Hypertension Management Platform Guide

The Hypertension Management Platform's recommendations are for informational purposes only. Always apply independent clinical judgment before prescribing treatment.

Overview

The insights in this section are based on an AI-generated model developed from longitudinal data from Mayo Clinic's primary care practices. The model covered 16K cases of eligible patients over 15 years (Jan 2005 -2021) and was validated on 1,000 patients. Patient eligibility criteria included:

- A primary hypertension diagnosis by ICD-10 code
- Having established care in a primary care setting *before* the diagnosis
- The existence of blood pressure and creatinine measurements pre-anti-hypertensive treatment
- At least one year of follow-up

Model Inputs

(Patient information is pulled automatically from the patient's EHR.)

1) **Demographics:** the patient's demographics (age, biological sex, race) are auto-populated from the patient's chart.

While our models are designed to minimize bias (using datasets that contain varied ethnic, racial, and biological sex information), our hypertension model, in line with clinical AHA/ACC/JNC guidelines, does consider race to guide monotherapy drug selections for two main clinical reasons:

a) Black hypertensive population has a lower average blood pressure response to angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), and beta blockers - compared with non-black population.
b) Thiazide diuretics and calcium antagonists have shown greater average blood pressure responses among black hypertensives than other monotherapies.[1]

In other words, for patients who identify as black, the model will suggest Thiazide or calcium blockers over ARB ACE beta blockers.

Note: the model is currently limited to two options: "black" and "non-black." That means that **patients who do not explicitly identify as black or patients whose ethnicity is undisclosed are automatically classified as 'non-black' (by default).**

2) **Comorbidities:** the model currently accounts for the following conditions:

[1] Race and Antihypertensive Drug Therapy: Edging Closer to a New Paradigm

- Type II diabetes
- Chronic kidney disease
- Ischemic heart disease
- Tachyarrhythmia (which includes atrial fibrillation, atrial flutter, paroxysmal tachycardia, unspecified tachycardia, and other cardiac arrhythmias such as ventricular fibrillation).
- Congestive heart failure
- Gout
- Asthma

3) **Blood pressure and creatinine measurements:** The patient's last blood pressure measurement *from the previous month* is pulled from the visit intake or their EHR, and their last creatinine measurement (up to 2 years) is pulled from the EHR. Note that the model will refrain from making hypertension-specific recommendations or suggestions if any relevant parameters are missing.

4) **Current treatment** refers to the patient's current list of hypertension medications. The medication list is pulled automatically based on the patient's status of active prescriptions that the model recognizes/supports as HTN-relevant, including the total daily dosage of each medication. This list will be empty if no current active prescription HTN medications exist.

NOTE: The model does not recognize certain ingredients as hypertension treatment. If any of the following forms part of the current treatment, the model will not consider them, thus not providing insights or predictions. These include medications containing: *amiloride, benazepril, bisoprolol, candesartan, captopril, carvedilol, chlorthalidone, clonidine, doxazosin, enalapril, eplerenone, felodipine, fosinopril, guanfacine, hydralazine, indapamide, irbesartan, labetalol, metolazone, minoxidil, nadolol, nebivolol, nifedipine, prazosin, quinapril, ramipril, spironolactone, telmisartan, terazosin, torsemide, triamterene, valsartan, verapamil.*

5) **Response to current treatment** measured in blood pressure and lab readings:
    a) **Blood pressure** measurements refer to readings from the *last two months of the current treatment***,** and selection options include *'controlled,' 'high,' or 'low' blood pressure.*

<u>According to the guidelines:</u>

- *'High blood pressure' must be selected if:*
- A patient <60 years old had a blood pressure reading of >160 mmHg systolic or >90 mmHg diastolic in the last two months of the current treatment,
- A patient over 60 had a blood pressure reading of >170 mmHg systolic or >90 mmHg diastolic in the past two months of the current treatment.
- *'Low blood pressure' must be selected if:*
- The patient had a blood pressure reading of <90 mmHg systolic or <60 mmHg diastolic in the past two months of treatment.

b) Labs refer to readings from the l*ast three months of the current treatment (*except creatinine; criteria outlined below). Here, options include:

- *Elevated potassium (>5.3 mEq/l)* | (in the last three months of current treatment)
- *Low potassium (<3.5 mEq/l)* | (in the previous three months of current therapy)
- *Low sodium (<130 mEq/l)* | (in the last three months of current treatment)
- *High glucose (>120 mg/dl)* | (in the previous three months of current therapy)
- *Elevated creatinine (if >30% from any creatinine reading in the last two years)*

"Treatment success" definition

"Treatment success" is defined as blood pressure control with no moderate or severe adverse effects for at least one year following antihypertensive treatment (based on the JNC8 guidelines at the time of model development).

- Blood pressure is considered successfully controlled for patients <60 years if the average blood pressure following treatment initiation is <140/90 and never surpasses >160 systolic or >90 diastolic.
- For patients over 60 years, blood pressure must average <150/90 and never surpass >170 systolic or >90 diastolic.

"Treatment failure" definition

Failure of treatment due to side effects is defined at any point after initial treatment if:

- The patient had hypotension (blood pressure <90 mmHg systolic or <60 mmHg diastolic)
- Bradycardia (heart rate <50) - symptomatic or asymptomatic
- Creatinine increase (relative to previous baseline of >30%)
- Sodium (<130 or >150 mEq/l)
- Potassium (<3.6 or >5.1 mEq/l)
- Fasting glucose levels (>120 mg/dl for patients on thiazides) out of normal range
- Adverse side effects to the medication as documented in the medical record in the allergies table, where symptomatic side effects are categorized by level of adverse effect (so, for instance, mild adverse effects such as diarrhea are not considered treatment failure, whereas moderate or severe symptoms such as cough for ACE inhibitor or edema with calcium channel blocker are considered treatment failure).

Results:

The model predicts treatment based on successful blood pressure control and no adverse effects for at least one year following treatment, considering both ingredient and dosage levels.

A custom casual deep neural network (DNN) based model was developed to predict the recommended treatment predictions based on key principles of causal inference. These include:

a) **Diverse data:** a broad and diverse patient population with various treatments to ensure sufficient data to compare patient groups across treatments.
b) **Treatment comparisons among similar subpopulations:** Treatment comparisons are performed on identical populations to avoid external factors affecting the treatment and the outcome ("confounding factors"). This is achieved by including all features relevant to treatment (age, sex, comorbidities, baseline measurements, etc.) and comparing treatments within subpopulations of patients with similar health profiles.
c) Predicting only treatments used in the patient subpopulation: this means both the *exclusion of rare treatments* that appear less than twice in the dataset (as the data is deemed insufficient to make reliable predictions) and having a *confidence threshold* that filters out prediction of treatments of the patient's specific subpopulation if there is insufficient data for meaningful treatment comparisons. (In other words, the model will avoid making predictions in such cases.)
d) **Well-defined treatment definition across patients:** the model treatment is defined by both ingredients and dosage. This allows consistency across patients and results comparison. The model's ability to infer the causal relationship between antihypertensive treatment and blood pressure success was measured by calculating the agreement between the model's top suggested drug class and the JNC 8 drug class recommendations.