Medical and Health Journal
Volume 4, Issue 2, 2025, pp. 198-203
e-ISSN: 2807-3541
Open Access: https://jos.unsoed.ac.id/index.php/mhj

The Relationship Between Blood Pressure and Blood Sugar Levels: The Moderating Role of Age and Gender

Wahyudin[1], Rizqi Yanuar Pauzi[2*], Novia Yunika[1], Muhamad Rifqi Setyanto[3], Arfi Nurul Hidayah[4]

[1]Departemen Farmakologi, Fakultas Kedokteran, Universitas Jenderal Soedirman, Purwokerto 53147, Indonesia
[2]Departemen Mikrobiologi, Fakultas Kedokteran, Universitas Jenderal Soedirman, Purwokerto 53147, Indonesia
[3]Departemen Kesehatan Mata, Fakultas Kedokteran, Universitas Jenderal Soedirman, Purwokerto 53147, Indonesia
[4]*Departemen Bioetika dan Humaniora, Fakultas Kedokteran, Universitas Jenderal Soedirman, Purwokerto 53147, Indonesia*

ARTICLE INFO

Article history:
Received January 9, 2025
Revised Februari 6, 2025
Accepted February 15, 2025
Available online February 17, 2025

Keywords:
Blood pressure, blood glucose, age, gender

Kata Kunci:
Tekanan darah, Glukosa darah, Umur, Jenis Kelamin

ABSTRACT

This study aimed to evaluate the relationship between blood pressure and blood sugar levels, and how age and gender moderate the relationship. The study involved 105 respondents who underwent health check-ups in Banyumas Regency. Blood pressure was categorized as normal or hypertension, while blood sugar levels were divided into normal, prediabetes, and diabetes. The Chi-Square test showed a significant association between blood pressure and blood sugar levels ($p < 0.05$), although the strength of the association was relatively weak. Individuals with hypertension have a higher risk of developing blood sugar disorders, especially in women and individuals over 45 years old. Ordinal regression analysis showed that age and gender played an important role in influencing this association. These findings emphasize the importance of an integrated approach in screening and management of hypertension and diabetes, to prevent long-term complications such as cardiovascular disease and renal failure. The practical implications of this study can be used to design more effective public health programs.

ABSTRAK

Studi ini bertujuan untuk mengevaluasi hubungan antara tekanan darah dan kadar gula darah, serta bagaimana usia dan jenis kelamin memoderasi hubungan tersebut. Penelitian ini melibatkan 105 responden yang menjalani pemeriksaan kesehatan di Kabupaten Banyumas. Tekanan darah dikategorikan sebagai normal atau hipertensi, sementara kadar gula darah dibagi menjadi normal, pradiabetes, dan diabetes. Uji Chi-Square menunjukkan adanya hubungan yang signifikan antara tekanan darah dan kadar gula darah ($p < 0,05$), meskipun kekuatan hubungan tersebut relatif lemah. Individu dengan hipertensi memiliki risiko lebih tinggi untuk mengembangkan gangguan gula darah, terutama pada wanita dan individu yang berusia di atas 45 tahun. Analisis regresi ordinal menunjukkan bahwa usia dan jenis kelamin memainkan peran penting dalam mempengaruhi hubungan ini. Temuan ini menekankan pentingnya pendekatan terintegrasi dalam skrining dan manajemen hipertensi serta diabetes, untuk mencegah komplikasi jangka panjang seperti penyakit kardiovaskular dan gagal ginjal. Implikasi praktis dari penelitian ini dapat digunakan untuk merancang program kesehatan masyarakat yang lebih efektif.

1. INTRODUCTION

Hypertension, characterized by systolic blood pressure >140 mmHg or diastolic blood pressure >90 mmHg, is one of the leading risk factors for cardiovascular diseases, chronic kidney disease, and diabetes (Roger et al., 2012). Arterial stiffness leads to a reduction in arterial buffering capacity, which subsequently contributes to hypertension (Hussainy and Shereen, 2024). Hypertension is associated with an increased risk of chronic kidney disease, elevated Body Mass Index (BMI), and cardiovascular diseases (Anjayati et al., 2022; Yeo et al., 2024). In both men and women, elevated blood pressure serves as a trigger for coronary heart disease and heart failure risks (Ji et al., 2020). The prevalence of

*Corresponding author
E-mail addresses rizqi.yanuar@unsoed.ac.id (Wahyudin)

hypertension in Indonesia reaches 30.8%, while diabetes affects 11.7% of the population (Kemenkes, 2023). Although the relationship between hypertension and blood glucose levels has been extensively studied, gaps remain in understanding how age and gender moderate this association. Previous research indicates that hypertension is often linked to an increased risk of diabetes, particularly in older populations and women (Zhang et al., 2020). However, studies specifically exploring the moderating roles of age and gender are still limited, especially in developing countries like Indonesia. Therefore, this study aims to address these gaps by analyzing the relationship between blood pressure and blood glucose levels, as well as examining how age and gender influence this relationship.

As individuals age, the risk factors for hypertension symptoms increase significantly. According to WHO data from 2023, approximately 1.28 billion adults aged 30–79 years worldwide suffer from hypertension, with the majority residing in low- and middle-income countries (WHO, 2023). Diastolic blood pressure fluctuates with age, while systolic blood pressure tends to rise progressively with advancing age. The anatomy, vascular function, and cardiac performance also decline during the aging process (Hussainy and Shereen, 2024). Research by Badego et al., (2020) highlights that older age (elderly) and male gender are significant risk factors for hypertension. Gender differences can influence the incidence and prevalence of hypertension. For instance, hormones such as estrogen, testosterone, and androgens play critical roles. Testosterone and androgens in men have been associated with increased blood pressure, whereas estrogen may protect women from salt-induced blood pressure elevation (Hussainy and Shereen, 2024).

Plasma glucose levels differ between men and women, influenced by biological, physiological, and lifestyle factors. Age is a crucial determinant of plasma glucose levels, with numerous studies showing that plasma glucose tends to increase with advancing age. This phenomenon is particularly evident in postmenopausal women, where hormonal changes exacerbate insulin resistance and glucose intolerance (Duru, 2014). Men experience a gradual decline in testosterone levels, which is also linked to increased insulin resistance and higher plasma glucose levels as they age. Similarly, women undergoing a decline in estrogen levels exhibit comparable trends (Othman et al., 2021). A study conducted in rural Nigeria found that postmenopausal women demonstrated significantly elevated fasting plasma glucose levels (Duru, 2014).

Reduced physical activity and poor dietary habits with advancing age contribute to insulin resistance and elevated plasma glucose levels in both men and women. Studies indicate that older women with low levels of physical activity tend to have higher plasma glucose levels, suggesting that lifestyle interventions may be crucial for managing glucose levels in aging populations (Ashraf et al., 2020). Multiple factors influence glucose regulation and the prevalence of hypertension in aging populations, affecting both men and women. In this context, it is essential to develop a deeper understanding of the interaction between blood pressure and glucose regulation, as well as how age and gender act as moderators. Insights gained from this research are expected to provide significant contributions to the development of more integrated prevention and health management strategies, particularly for populations vulnerable to hypertension and glucose disorders. This study aims to contribute to more effective intervention measures to improve the quality of life for individuals facing these health challenges.

2. METHOD

This study employed an observational design, involving 105 respondents who underwent health examinations in Banyumas Regency. Sampling was conducted using stratified sampling to ensure balanced representation based on age and gender. Blood pressure was measured using a calibrated digital sphygmomanometer according to WHO standards, while fasting blood glucose levels were assessed using a standardized glucometer. Blood pressure was categorized into normal (<120/80 mmHg) and hypertensive (≥140/90 mmHg), whereas blood glucose levels were divided into three categories: normal (<100 mg/dL), prediabetes (100–125 mg/dL), and diabetes (≥126 mg/dL). Data analysis was performed using the Chi-Square test to evaluate the relationship between blood pressure and blood glucose levels. The strength of the association was assessed using Cramer's V. Additionally, ordinal regression analysis was conducted to evaluate the influence of demographic factors (age and gender) and the interaction between hypertension, age, and gender on blood glucose levels.

The ordinal regression coefficients were interpreted as the probability of changes in blood glucose status based on independent variables. Potential biases, such as dietary patterns and physical activity, could not be fully controlled in this study, necessitating cautious interpretation of the findings. The coefficients derived from the ordinal regression reflected significant associations between hypertension and an increased risk of abnormal blood glucose status, also indicating the effects of gender and age on blood glucose variables. To strengthen the results, all statistical analyses were conducted at a 5% significance level and presented with relevant confidence intervals. The findings of this study aim to provide deeper insights into the interaction between blood pressure regulation and glucose metabolism, as well as their implications for improved public health management.

3. RESULT AND DISCUSSION

This study evaluated the relationship between blood pressure (normal and hypertensive) and blood glucose levels (normal, prediabetes, and diabetes). The Chi-Square test revealed a significant association between blood pressure and blood glucose levels (χ^2 = 7.207, df = 2, p = 0.027), although the analysis of association strength using Cramer's V indicated a weak relationship (V = 0.262; 95% CI: 0.1173–0.4399) between the two variables. Analysis of the relationship between blood pressure and fasting blood glucose levels in the study population (N=105) revealed intriguing patterns of association. The results presented in Figure 1 show that among the total sample, the group with normal blood pressure (n=52, 49.53%) exhibited a varied distribution of glycemic status. The majority of participants in the normal blood pressure group maintained normal glycemic status (n=33, 31.43%), followed by the prediabetes group (n=16, 15.24%), and only a small proportion showed diabetic levels (n=3, 2.86%). In contrast, the hypertensive group (n=53, 50.47%) displayed a different and more evenly distributed glycemic status. Normal glycemic status was observed in 22 respondents (20.95%), prediabetes in 20 respondents (19.05%), and notably, diabetes was found in 11 respondents (10.48%).

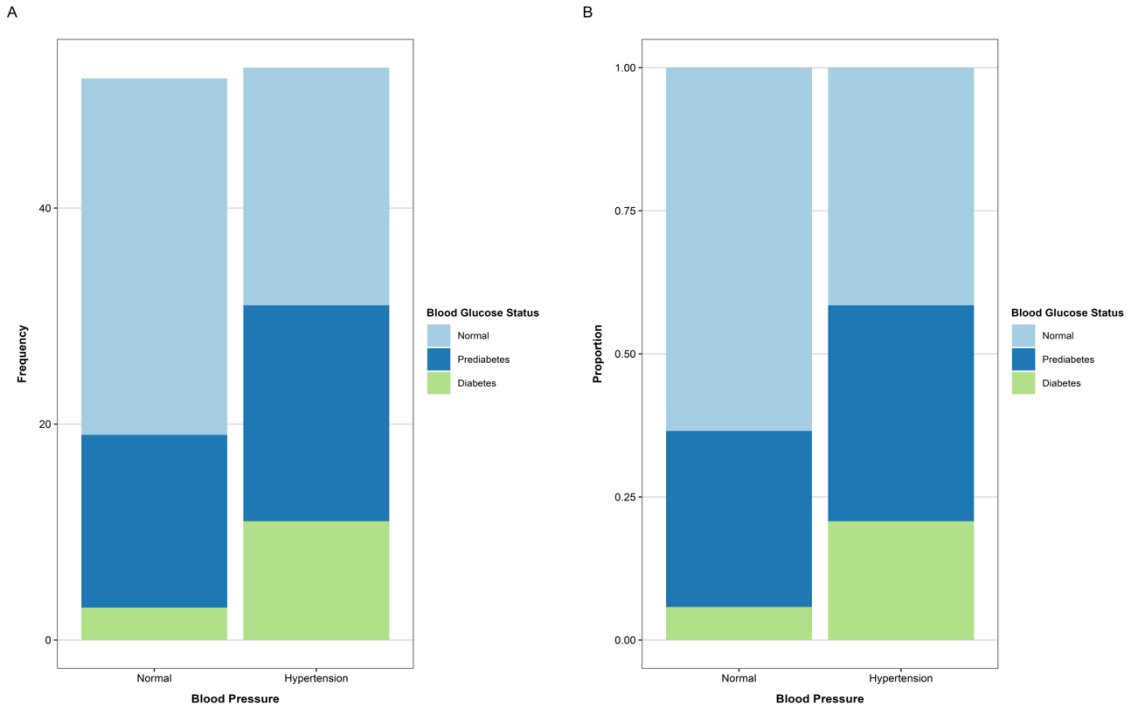

Figure 1. Distribution of blood glucose status based on blood pressure categories. (A) Frequency distribution of blood glucose status (normal, prediabetes, and diabetes) among individuals with normal blood pressure and hypertension. (B) Proportion distribution of blood glucose status in groups with normal blood pressure and hypertension.

These findings reveal a significant contrast in diabetes prevalence between the two blood pressure groups, with hypertensive individuals exhibiting nearly four times higher diabetes

prevalence compared to those with normal blood pressure. These results are consistent with previous studies showing that individuals with hypertension have a higher risk of developing glucose disorders, including diabetes (Wicaksono, 2011). The prediabetes status demonstrated a relatively balanced distribution between the normal and hypertensive groups, suggesting that changes in blood pressure may precede or develop concurrently with early-stage glycemic dysregulation. Overall, the largest category consisted of individuals with normal blood pressure and normal glycemic status (31.43%), while the smallest group comprised those with normal blood pressure and diabetes (2.86%). The observed distribution patterns provide strong evidence of the interconnection between blood pressure regulation and glucose metabolism. These findings carry significant clinical implications, particularly in the context of screening and patient management. The robust association between hypertension and diabetes uncovered in this study underscores the importance of an integrated approach in managing both conditions, as well as the critical need for early screening of these health parameters in at-risk populations.

In this study, we analyzed the influence of various demographic factors on blood glucose status (normal, prediabetes, diabetes) using an ordinal regression model. The factors examined included hypertension, gender, and age categories, while also considering interactions between several variables to gain a more comprehensive understanding. The analysis revealed several key findings. First, the group with high blood pressure exhibited a positive coefficient of 2.5128, indicating that individuals in the hypertensive group are more likely to have higher blood glucose levels, contributing to prediabetes or diabetes status. This aligns with the argument that hypertension is a significant risk factor in the development of diabetes (Sudayasa et al., 2020). Furthermore, the coefficient for females reached 1.8796, suggesting that women are more likely to fall into abnormal blood glucose categories compared to men. This finding supports the hypothesis that biological and psychosocial factors may influence women's sensitivity to the health impacts of hypertension (Priyoto, 2017). These results underscore the importance of gender-based approaches in addressing health issues. Individuals aged above 45 years also showed a positive coefficient of 2.1369, indicating that this age group is at higher risk for potential blood glucose disorders as they grow older.

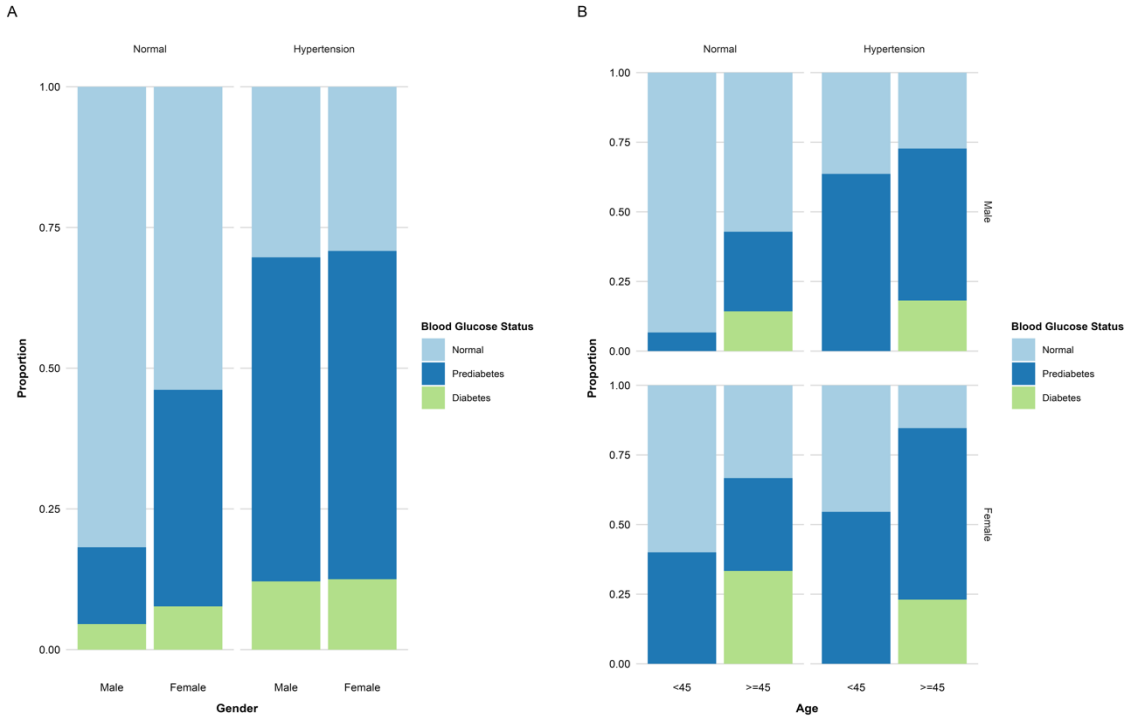

Figure 2. (A) Proportion distribution of blood glucose status among individuals with normal blood pressure and hypertension based on gender. (B) Proportion distribution of blood glucose status among individuals with normal blood pressure and hypertension based on gender and age.

However, the interaction analysis between the hypertensive blood pressure group and female gender revealed a negative influence with a coefficient of -1.7008. This suggests that although individuals in the hypertensive category generally face higher risks, women in this group experience a reduction in blood glucose status, making them less likely to develop prediabetes or diabetes. Similarly, the interaction between the hypertensive blood pressure group and the age group >45 years indicated a negative influence with a coefficient of -0.9985. This implies that individuals aged above 45 years who also have hypertension show a reduced contribution to abnormal blood glucose status, potentially due to better health management in older age. The ordinal regression analysis demonstrated that hypertension, age above 45 years, and female gender significantly contribute to the risk of blood glucose disorders. The ordinal regression model yielded a Residual Deviance of 167.65 and an AIC of 181.65, indicating a good model fit in explaining variations in blood glucose status. These findings suggest the importance of considering interactions between health factors, gender, and age in addressing blood glucose-related issues, providing valuable insights for policymakers to develop targeted health programs that account for the demographic characteristics of the population. An integrated approach to managing hypertension and diabetes is crucial to prevent long-term complications that may arise from both conditions (Ernawati, 2020). The practical implications of these findings highlight the importance of an integrated approach in screening and managing hypertension and diabetes, particularly among vulnerable groups. Limitations of this study include potential biases from external factors such as dietary patterns and physical activity, which were not fully controlled.

4. CONCLUSION

This study demonstrates a significant relationship between blood pressure and blood glucose levels, with hypertensive individuals exhibiting a higher risk of prediabetes or diabetes. Although the strength of this association is relatively weak, the findings underscore the importance of targeted attention toward hypertensive populations, particularly women and individuals aged over 45 years. Ordinal regression analysis revealed that age and gender play crucial roles in moderating this relationship. The results of this study provide valuable insights for the development of screening and management strategies for hypertension and diabetes, aiming to prevent long-term complications such as cardiovascular disease and kidney failure. The practical implications of this research can be utilized to design more effective public health programs, especially for vulnerable groups. Further research is recommended to involve larger sample sizes and employ more advanced analytical methods, such as multivariate regression models, to gain a deeper understanding of these relationships.

5. REFERENCES

Anjayati, S., Tosepu, R., Effendy, D.S., 2022. Proportion of Hypertension Cases by Gender in the North Buton Regency, Southeast Sulawesi Province. kls 0, 14–18. https://doi.org/10.18502/kls.v0i0.11764

Ashraf, K., Jamsheed, I., Zaidi, F., Mostafa, M.Y.A., 2020. Assessment of Blood Glucose and Calcium Concentrations Among healthy female volunteers: Blood glucose & calcium in females. Pakistan BioMedical Journal 3. https://doi.org/10.52229/pbmj.v3i1.7

Badego, B., Yoseph, A., Astatkie, A., 2020. Prevalence and risk factors of hypertension among civil servants in Sidama Zone, south Ethiopia. PLOS ONE 15, e0234485. https://doi.org/10.1371/journal.pone.0234485

Duru, B., 2014. Assessment of Fasting Blood Plasma Glucose Level in Menopausal Women in Rural Area of Vom and Environs. IOSR Journal of Nursing and Health Science 3, 57–60. https://doi.org/10.9790/1959-03345760

Ernawati, S.S.F., Iin, 2020. Management terapi pada penyakit degeneratif (diabetes mellitus dan hipertensi) : mengenal, mencegah dan mengatasi penyakit degeneratif (diabates mellitus dan hipertensi). Penerbit Graniti.

Hussainy, S.A., Shereen, S., 2024. Blood Pressure in Relation to Age and Gender. Journal of Drug Delivery and Therapeutics 14, 39–43. https://doi.org/10.22270/jddt.v14i3.6456

Ji, H., Kim, A., Ebinger, J.E., Niiranen, T.J., Claggett, B.L., Bairey Merz, C.N., Cheng, S., 2020. Sex Differences in Blood Pressure Trajectories Over the Life Course. JAMA Cardiology 5, 255–262. https://doi.org/10.1001/jamacardio.2019.5306

Kemenkes, 2023. Profil Kesehatan Indonesia 2022. Kementerian Kesehatan RI, Jakarta.

Othman, N.S., Bhat, R.S., Warsy, A., 2021. Correlation Studies between Leptin, Glucose and Insulin in Pre and Postmenopausal Saudi. Journal of Pharmaceutical Research International 2753–2764. https://doi.org/10.9734/jpri/2021/v33i60B35198

Priyoto, P., 2017. Hubungan Depresi Dengan Kejadian Hipertensi Pada Lansia Di Unit Pelaksana Teknis Pelayanan Sosial Lanjut Usia Kecamatan Selosari Kabupaten Magetan. Warta Bhakti Husada Mulia : Jurnal Kesehatan 4.

Roger, V.L., Go, A.S., Lloyd-Jones, D.M., Benjamin, E.J., Berry, J.D., Borden, W.B., Bravata, D.M., Dai, S., Ford, E.S., Fox, C.S., Fullerton, H.J., Gillespie, C., Hailpern, S.M., Heit, J.A., Howard, V.J., Kissela, B.M., Kittner, S.J., Lackland, D.T., Lichtman, J.H., Lisabeth, L.D., Makuc, D.M., Marcus, G.M., Marelli, A., Matchar, D.B., Moy, C.S., Mozaffarian, D., Mussolino, M.E., Nichol, G., Paynter, N.P., Soliman, E.Z., Sorlie, P.D., Sotoodehnia, N., Turan, T.N., Virani, S.S., Wong, N.D., Woo, D., Turner, M.B., American Heart Association Statistics Committee and Stroke Statistics Subcommittee, 2012. Heart disease and stroke statistics--2012 update: a report from the American Heart Association. Circulation 125, e2–e220. https://doi.org/10.1161/CIR.0b013e31823ac046

Sudayasa, I.P., Rahman, M.F., Eso, A., Jamaluddin, J., Parawansah, P., Alifariki, L.O., Arimaswati, A., Kholidha, A.N., 2020. Deteksi Dini Faktor Risiko Penyakit Tidak Menular Pada Masyarakat Desa Andepali Kecamatan Sampara Kabupaten Konawe. Journal of Community Engagement in Health 3, 60–66. https://doi.org/10.30994/jceh.v3i1.37

Wicaksono, R.P., 2011. Faktor-Faktor Yang Berhubungan Dengan Kejadian Diabetes Melitus Tipe 2 (Studi Kasus di Poliklinik Penyakit Dalam Rumah Sakit Dr. Kariadi (other). Faculty of Medicine.

Yeo, W.-J., Abraham, R., Surapaneni, A.L., Schlosser, P., Ballew, S.H., Ozkan, B., Flaherty, C.M., Yu, B., Bonventre, J.V., Parikh, C.R., Kimmel, P.L., Vasan, R.S., Coresh, J., Grams, M.E., 2024. Sex Differences in Hypertension and Its Management Throughout Life. Hypertension 81, 2263–2274. https://doi.org/10.1161/HYPERTENSIONAHA.124.22980

Zhang, W., Liu, C.-Y., Ji, L.-N., Wang, J.-G., ATTEND investigators, 2020. Blood pressure and glucose control and the prevalence of albuminuria and left ventricular hypertrophy in patients with hypertension and diabetes. J Clin Hypertens (Greenwich) 22, 212–220. https://doi.org/10.1111/jch.13793