World Academy of Science, Engineering and Technology
International Journal of Medical and Health Sciences
Vol:19, No:04, 2025

Advanced Statistical Approaches for Identifying Predictors of Poor Blood Pressure Control: A Comprehensive Analysis Using Multivariable Logistic Regression and Generalized Estimating Equations (GEE)

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Abstract : Effective management of hypertension remains a critical public health challenge, particularly among racially and ethnically diverse populations. This study employs sophisticated statistical models to rigorously investigate the predictors of poor blood pressure (BP) control, with a specific focus on demographic, socioeconomic, and clinical risk factors. Leveraging a large sample of 19,253 adults drawn from the National Health and Nutrition Examination Survey (NHANES) across three distinct time periods (2013-2014, 2015-2016, and 2017-2020), we applied multivariable logistic regression and generalized estimating equations (GEE) to account for the clustered structure of the data and potential within-subject correlations. Our multivariable models identified significant associations between poor BP control and several key predictors, including race/ethnicity, age, gender, body mass index (BMI), prevalent diabetes, and chronic kidney disease (CKD). Non-Hispanic Black individuals consistently exhibited higher odds of poor BP control across all periods (OR = 1.99; 95% CI: 1.69, 2.36 for the overall sample; OR = 2.33; 95% CI: 1.79, 3.02 for 2017-2020). Younger age groups demonstrated substantially lower odds of poor BP control compared to individuals aged 75 and older (OR = 0.15; 95% CI: 0.11, 0.20 for ages 18-44). Men also had a higher likelihood of poor BP control relative to women (OR = 1.55; 95% CI: 1.31, 1.82), while BMI ≥35 kg/m² (OR = 1.76; 95% CI: 1.40, 2.20) and the presence of diabetes (OR = 2.20; 95% CI: 1.80, 2.68) were associated with increased odds of poor BP management. Further analysis using GEE models, accounting for temporal correlations and repeated measures, confirmed the robustness of these findings. Notably, individuals with chronic kidney disease displayed markedly elevated odds of poor BP control (OR = 3.72; 95% CI: 3.09, 4.48), with significant differences across the survey periods. Additionally, higher education levels and better self-reported diet quality were associated with improved BP control. College graduates exhibited a reduced likelihood of poor BP control (OR = 0.64; 95% CI: 0.46, 0.89), particularly in the 2015-2016 period (OR = 0.48; 95% CI: 0.28, 0.84). Similarly, excellent dietary habits were associated with significantly lower odds of poor BP control (OR = 0.64; 95% CI: 0.44, 0.94), underscoring the importance of lifestyle factors in hypertension management. In conclusion, our findings provide compelling evidence of the complex interplay between demographic, clinical, and socioeconomic factors in predicting poor BP control. The application of advanced statistical techniques such as GEE enhances the reliability of these results by addressing the correlated nature of repeated observations. This study highlights the need for targeted interventions that consider racial/ethnic disparities, clinical comorbidities, and lifestyle modifications in improving BP control outcomes.

Keywords : hypertension, blood pressure, NHANES, generalized estimating equations
Conference Title : ICH 2025 : International Conference on Hematology
Conference Location : Washington, Australia
Conference Dates : April 24-25, 2025