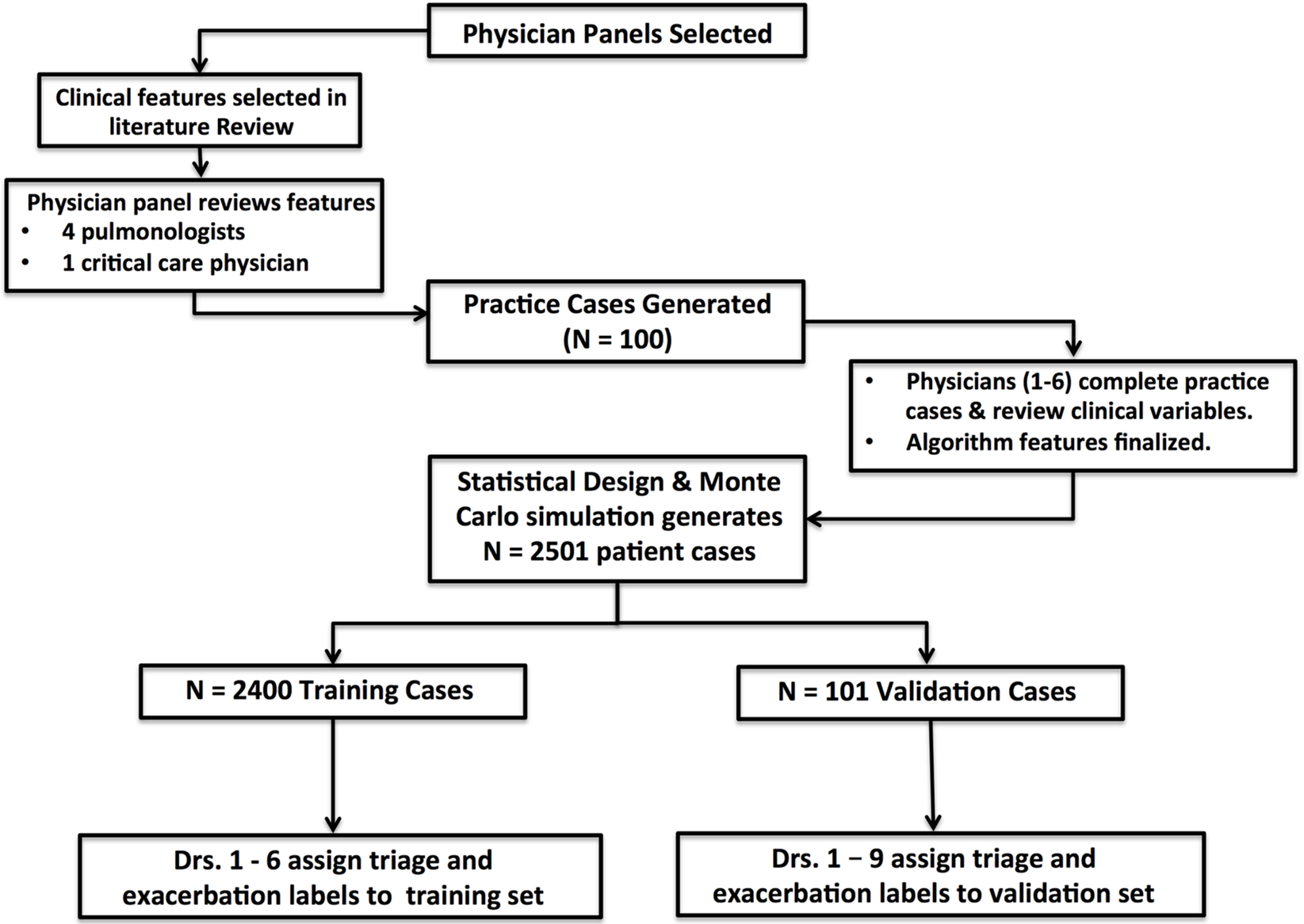


Figure 4: Performance studies of *CovidX* disease severity algorithm. The confusion matrix in figure (a) shows the overall classification accuracy (87.6%) and missed classifications in each of the nonsevere and emergency medical event classes. The feature importance figure (b) indicates that the *CovidX* algorithm weights shortness of breath, age, and comorbidities among the top considerations for discerning illness severity. Finally, the distribution of algorithm severity probabilities in figure (c) yields a profile of severities that is consistent with treated patients in the EU and China.

S. Swaminathan, et al., CovidX: Remote Screening, Surveillance, Triage, and Management of Novel Coronavirus https://covidx.vironix.ai/CovidX_CoronaVirus_WhitePaper04052020.pdf

Method 2: Predicting on Physician Labeled Data



Algorithms Are Sensitive, Specific, and Out-Triage Specialists

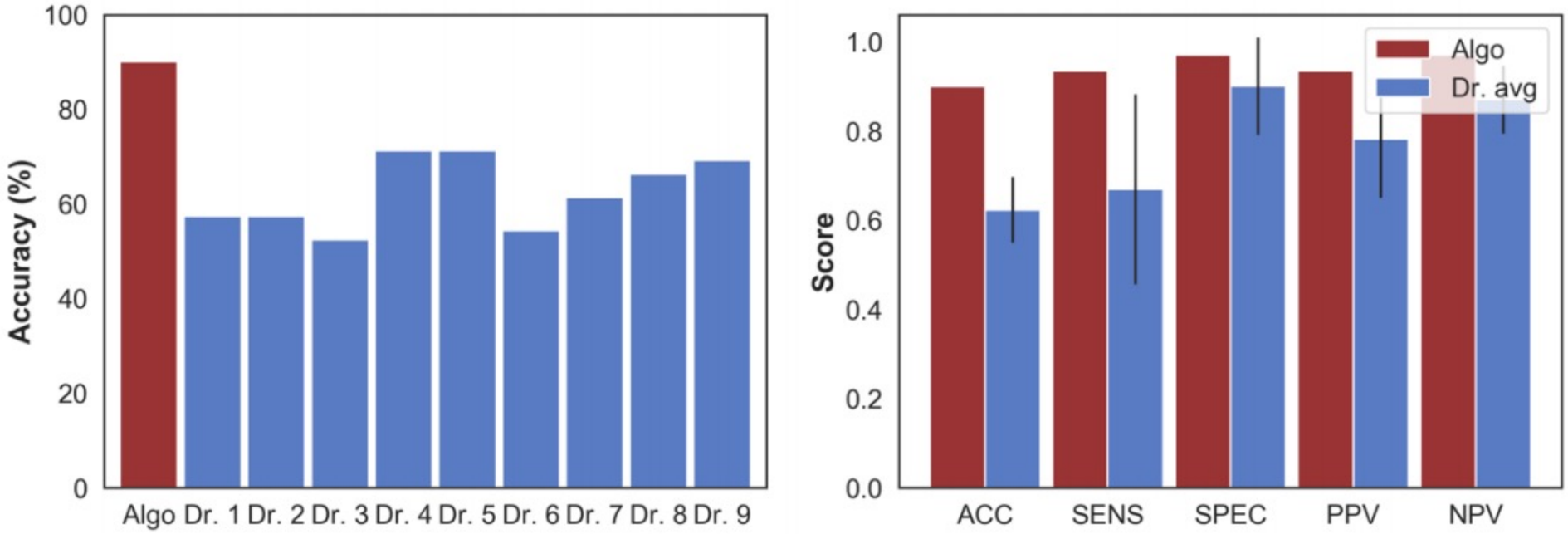


Figure 5: Data comparing individual pulmonary specialist performance with respiratory triage algorithm performance in a 100-patient, out-of-sample validation test that assessed (a) agreement with panel consensus on the severity of medical care needed and (b) the accuracy, sensitivity, specificity, positive predictive value, and negative predictive value in identifying cases that require emergency room care.

Algorithms Err in Favor of Patient Safety

(a)

ML Algorithm

True Class \ Predicted Class	OK	PLAN	DOC	ER
OK	5	0	0	0
PLAN	0	9	7	0
DOC	0	0	49	1
ER	0	0	4	26

Top Physician

True Class \ Predicted Class	OK	PLAN	DOC	ER
OK	4	1	0	0
PLAN	3	11	2	0
DOC	1	10	39	0
ER	0	0	9	21

(b)

ML Algorithm

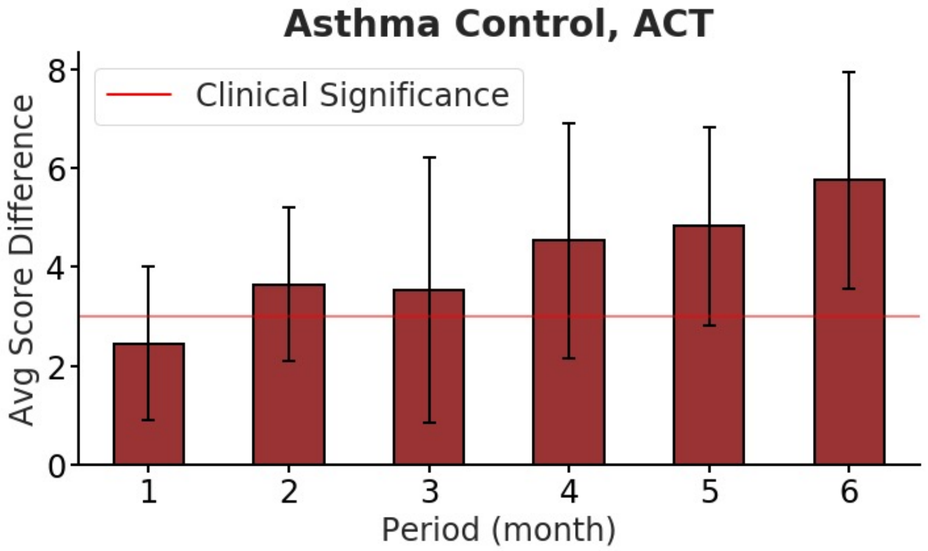
True Class \ Predicted Class	NEG	POS
NEG	29	2
POS	1	69

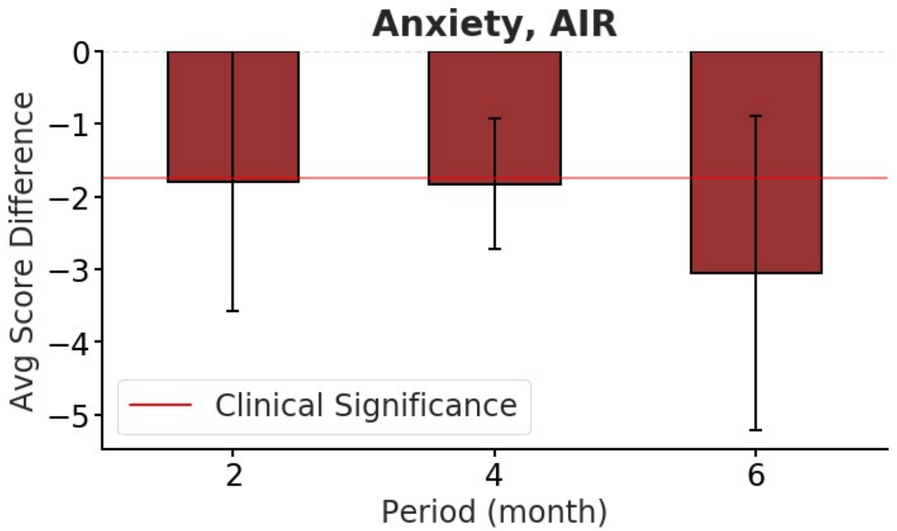
Top Physician

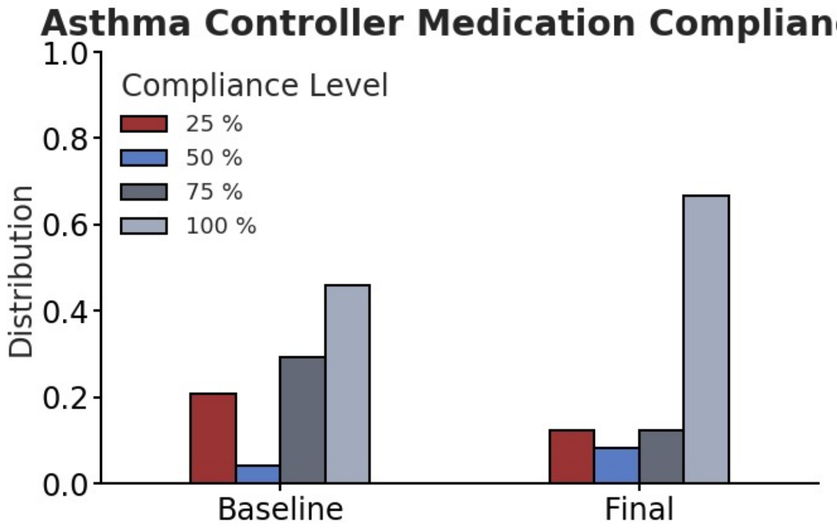
True Class \ Predicted Class	NEG	POS
NEG	28	3
POS	2	68

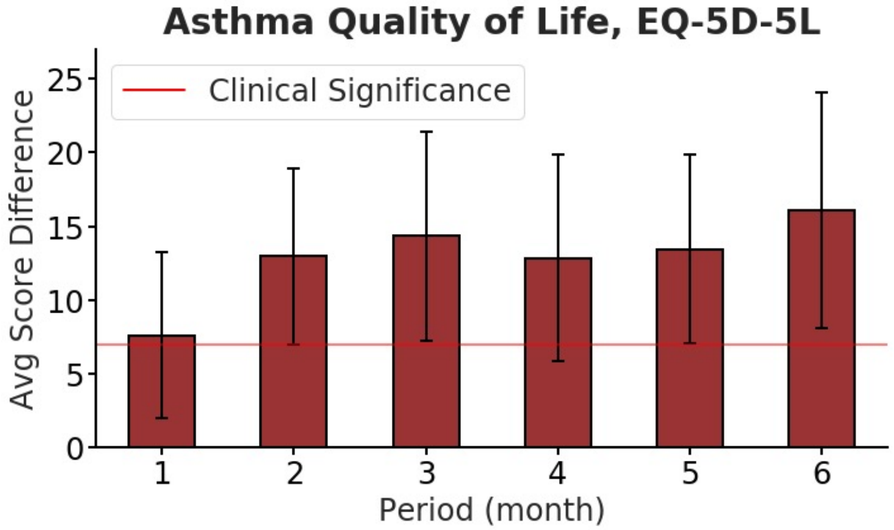
Product Efficacy & Testing

Lung Disease Mobile Apps Improve Symptoms, Anxiety and QOL





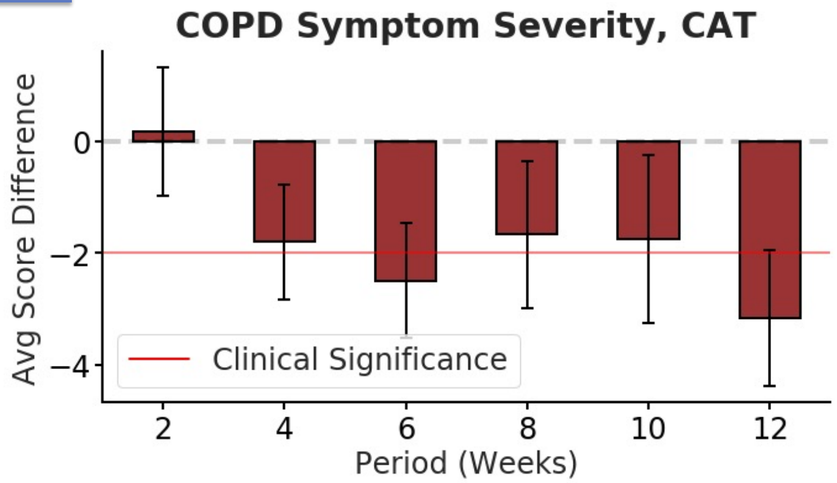


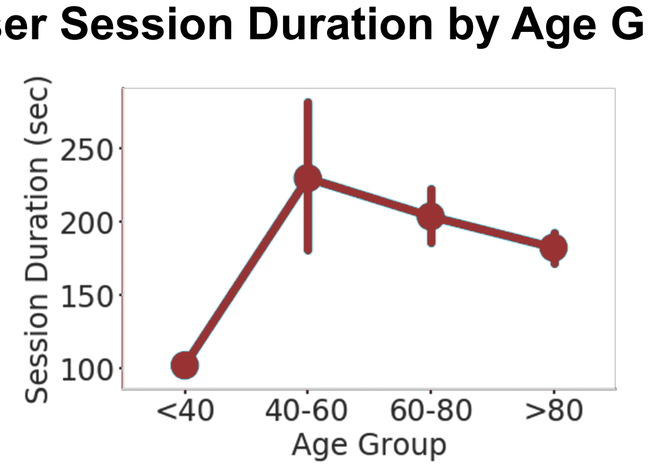


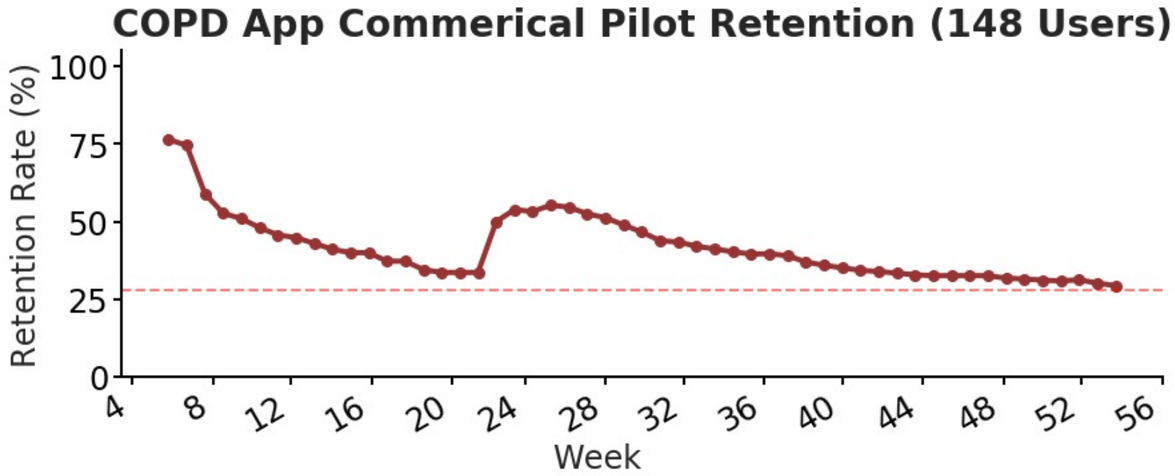
COPD App Reduces Symptoms and Shows Long-Term Engagement

Consumer Pilot: 12-months

- *Disease Category: COPD*
- *Study Endpoints/Measures: CAT (symptom severity) and Retention*
- *Period: 12 months*
- *Population: 148 COPD patients*
- *age>40 with no other major respiratory condition.*

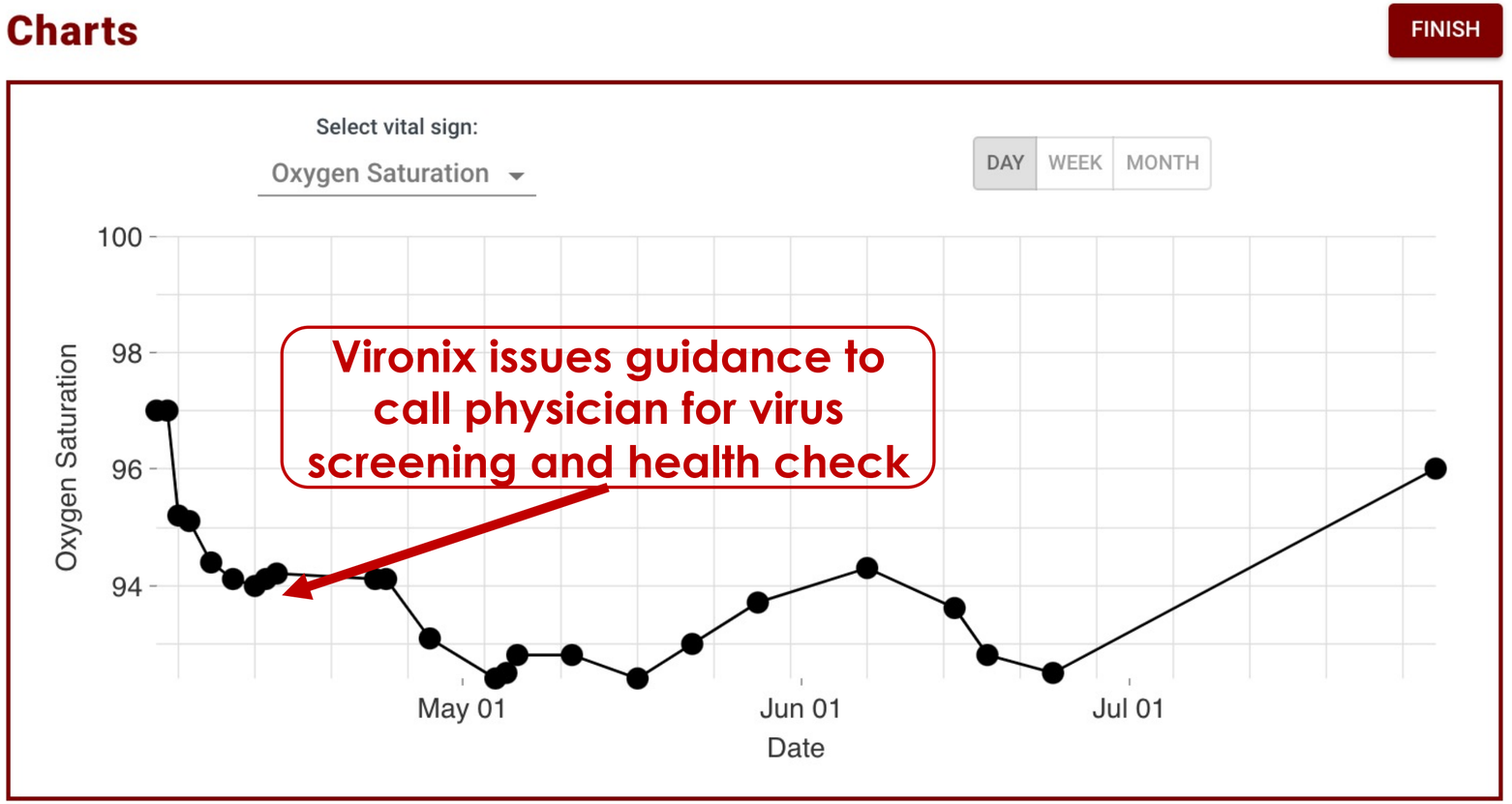






Organic App Usage in Commercial Pilot Shows 30-day retention steadying at **25% after a full year (well above national mobile app averages of all types)!**

VIRONIX FLAGS ASYMPTOMATIC RESPIRATORY INFECTIONS



- Oxygen saturation
- Heart rate
- Temperature
- General activities

Users can monitor and catch health deterioration trends early and in real-time

Vironix maintains *Industry standard, secured, & HIPAA compliant FHIR data stores*

MPI PROBLEM

MPI 2021: Fundamental Questions

I. What collection of patient signs, symptoms, and baseline health factors are indicative of severe and non-severe presentations of chronic lung disease?

II. Can we generate realistic patient scenarios from clinical characteristic data that have labels of mild/moderate/severe?

III. What set of patient health states are indicative of a lung exacerbation and a septic infection? Can we understand the likelihood of misdiagnosing a patient's symptoms?

IV. Can we build an analytic model to predict patient scenarios indicative of a mild/severe presentation of chronic lung disease?

V. What are performance differences between models built using 1) physician labelled data vs 2) clinical characteristic severity data.

MPI 2021: Tasks to Complete

1. **Complete exploratory data analysis on physician labeled and clinical characteristic datasets.**
    1. Visualize relationships between variables and identify:
        2. Trends between patient health variables and medical events
        3. Physician biases
        4. Feature correlations and relative importance.

2. **Train and validate a set of prediction models to:**
    1. Predict mild vs severe presentations of Chronic Lung Disease using both physician labelled data and clinical characteristic data.
    2. Indicate the set of signs, symptoms, and baseline health descriptions that are indicative of a “high risk medical event”.

Logistics

I. Programming Language Preferences:
   I. Python
   II. R
   III. Matlab

II. Please comment code extensively and break code into functions/subroutines!
   I. Try as much as possible to conform to PEP 8 style guide for python programming https://www.python.org/dev/peps/pep-0008/

III. Remember to keep good records of citations used.

IV. **All data needs to be removed from your local machines by the end of the conference.**

Thank You!

Dr. Sumanth Swaminathan,
Co-Founder

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(267) 634 – 9997

https://vironix.ai
https://signup.vironix.ai

VIRONIX

Disease-Specific API Development Path