Analyzing the Influence of Virtual Care Management on Patient Health Outcomes & Risk Stratifying Chronic Kidney Disease Patients for Stage Degeneration

Company Background: Vironix Health Inc is an AI-SaaS company that enables early, at-anywhere detection and triage of health deterioration episodes due to chronic illnesses (COPD, Asthma, Congestive Heart Failure, etc). Vironix's key product is a turnkey Virtual Care Management solution that supplies patients with 4G/5G physiologic measurement devices (BP cuffs, weight scales, oximeters, etc), AI-interpretation software, and managed care staff. Vironix is interested in refinding it's early detection methods, discerning its real-life impact on patient health outcomes, and developing models for identifying and intervening on patient health deterioration before it's too late.

Problem Background: Chronic Kidney Disease (CKD) is a major public health problem with silent disease progression [1]. Gradual decline in kidney function in CKD patients can lead to End Stage Kidney Disease (ESKD) requiring kidney transplants [1]. Early intervention in CKD patients can lead to an improved quality of life by slowing down the progression of CKD and healthcare expenses [1]. Predictive models and dynamic risk stratification algorithms can aid in identifying patients at high risk of CKD degeneration (e.g. through changes in controller/BP medications and adjustments in diet, sleep, and exercise) as well as insights on how to manage and screen outpatients with CKD [3].

Description of Project: The project has 3 principal objectives:

1)   Research & Data Acquisition
2)   Data Analytics & Visualization
3)   Modeling, Validation, and Analysis

I.   Research & Data Acquisition

Vironix has gathered and cleaned publicly available CKD data from global literature. This data will be provided to the MPI participants to help with modelling and analytics. We further have preliminary models built along with some literature review of past modelling efforts in predicting CKD degeneration. We are anxious to 1) find and gather more publicly available data and 2) obtain more lit review with a solid summary of previous modelling efforts in modelling stage degeneration of CKD.

II.   Data Analytics and Clustering Algorithms

Vironix has been serving commercial Medicare patients for nearly a year and has its own proprietary, de-identified datasets detailing the disease progression of various lung, heart, and kidney disease patients undergoing remote patient monitoring. We are eager to study this data and answer the following questions (potential techniques to inform these questions could include statistical studies, analytics, clustering/classification algorithms, and ML modeling)

1) What positive health outcomes have emerged from patient monitoring efforts
   a. Potential outcome metrics
      i. Improvement in baseline physiologic data (BP, weight, blood glucose, etc).
      ii. Reduction in hospitalization events and/or identification of symptom escalations that did not result in hospitalization.
      iii. Early identification of potentially concerning physiologic data escalations.
      iv. Comments from patients, caregivers, or clinicians indicating a positive health event
2) Can any adverse patient episodes be predicted from patient profiles, disease trajectory, and/or temporal events leading up to adverse episodes?
3) What types of patients are most compliant with patient monitoring (describe specific patient profiles)?
4) What types of patients engage with clinical staff the most often and/or require the most staff time?

III.   Modeling degradation of CKD using GFR

CKD degeneration is commonly understood by looking at accumulation of toxins/proteins in the blood (such as creatinine) and/or tracking the rate of toxin removal (GFR - glomerular filtration rate). By looking at a population's GFR relative to the expected GFR as a type of time variable, we'd like to analyze changes in patient profiles that lead to degradation in GFR and build a model to predict temporal degradation of GFR from blood data and other clinical characteristics. Vironix will provide data sets for this exercise though we also hope that MPI is able to supplement these data sets.

Other Specific questions/Aims:

1) Identify from scientific literature and/or public databases – a representative set of data that captures the clinical characteristics of patients presenting with CKD. Initial publicly available, cleaned data sets are available.

2) Identify a methodology for utilizing both Vironix provided data and data found in phase I to predict severe/non-severe presentations of CKD or degeneration of CKD from one stage to another. Vironix has some approaches for an alternate disease, but we would be looking to explore others.

3) Develop and validate a prediction model and show reasonable accuracy, sensitivity, and specificity in CKD.

4) Describe and detail the most important clinical features relevant to predicting CKD degeneration

References

[1] Bai, Q., Su, C., Tang, W. and Li, Y., 2022. Machine learning to predict end stage kidney disease in chronic kidney disease. Scientific reports, 12(1), pp.1-8.

[2] Alaa, A.M. and van der Schaar, M., 2019. Attentive state-space modeling of disease progression. Advances in neural information processing systems, 32.

[3] Xiao, J., Ding, R., Xu, X., Guan, H., Feng, X., Sun, T., Zhu, S. and Ye, Z., 2019. Comparison and development of machine learning tools in the prediction of chronic kidney disease progression. Journal of translational medicine, 17(1), pp.1-13.

[4] https://archive.ics.uci.edu/ml/datasets/chronic_kidney_disease

[5] Choi, E., Biswal, S., Malin, B., Duke, J., Stewart, W.F. and Sun, J., 2017, November. Generating multi-label discrete patient records using generative adversarial networks. In *Machine learning for healthcare conference* (pp. 286-305). PMLR.

[6] https://github.com/mp2893/medgan

Additional literature and links:

Company website: https://vironix.ai/

A Machine Learning Methodology for Identification and Triage of Heart Failure Exacerbations
https://link.springer.com/article/10.1007/s12265-021-10151-7

CovidX: Remote Screening, Surveillance, Triage, and Management of Novel Coronavirus
https://vironix.ai/wp-content/uploads/2021/02/CovidX_CoronaVirus_WhitePaper.pdf

Machine Learning Based Triage Models for Remote Detection and Care of Influenza
https://vironix.ai/wp-content/uploads/2021/02/Vironix_MP2_Influenza_Tech_report_2020-1.pdf

A machine learning approach to triaging patients with chronic obstructive pulmonary disease https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0188532