

Quality Predictive Modeling for Diabetes and Hypertension

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Background and Project Motivation

- Boston Medical Center (BMC) the General Internal Medicine Clinic serves 40,000+ patients as a MassHealth ACO
- The hospital has just switched to a Pay-for-Performance system
- Payments from Medicaid are pegged to whether they achieve their target for control
 - Diabetes: at least 60% of patients with A1c level ≤ 9
 - Hypertension: at least 60% of patients with BP $< 140/90$
- Build a quantitative model to predict whether BMC is likely to meet its targets in the next three years

Objective

Summarize effectiveness of current treatment pathways and develop predictions for quality measures over the next three years assuming annual increase in quality requirements and population

Relevant Literature

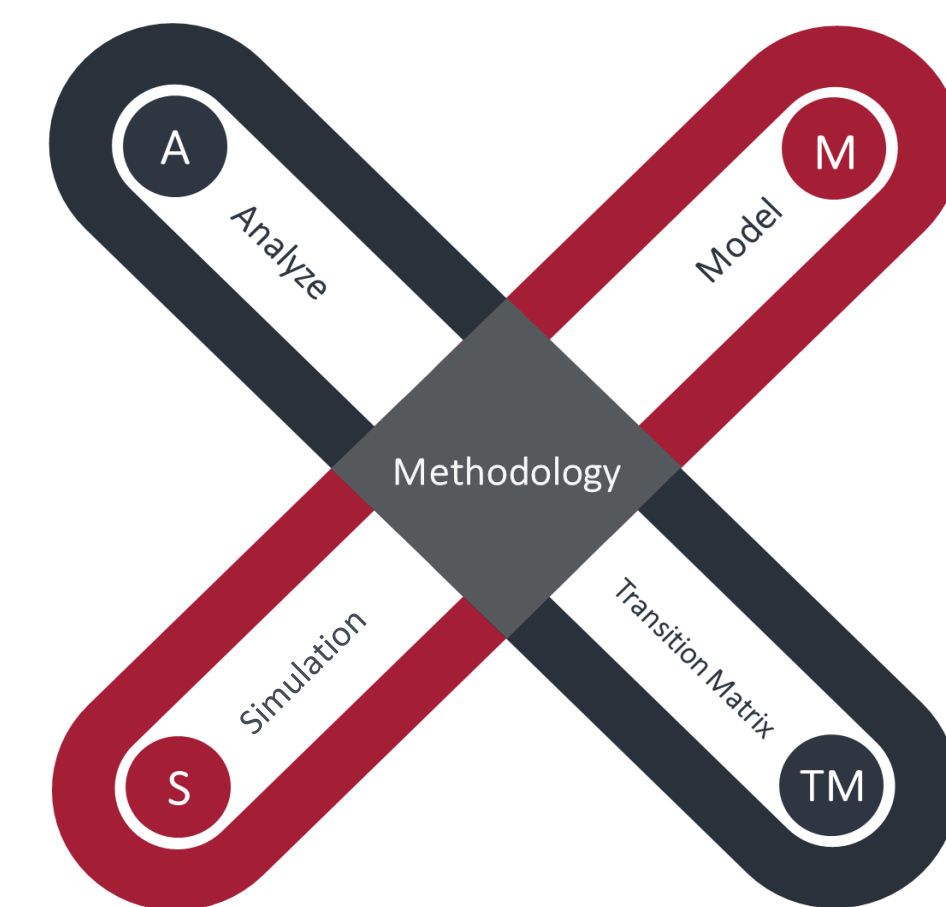
- American Diabetes Association, 2017, "Hemoglobin A1c and Mortality in Older Adults With and Without Diabetes: Results From the National Health and Nutrition Examination Surveys (1988–2011)"
- American Diabetes Association, 2018, "Economic Costs of Diabetes in the U.S. in 2017"
- Macrotrends, 2019, "U.S. Death Rate 1950-2020"

Methodology

- Analyzed A1c and blood pressure measurements for 1262 patients recorded between 2018 Q1 and 2019 Q3
- For each patient, two A1c / blood pressure measurements recorded between 3 – 16 months apart (mean: 7.06 ± 3.21) were analyzed
- Constructed a transition matrix to capture patient movement among A1c / blood pressure bands between the two time points
- The distribution of patients in each A1c / blood pressure bands at the first recorded A1c / blood pressure is the initial vector, the transition matrix propagated the distribution for the next three years
 - The proportion of deaths in each band was estimated from the literature
 - New incoming patients assumed equal to initial distribution
- Several models were analyzed to fit to the data
 - Linear Regression
 - Logarithmic Regression
 - Logarithmic Regression with Constant Annual Growth Rate
 - Logarithmic Regression with Moving Average (order 3)
- Monte Carlo simulation was used to generate a confidence interval

Analyze
Analyze initial state of patient population A1c and blood pressure measurements

Simulation
Monte Carlo simulation to validate model and assumptions while defining confidence levels



Model
Determine best fit model for predicting the trend in A1c and blood pressure measurements

Transition Matrix
Develop transition matrix using the first recorded values as the initial vector within defined bins

Results

Diabetes – A1c

- Logarithmic Regression with Moving Average (order 3) was the best fit: $R^2 = 0.98$
- Model Results: the percentage of patients with A1c < 9 will be slightly over 75% in every semester from 2019 semester 2 to 2022 semester 2
 - Expected to continue meeting A1c quality target over the next 3 years

All px including incoming (new diagnosed px)							
	2019_2	2020_1	2020_2	2021_1	2021_2	2022_1	2022_2
<7	44.13%	44.16%	44.18%	44.20%	44.23%	44.25%	44.28%
8	31.99%	31.99%	31.99%	31.99%	31.99%	31.99%	31.99%
>9	23.88%	23.86%	23.83%	23.81%	23.78%	23.76%	23.73%

Diabetes – A1c

Hypertension – Blood Pressures

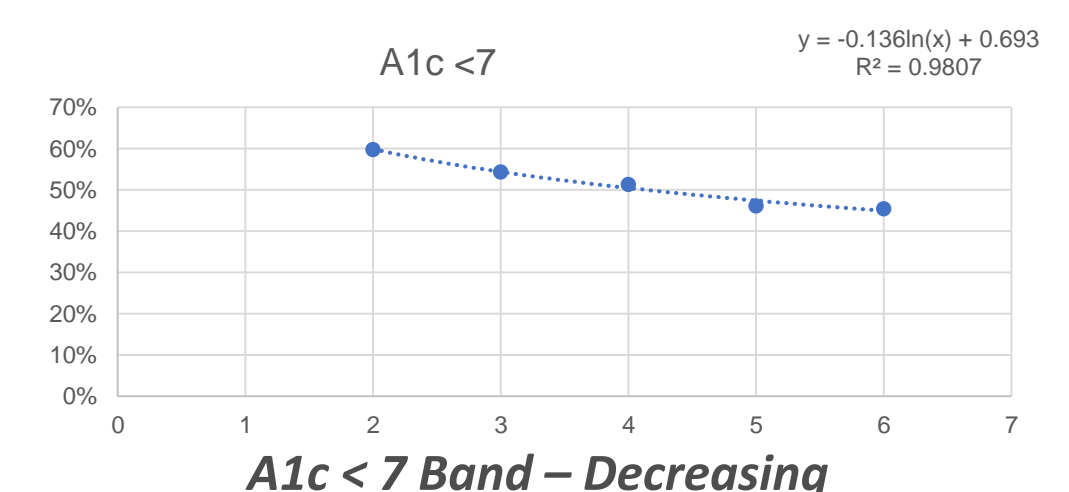
- Transition Matrix was only model that fit the data
- Current available blood pressure does not show a noticeable trend

All px including incoming (new diagnosed px)							
	2019_2	2020_1	2020_2	2021_1	2021_2	2022_1	2022_2
Normal	19.40%	19.39%	19.37%	19.36%	19.34%	19.33%	19.31%
Elevated	11.66%	11.67%	11.69%	11.70%	11.71%	11.72%	11.73%
HBP S1	34.96%	34.97%	34.98%	34.99%	35.00%	35.00%	35.01%
HBP S2	32.03%	32.02%	32.01%	32.00%	31.99%	31.99%	31.98%
Critical	1.94%	1.95%	1.95%	1.95%	1.96%	1.96%	1.96%

Hypertension – Blood Pressure

Recommendations for BMC

- Save all A1c and BP values for each patient instead of overwriting them each time a new one is recorded
 - To observe long-term trends and build more robust models
- Record patients' medication histories and pharmacist interventions in an easily accessible format
 - To examine the effect of medication changes and pharmacist interventions on A1c values
- Examine possible reasons why the proportion of patients in the clinically healthy band (A1c < 7) has been decreasing
 - Ideally, the goal would be to increase or maintain the proportion of patients in the A1c < 7 band



Key Finding

With a confidence level of 95%, Boston Medical Center will be able to achieve its diabetes quality target in the years ranging from 2020-2022

Non-conclusive predictions for addressing the quality metric for hypertension

The Team



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