

Decoding Nonadherence to Hypertensive Medication in New York City: A Population Segmentation Approach

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Abstract

Objective: Nearly one-third of adults in New York City (NYC) have high blood pressure and many social, economic, and behavioral factors may influence nonadherence to antihypertensive medication. The objective of this study is to identify profiles of adults who are not taking antihypertensive medications despite being advised to do so. **Methods:** We used a machine learning–based population segmentation approach to identify population profiles related to nonadherence to antihypertensive medication. We used data from the 2016 NYC Community Health Survey to identify and segment adults into subgroups according to their level of nonadherence to antihypertensive medications. **Results:** We found that more than 10% of adults in NYC were not taking antihypertensive medications despite being advised to do so by their health care providers. We identified age, neighborhood poverty, diabetes, household income, health insurance coverage, and race/ethnicity as important characteristics that can be used to predict nonadherence behaviors as well as used to segment adults with hypertension into 10 subgroups. **Conclusions:** Identifying segments of adults who do not adhere to hypertensive medications has practical implications as this knowledge can be used to develop targeted interventions to address this population health management challenge and reduce health disparities.

Keywords

community health, disease management, health promotion, managed care, medications, primary care, prevention

Introduction

Termed the “silent killer,” hypertension, or high blood pressure, remains one of the leading causes of premature death worldwide and has become an important public health concern in major cities around the world.¹ According to Take Care New York 2020, the agenda of the New York City (NYC) Department of Health and Mental Hygiene (DOHMH) for helping every New Yorker achieve healthier lives, controlling hypertension has become one of the city’s top priorities.² Hypertension has been referred to as the largest modifiable risk factor for heart disease and stroke, but the prevalence of hypertension in NYC has risen by 11% over the past decade.³ According to 2016 data, 1.8 million adults in NYC reported having hypertension, nearly 1 in 3 of the city’s adult population.^{3,4}

Hypertension is a large public health concern in NYC, especially with regard to how it affects different population groups and neighborhoods within the city.^{5,6} For adults aged

65 years and older in NYC, nearly two-thirds reported having this condition in comparison with 11% of adults aged between 18 and 44 years. Prevalence varies by race and ethnicity; according to the most recent estimates using measured blood pressures, hypertension affects 43.5% of Black adults, 33% of Latino adults, 27.5% of White adults, and

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38.0% of Asian/Pacific Islander adults; with further variation observed within racial/ethnic groups (eg, 39.4% in Dominicans, 43.0% in South Asians).⁴ There are also substantial disparities by socioeconomic status, as higher neighborhood poverty correlates with a higher prevalence of hypertension. Specifically, the prevalence of hypertension varies widely across different neighborhoods, ranging from 14% in the Upper East Side to 41% in the South Bronx.³

Clinical practice guidelines for managing hypertension typically include strategies such as maintaining a healthy weight, being physically active, having a heart-healthy diet, and taking prescribed antihypertensive medications. For many adults with hypertension, taking medication as directed is a very effective way of getting blood pressure under control. Treatment with antihypertensive drugs also can result in significant reductions in severe cardiovascular outcomes, evidenced by studies showing a 20% to 25% reduction in acute coronary syndrome, a 30% to 35% reduction in stroke, and a 50% reduction in heart failure.⁷ Despite these health benefits, many adults with hypertension do not take their antihypertensive medications. Poor adherence to antihypertensive medication is associated with a higher incidence of cardiovascular disease and end-stage renal disease as well as increased mortality for adults with high blood pressure.^{7,8}

Despite recommendations from medical professionals and the overall benefits of antihypertensive drugs, nonadherence remains an issue in hypertension patient care and treatment. To our knowledge, limited research has been done to capture the characteristics of adults who do not comply with taking antihypertensive medications despite being told to do so by their health care providers.^{8,9} Over the years, much time and effort has been spent on the study of the effects of antihypertensive drugs, but little attention has been devoted to understanding whether or not hypertensive patients take them as directed.⁵ Such information is needed to develop targeted interventions for specific groups and improve adherence to treatment regimes. Based on data from NYC, this study aims to use a population segmentation approach to analyze medication nonadherence behavior and identify population subgroups who do not follow professional advice related to taking antihypertensive medications.

Methods

We used data from the 2016 New York City Community Health Survey (CHS) to conduct our segmentation analysis of antihypertensive medication nonadherence. The data were analyzed in 2018. Every year, the NYC DOHMH randomly selects a large number of adults aged 18 years and older to participate by telephone in the CHS, which provides data on health indicators and risk factors for residents

in each of the 5 boroughs and up to 42 neighborhoods in NYC. After poststratification and weighting, the CHS is representative of the total adult population in NYC. The CHS provides citywide estimates on health care access, prevention measures, and health outcomes. The total number of respondents in 2016 was 10 000.

We restricted our analysis to respondents who have been told that they have hypertension and need to take antihypertensive medications (ie, those who responded “yes” to the question “Have you ever been told by a doctor, nurse or other health professional that you need to take medicine for your high blood pressure?”). Our primary outcome of interest was self-reported action to take antihypertensive medications if they have been told to do so (ie, “Are you currently taking medication for your high blood pressure?”). Independent variables we included in our analysis were age, sex, race/ethnicity, household annual income, educational attainment, health insurance coverage, body mass index (BMI), marital status, diabetes, and neighborhood poverty, as these factors have been shown to be associated with medication nonadherence.⁹

We used Exhaustive Chi-squared Automatic Interaction Detection (CHAID)—a machine learning approach—to determine the best predictors of nonadherence to antihypertensive medications while segmenting the population into different subcategories.¹⁰

Exhaustive CHAID operates by cycling through 2 steps recursively. The first step is to perform optimal merging of all the splitting variables by conducting statistical association tests (ie, chi-square) over all possible combinations and then it merges splits of variables that have a weak association with the response variable. After all splitting variables have an optimally merged structure, the second step is to determine which variable should be used to split the data into clusters by conducting Bonferroni-adjusted chi-square tests of all splitting variables on the response variable and identifying the variable with the smallest *P* value. After a split is produced in the data, it begins again at the first step and continues the cycle until all the stopping criteria are met.

Population segmentation approaches have several advantages compared with traditional regression models in that (a) it makes no assumptions about the relationship of the underlying data, (b) it is flexible in handling missing data, and (c) it summarizes complex relationships and interactions into actionable clusters. Population segmentation has been used to, for example, identify population groups who refuse to reduce sodium consumption regardless of their risk of having cardiovascular disease and tailoring intervention efforts for integrated care and support to improve patient outcomes.^{11,12}

To examine the validity of the resulting subpopulations identified through Exhaustive CHAID, we also conducted the analysis on two-thirds of the sample

Table 1. Population Segmentation Results and the Proportion of People Who Are Not Adherent in Taking Antihypertensive Medication Despite Being Advised to Do so.

Population Group	Level 1 Predictor	Level 2 Predictor	Level 3 Predictor	Nonadherence Rate (%)
1	Age 18-44 y	No diabetes	White, Asian, Hispanic	48.0
2	Age 18-44 y	No diabetes	Black	31.1
3	Age 18-44 y	Diabetes	N/A	12.3
4	Age 45-64 y	No diabetes	Uninsured	36.8
5	Age 45-64 y	No diabetes	Insured, Medicare, Medicaid	13.3
6	Age 45-64 y	Diabetes	Medium or high neighborhood poverty	7.4
7	Age 45-64 y	Diabetes	Low neighborhood poverty	0.0
8	Age 65 y or older	Medium or high neighborhood poverty	Household income >200 FPL	4.0
9	Age 65 y or older	Medium or high neighborhood poverty	Household income <200 FPL	6.8
10	Age 65 y or older	Low neighborhood poverty	N/A	2.5
Overall nonadherence rate (%)				10.2

Abbreviations: FPL, federal poverty line; N/A, not available.

selected at random and then tested replicability with the rest one-third of the sample. Both the training and test sample sets resulted in the same segmentation subgroups. All analyses were conducted using IBM SPSS 25 (IBM Corp, Armonk, NY, USA).

Results

Table 1 presents the results from the population segmentation analysis. According to data from the 2016 CHS, about 10.2% of adults in NYC were not taking antihypertensive medication despite being advised to do so by their health care providers. The segmentation approach automatically divided the sample population into 10 groups based on their likelihood of following medical advice on hypertension medication. Each group was characterized by 2 or 3 key predictors. The variables identified through our analysis included age, neighborhood poverty, diabetes, household income, health insurance coverage, and race/ethnicity.

Age was the most important predictor (ie, level 1 predictor) of nonadherence to antihypertensive medication use. About 36% of adults aged 18 to 44 years did not adhere to medical advice for taking antihypertensive medication, while the nonadherence rates were 11.9% and 4.7% for adults aged 45 to 64 years and those 65 years and older, respectively (results not shown in Table 1). People from different age groups had different predictors of their choice of taking antihypertensive medication. Specifically, the 2 most important predictors for young adults aged 18 to 44 years were diabetes and race/ethnicity. About 12.3% of young adults with diabetes did not follow medical advice on antihypertensive medication (Population Group 3, Table 1), while the nonadherence rate increased to 41.6% for young adults without diabetes (combining Population Groups 1 and 2 with weights).

Being a white, Hispanic, or Asian further increased the nonadherence rate to 48% (Population Group 1, Table 1). The predictors for midlife adults aged 45 to 64 years were diabetes, health insurance coverage, and neighborhood poverty. All the midlife adults who had diabetes and lived in a low-poverty neighborhood followed their providers' advice in taking antihypertensive medication (Population Group 7, Table 1), while 36.8% of midlife adults who were uninsured and without diabetes did not take antihypertensive medication as advised (Population Group 4, Table 1).

Finally, the primary predictors for older adults aged 65 years and older were neighborhood poverty and household income. The least adherent group among older adults—which had a nonadherence rate of 6.8%—were those who lived in a medium- or high-poverty neighborhood and whose household income was below 200% of federal poverty line (Population Group 9, Table 1).

Discussion

In this study, we used a machine learning approach to identify key demographic, clinical, and neighborhood level factors that can be used to classify hypertensive patients in NYC into groups based on the likelihood of following professional advice on taking antihypertensive medication. We found that age was the most important predictor of adherence to antihypertensive medication. Within each age group, different predictors came into play in influencing people's behaviors. Being diagnosed with diabetes was identified as an important predictor among young and midlife adults, while neighborhood poverty level played an important role in medication adherence among midlife and older adults. Although our analysis included a broader set of independent variables and used a new approach, our findings are in general consistent with the literature.^{8,9}

Given that antihypertensive medication is the most effective means to achieve optimal blood pressure control and reduce the risk of severe cardiovascular disease outcomes, this study provides critical information to health care providers and policymakers on the specific patient groups they should prioritize and focus on to increase the rate of hypertension control and reduce associated disparities. Compared with regression analysis, population segmentation analysis can provide more actionable results which are easier to interpret and that can enable effective population health interventions specific for each segment.

This study has several limitations. First, we do not have access to other variables that could be related to nonadherence, such as the cost of drugs, side effects of medication, and geographical proximity to a health care provider.¹³ Second, we could not identify the causal relationship between independent factors and nonadherence behaviors due to the nature of our machine learning approach. However, the identification of important predictors could inform future research on causal inference. Finally, taking antihypertensive medication is only the first step in achieving optimal blood pressure control. Future research is needed to understand other important factors that may hamper optimal blood pressure control.

Declaration of Conflicting Interests

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