Predicting HbA1c Levels and Type II Diabetes Diagnosis with Demographic, Biometric, and Medical History Data

Thaina Gomez & Maxwell Miller-Golub STAT 627 – American University

Introduction/Context

- Type II diabetes affects over 10% of adults, with nearly half undiagnosed [1]. Early detection is critical for preventing complications.
- Even after accounting for health insurance, immigrants and racial/ethnic minority adults have increased odds of undiagnosed diabetes [2].

RO1: Investigates whether demographic and biometric factors can predict HbA1c levels.

RO2: Cross-examines different classification models to determine the best method for accurately attributing Diabetes diagnosis

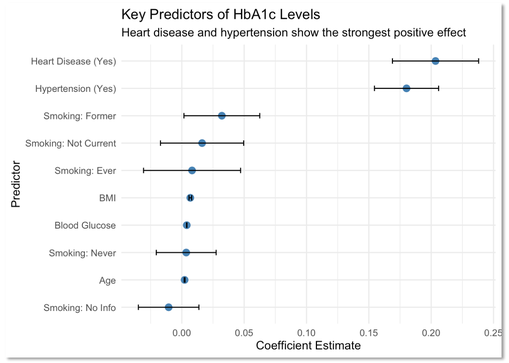
Approach

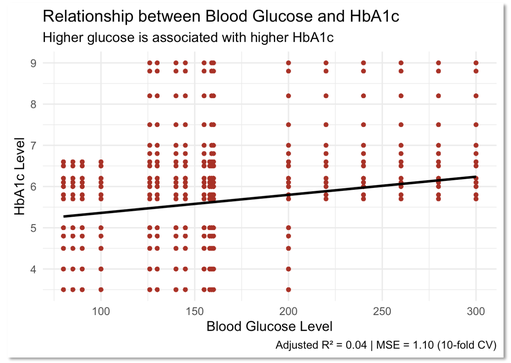
Cleaned and explored a dataset (N = 100,000) with predictors: age, BMI, glucose, hypertension, heart disease, and smoking history.

RO1: Built a multiple linear regression model for HbA1c using stepwise selection, assessed multicollinearity with VIF, and conducted residual diagnostics.

RO2: With "Diabetes" diagnosis as the target variable, we conducted a 90-10 train-test split with 10-fold CV in the training set. This led to Confusion Matrices for the following models: Logistic, Lasso, Ridge, and ElasticNet Regressions, KNN, LDA, and Random Forest.

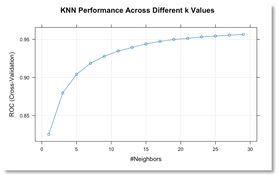
RO1: Demographic/Biometric Features vs HbA1c levels

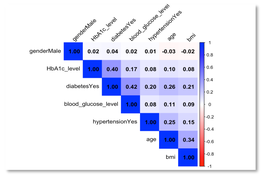




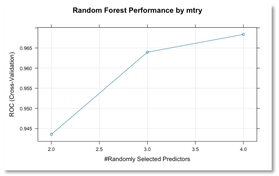
- BMI, glucose, hypertension, & heart disease were significant predictors ($p < 0.001$).
- The model explains a modest portion of variance & residuals met key model assumptions.

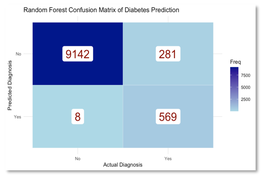
RO2: Finding best Classification Model for Diabetes diagnosis





Model	Accuracy	Precision	Recall	F1	AUC	KNeighbors.Best_MTry.lambda
Logistic Regression	0.9600000	0.8652597	0.6270588	0.7271487	0.9589914	NA
KNN	0.9573000	0.9731544	0.5117647	0.6707787	0.9552005	39
LDA	0.9547000	0.8358714	0.5811765	0.6856350	0.9517544	N/A
Random Forest	0.9711000	0.9861352	0.6694118	0.7974772	0.9680602	4
Lasso Regression	0.9605444	0.8790457	0.6213072	0.7280386	0.9619369	0.000514695191165332
Ridge Regression	0.9573222	0.9269222	0.5405229	0.6828503	0.9616148	0.0113497018771895
ElasticNet Regression	0.9602667	0.8926369	0.6053595	0.7214519	0.9621162	0.00186683648874033





- ANOVA determined all variables relevant in modeling
- Random Forest (m = 4, trees = 500) led to every highest metric

Results/Implications

Even a simple model using routine health data can support early risk detection.

RO1: Predicting HbA1c may help flag patients needing further diabetes screening.

RO2: With our best model (RF), an unseen case has a 97% chance of an accurate diabetes diagnosis.

Assumptions/Limitations/ Challenges or Secondary Results

RO1: Stepwise regression may overlook important interaction terms.
The model assumes linearity, independence, and constant variance; all were verified.

RO2: SVM, PCA/PCS not explored, though they may produce more accurate/efficient models.

Both: Dataset limited in scope and may not represent all demographics equally.
Future work should include more predictors (e.g., diet, physical activity). As medical data becomes more robust, more interesting and surprising relationships will be discovered.

Primary References

1. International Diabetes Federation. (2021). *Diabetes facts & figures*. https://idf.org/about-diabetes/diabetes-facts-figures/
2. Loretta Hsueh, Wei Wu, Adam T. Hirsh, Mary de Groot, Kieren J. Mather, Jesse C. Stewart. Undiagnosed diabetes among immigrant and racial/ethnic minority adults in the United States: National Health and Nutrition Examination Survey 2011–2018. *Annals of Epidemiology*, 51: 14-19, 2020.

Data

Mustafa, M. (n.d.). *Diabetes prediction dataset*. Kaggle. Retrieved March, 2025, from https://www.kaggle.com/datasets/iammustafatz/diabetes-prediction-dataset

Size: 100,000 patient records
Scale: Demographics, biometric info (age, BMI, blood glucose), and medical history (heart disease, hypertension, smoking)

Acknowledgments

- Professor Ahmad Mousavi
- STAT 427/627-001 Spring 2025