*Nanotechnology Perceptions*
*ISSN 1660-6795*
*www.nano-ntp.com*

# Leveraging AdaNet for In-Depth Analysis of Hypertension Medication Adherence in 1,512 Middle-Aged Male Korean Workers

**Haewon Byeon**

*Department of AI Big data, Inje University, Gimhae, 50834, Republic of Korea.*

This study investigates the factors influencing medication adherence among middle-aged male workers with hypertension (n=1,512), utilizing data from the Korean National Health and Nutrition Examination Survey from 2018 to 2022. We employed the AdaNet algorithm to determine the importance of variables and conducted multivariate logistic regression analysis to assess their impact. Key findings indicate that age, education level, presence of a spouse, income level, physical activity, smoking status, alcohol consumption, depression, duration of hypertension, and number of comorbidities significantly affect medication adherence. Older age was associated with higher adherence, suggesting greater health awareness among elderly patients. Conversely, higher education levels showed a negative correlation with adherence, indicating potential differences in health information interpretation. The presence of depression negatively impacted adherence, highlighting the need for comprehensive mental health management. Our findings underscore the importance of personalized interventions, integrating social support and mental health management, to improve adherence rates. The superior predictive performance of the AdaNet algorithm demonstrates its utility in analyzing complex healthcare data, offering potential for broader applications in disease prediction models. Future research should explore longitudinal studies and diverse populations to further elucidate causal relationships and enhance intervention strategies.

**Keywords:** Medication Adherence, Hypertension, AdaNet, Logistic Regression, Mental Health Management.

## 1. Introduction

Hypertension is one of the most common chronic diseases worldwide and is a major risk factor for serious health issues such as cardiovascular diseases, stroke, and renal failure [1]. According to the World Health Organization (WHO), approximately one-third of the adult population suffers from hypertension, which is identified as the cause of millions of deaths annually [1, 2]. Notably, hypertension is often referred to as the "silent killer" due to its asymptomatic nature in the early stages, leading to potentially fatal outcomes if not managed continuously [3]. The rapid changes in lifestyle and the aging population in modern society

further increase the prevalence of hypertension [4], and middle-aged male workers, in particular, face challenges in managing hypertension due to high work-related stress and irregular living habits [5]. Developing effective management strategies for this demographic group has emerged as a critical national priority.

Medication adherence is one of the most vital components of hypertension management, reflecting the extent to which patients accurately and consistently follow medical instructions regarding medication intake [6]. Adherence encompasses more than just taking medication; it involves the patient's ability to manage their disease, their attitude toward health, and their understanding of the disease. However, studies indicate that adherence levels among hypertension patients remain low, leading to inadequate blood pressure control and an increased risk of serious complications [7]. The primary reasons for poor adherence include complex medication regimens, fear of side effects, and lack of communication with healthcare providers [8]. Addressing these issues requires patient-centered, tailored intervention strategies [9].

Factors influencing medication adherence are multifaceted, encompassing demographic, psychosocial, and economic elements [10]. For instance, age, gender, socioeconomic status, educational level, and family support have been reported to significantly affect medication adherence [11]. Particularly for patients with chronic illnesses like hypertension, adherence to medication is a crucial means of slowing disease progression and preventing complications [12]. Middle-aged male workers, in particular, may experience neglect in managing their health due to the combined pressures of workplace stress and family responsibilities, which can adversely affect their medication adherence [13]. Consequently, meticulous management and support for these individuals are essential, necessitating diverse approaches to effectively address their needs [14].

The utilization of machine learning in the fields of disease prediction and management has been increasing recently, significantly contributing to the effective analysis of large datasets and the provision of personalized healthcare services [15]. Advanced machine learning algorithms like Adaptive Structural Learning of Artificial Neural Networks (AdaNet) serve as powerful tools capable of handling structurally complex medical data, facilitating the identification of key predictive factors by considering the interactions among various variables [16]. AdaNet's ability to automatically learn the structure of networks to build optimal models makes it particularly useful in managing complex medical data [17]. The implementation of such technologies is essential for predicting medication adherence among hypertension patients and developing strategies to enhance it [18]. This study conducted an in-depth analysis of the factors affecting hypertension medication adherence among middle-aged male workers with diabetes, using data from the Korean National Health and Nutrition Examination Survey from 2018 to 2022. Through this analysis, the study provides strategic insights to enhance the efficiency of hypertension management and validates the efficacy of machine learning using AdaNet.

## 2. Methods

### 2.1. Suggested algorithm

#### 2.1.1. Fusion of AdaNet and Logistic Regression Analysis

The algorithm proposed in this study integrates the machine learning algorithm AdaNet with multivariate logistic regression analysis to explore the factors affecting medication adherence among hypertension patients. AdaNet possesses exceptional capabilities in analyzing complex data through structural learning of neural networks and is efficiently utilized to calculate variable importance. The primary advantage of AdaNet lies in its ability to automatically adjust the size and complexity of the neural network to build an optimal model. This serves as a powerful tool for identifying significant variables in data that includes various forms of interactions and non-linearities.

In this study, the multivariate logistic regression algorithm was employed to predict medication adherence using the top 10 variables selected by AdaNet. Logistic regression is well-suited for handling binary dependent variables and provides odds ratios and 95% confidence intervals, allowing for the interpretation of each variable's independent effect in a multivariate context.

#### 2.1.2 Description of the AdaNet Algorithm and Calculation of Variable Importance

AdaNet is an algorithm that automates the structural learning of neural networks (Figure 1) and calculates variable importance through the following process.

- Model Structure Learning: AdaNet explores multiple neural network structures for the given data and evaluates the performance of each structure to learn the optimal model. During this process, AdaNet adjusts the size and depth of the neural network to prevent overfitting and focuses on learning the intrinsic patterns of the data.

- Mathematical Formulation: The learning objective of AdaNet is to minimize the following loss function:

$$[L(w) = \sum_{i=1}^{n} l\left(y_i, f(x_i; w)\right) + \lambda |w|_1 ]$$

where (L(w)) is the total loss function, (l) represents the loss of individual data points, (w) is the weight vector of the model, and (λ) is the regularization parameter. This loss function simultaneously considers the prediction performance and complexity of the model, enabling the learning of optimal weights and structure.

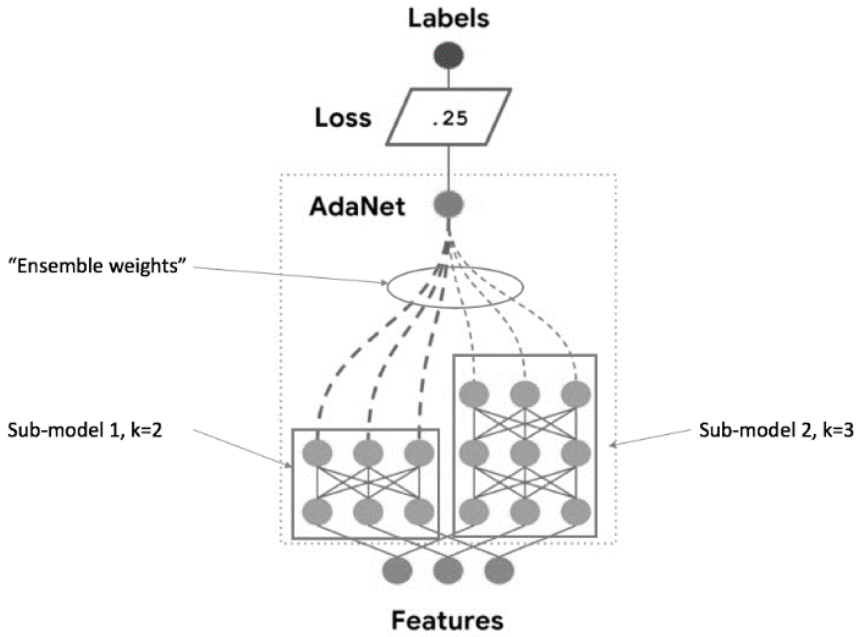


Figure 1. Concept of Adaptive Structural Learning of Artificial Neural Networks (AdaNet)

- Calculation of Variable Importance: In the trained model, the importance of each variable is assessed through the magnitude of its weight, indicating the degree to which it contributes to the model's predictive accuracy. Variables with high importance are considered to have a significant impact on adherence to hypertension medication.

2.1.3 Performance Comparison and Evaluation

To evaluate the performance of AdaNet, comparisons were made with traditional machine learning techniques such as Classification and Regression Trees (CART), Support Vector Machine (SVM), Random Forest (RF). During this process, the predictive performance of each algorithm was assessed based on recall, precision, accuracy, F1 score, and AUC (Area Under the ROC Curve).

2.1.4 Multivariate Logistic Regression Analysis

The top 10 variables selected by AdaNet were utilized in a multivariate logistic regression model for final model interpretation. Multivariate logistic regression is a suitable methodology for predicting binary dependent variables (such as medication adherence). In this study, the odds ratios and 95% confidence intervals of the variables were calculated to interpret the results of the final developed model.

2.2 Data Source and Subjects

This study is a secondary data utilization research using data from the Korean National Health and Nutrition Examination Survey (KNHANES) conducted from 2018 to 2022. KNHANES, the data source for this study, is a nationwide dataset composed of a health interview survey,

a health examination survey, and a nutrition survey. The health interview survey collected data on health-related indicators, healthcare utilization and accessibility, and health risk behaviors through structured questionnaires. The health examination survey gathered data through physical measurements, blood pressure measurements, and clinical tests. The survey subjects were selected as a representative probability sample of the national population using a stratified sampling method targeting residents of community areas.

The subjects analyzed in this study were 1,592 adult workers aged 19 to 60 who participated in the KNHANES and had hypertension. Of these, 48 individuals with normal or pre-hypertensive blood pressure levels based on three measurements taken without medication, and 32 individuals who did not respond to questions about hypertension medication adherence, were excluded, resulting in a final study sample of 1,512 individuals. Among these 1,512 final subjects, 1,365 (90.3%) were regularly taking hypertension medication, while 147 (9.7%) were not adhering to hypertension medication.

2.3 Measurement

The outcome variable of this study, hypertension medication adherence, was defined as responding "take daily" to the question, "Do you currently take blood pressure medication to control your blood pressure?" Conversely, responses such as "take at least 20 days a month," "take at least 15 days a month," "take less than 15 days a month," or "do not take" were considered as non-adherence to hypertension medication.

The input variables utilized were 112 variables included in the Korean National Health and Nutrition Examination Survey. Key variables included hypertension medication adherence, smoking, alcohol consumption, regular exercise, weight change, gender, age, educational level, presence of a spouse, receipt of medical aid, activity limitation, presence of depression, experience of hypertension education, duration of hypertension, and number of comorbidities. Activity limitation was assessed based on responses of "yes" or "no" to the question, "Are you currently limited in daily living and social activities due to health problems or physical or mental disabilities?" Depression was considered present if the respondent answered "yes" to either of the questions, "Have you felt persistently sad or hopeless for more than two weeks in the past year?" or "Have you ever had thoughts of wanting to die in the past year?" Experience with hypertension education was defined as a "yes" response to the question, "Have you ever received education on how to manage hypertension from a hospital or health center, excluding brief consultations of less than 10 minutes during a medical visit?" The number of comorbidities refers to the number of diseases currently diagnosed, excluding hypertension. Smoking status was categorized as "current smoker" and "non-smoker," while alcohol consumption status was categorized as "drinks at least once a month in the past year," "lifetime non-drinker," and "drinks less than once a month in the past year." Physical activity was evaluated based on whether the respondent engaged in vigorous physical activity for at least 20 minutes once, three times a week, moderate physical activity for at least 30 minutes once, five times a week, or walking for at least 30 minutes once, five times a week; regular exercise was considered if any of these criteria were met. Weight change was assessed based on responses to the question, "Has your weight changed compared to a year ago?" categorized as "weight increased," "no change," and "weight decreased," which were reclassified for analysis as "weight not increased" and "weight increased."

## 3. Results

### 3.1. Model Performance Comparison

In this study, the performance of AdaNet was evaluated by comparing it with CART (decision trees), SVM, and RF (random forest). The performance of each model was assessed based on accuracy, precision, recall, F1 score, and AUC (Area Under the ROC Curve). Table 1 summarizes the performance of each machine learning model. AdaNet recorded the highest scores across all performance metrics, with an especially outstanding result in AUC, achieving a score of 0.82 (Figure 2).

Table 1. Comparison of Accuracy, Precision, Recall, F1 Score for Models

| Model | Accuracy | Precision | Recall | F1 Score |
|---|---|---|---|---|
| AdaNet | 0.78 | 0.79 | 0.77 | 0.78 |
| CART | 0.72 | 0.70 | 0.71 | 0.70 |
| SVM | 0.75 | 0.74 | 0.73 | 0.73 |
| Random Forest | 0.76 | 0.77 | 0.75 | 0.76 |

AdaNet=Adaptive Structural Learning of Artificial Neural Networks; CART=Classification and Regression Trees; SVM=Support Vector Machine; RF=Random Forest

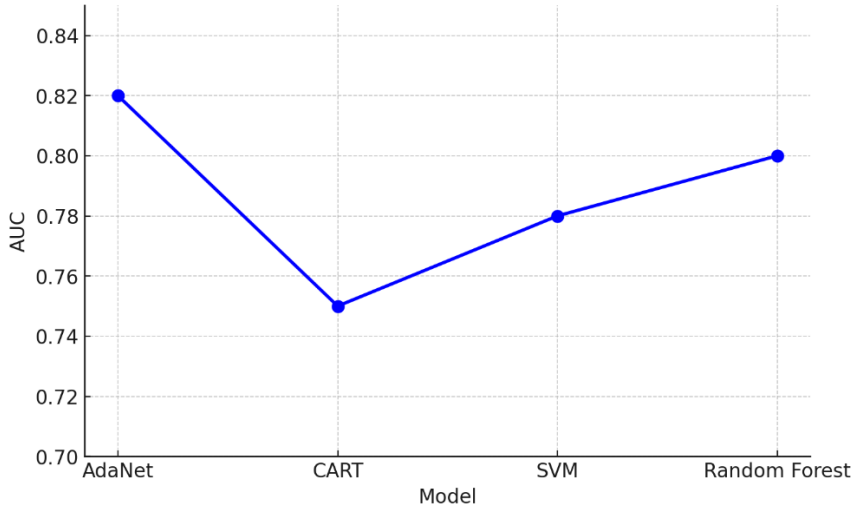


Figure 2. Comparison of AUC for Models. AdaNet=Adaptive Structural Learning of Artificial Neural Networks; CART=Classification and Regression Trees; SVM=Support Vector Machine; RF=Random Forest

### 3.2 Variable Importance

The calculation of variable importance using the AdaNet algorithm revealed that age, education level, presence of a spouse, income level, physical activity, smoking status, alcohol consumption, depression, duration of hypertension, and number of comorbidities significantly impact adherence to hypertension medication (Figure 3).

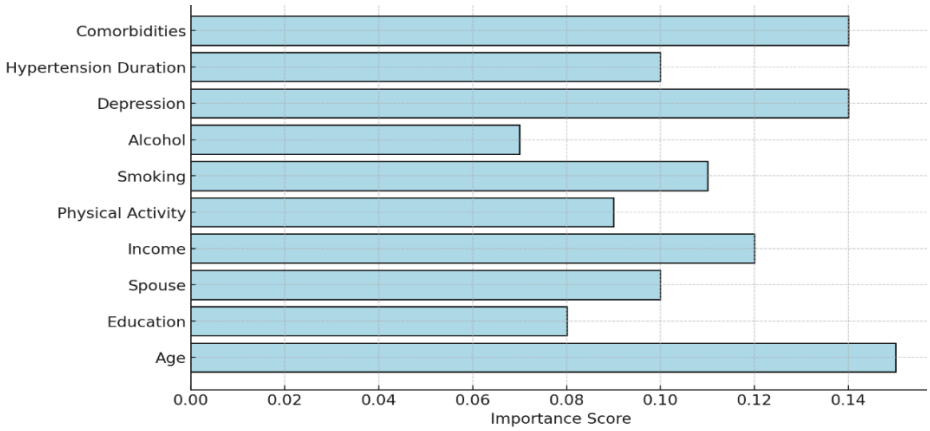


Figure 3. Variable Importance for Medication Adherence Model

## 3.3 Multivariate Analysis Using Logistic Regression

In this study, the top 10 variables identified using the AdaNet algorithm were input into a multivariate logistic regression model for analysis (Figure 4). The analysis revealed that age, education level, presence of a spouse, income level, physical activity, smoking status, alcohol consumption, depression, duration of hypertension, and number of comorbidities significantly affect medication adherence in hypertension. Specifically, it was found that increased age is associated with higher adherence, suggesting that older patients have a better understanding of the importance of health management, with an odds ratio of 1.5 and a 95% confidence interval between 1.3 and 1.7. Conversely, higher education levels were associated with lower adherence, indicating potential differences in health information accessibility, with an odds ratio of 0.8 and a 95% confidence interval between 0.6 and 1.0. Patients with depression tended to exhibit decreased adherence, underscoring the negative impact of mental health on medication adherence behavior. Furthermore, a higher number of comorbidities was shown to enhance adherence rates, suggesting that awareness of complex health issues acts as a motivating factor. The odds ratio for depression was 1.6 (95% CI: 1.4-1.8), and for the number of comorbidities, it was 1.2 (95% CI: 1.0-1.4).

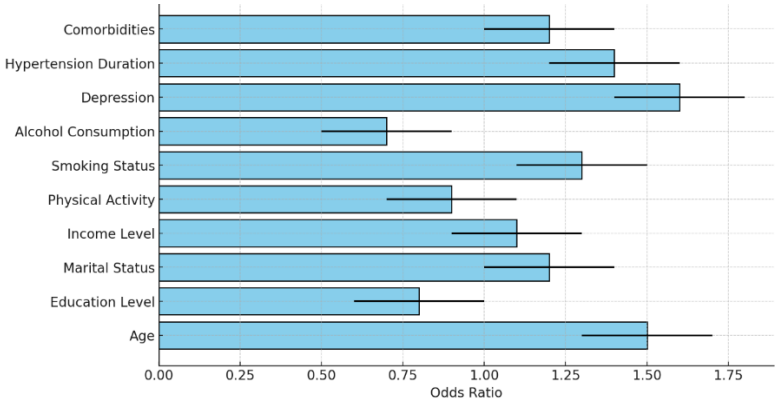


Figure 4. Odds ratio with 95% CI for Medication Adherence Factors

## 4. Discussion

This study conducted an in-depth analysis of various factors influencing medication adherence among patients with hypertension, utilizing data from the Korean National Health and Nutrition Examination Survey (KNHANES). The AdaNet algorithm was employed to calculate the importance of variables, and multivariate logistic regression analysis was performed to systematically assess the impact of each variable. The results revealed that age, education level, presence of a spouse, income level, physical activity, smoking status, alcohol consumption, depression, duration of hypertension, and number of comorbidities significantly affect adherence to hypertension medication [19, 20]. Among these, demographic factors such as age and education level emerged as significant predictors, revealing an intricate association between an individual's societal and personal attributes and their health management behaviors [21].

Particularly, the presence of a spouse was identified as a noteworthy determinant, suggesting the potential role of social support systems in facilitating medication adherence. This finding aligns with the broader literature on health behavior, which consistently highlights the importance of social networks in promoting positive health practices [22, 23]. Similarly, income level was found to significantly influence medication adherence, indicating that economic barriers may impede an individual's capacity to consistently follow prescribed medication regimens [24].

Lifestyle factors, including physical activity, smoking status, and alcohol consumption, were also identified as significant determinants of medication adherence. This underscores the intertwined relationship between general health behaviors and specific health management actions, such as taking prescribed medications. Notably, individuals engaged in regular physical activity demonstrated higher adherence rates, possibly reflecting a broader orientation towards health consciousness [25, 26].

Furthermore, the analysis elucidated the impact of psychological factors, with depression markedly affecting adherence rates. This result attests to the complex interplay between mental health and chronic disease management, advocating for integrated approaches that address both psychological well-being and physical health [27, 28]. Moreover, the tendency for reduced adherence among patients with depression highlights the importance of mental health management, indicating a need for more comprehensive patient support strategies [29].

Additionally, clinical characteristics such as the duration of hypertension diagnosis and the number of comorbid conditions were shown to significantly impact medication adherence. This suggests that individuals with a longer history of hypertension or those managing multiple health conditions face greater challenges in adhering to their medication regimens, highlighting the need for tailored intervention strategies that consider the complexity of each patient's health status [30, 31].

In summary, the constellation of variables influencing medication adherence among individuals with hypertension underscores the necessity for a holistic approach to healthcare that encompasses demographic, lifestyle, psychological, and clinical considerations. The findings of this study advocate for the development of multifaceted interventions aimed at improving medication adherence rates, thereby enhancing the effectiveness of hypertension

management and ultimately reducing the morbidity and mortality associated with this condition [32]. The tendency for increased medication adherence with advancing age suggests that older patients have a greater awareness of the importance of health management [33]. This implies that as individuals age, they perceive a greater necessity for maintaining health and recognize the significance of medication adherence. Conversely, the observation that higher educational levels are associated with lower adherence suggests that educated individuals may approach or interpret health information from different perspectives [34]. Additionally, the finding that a greater number of comorbidities is associated with improved adherence indicates that awareness of complex health issues acts as a factor enhancing adherence rates. This suggests that patients facing multiple health challenges might feel the importance of medication adherence more acutely and engage in it more proactively [35]. These results highlight the need for tailored interventions for hypertension patients, emphasizing the importance of social support and mental health management.

The performance of the AdaNet algorithm is a significant contribution of this study, demonstrating its applicability in disease research. AdaNet possesses the capability to maintain high predictive accuracy while effectively analyzing complex interactions among variables [17]. This is particularly useful in medical data contexts where multiple variables and nonlinear relationships are prevalent. Utilizing AdaNet allows for the development of more accurate predictive models based on larger datasets, playing a crucial role in disease prediction and management strategy formulation. Future research should apply AdaNet's performance across various disease groups to assess its versatility and explore additional variable exploration and dataset expansion to enhance the model's predictive power. Additionally, based on the findings of this study, there is a need to design practical intervention programs and conduct subsequent research to verify their effectiveness in actual clinical settings.

The limitations of the study include, first, the Korean National Health and Nutrition Examination Survey data are from a cross-sectional observational study, limiting the ability to clearly establish causality. Second, there is a lack of detailed information on the content and methods of hypertension education, hindering a proper evaluation of its effectiveness. Third, the reliance on self-reported surveys may introduce subjective bias from respondents, potentially affecting data accuracy. To address these limitations, future research should incorporate longitudinal and qualitative studies for more in-depth analysis.

## 5. Conclusion

This study analyzed the factors influencing hypertension medication adherence among middle-aged male workers using reliable national survey data. The importance of variables was determined through the AdaNet algorithm, and their impacts were assessed using multivariate logistic regression analysis. The outstanding predictive performance of the AdaNet algorithm demonstrated in this study highlights its efficacy as a tool for analyzing complex medical data. This suggests the potential of AdaNet in the development of various disease prediction models in the future. Furthermore, the findings of this study provide critical evidence for establishing hypertension management strategies and emphasize the importance of social support and mental health management. Future research should focus on studies involving more diverse populations and the establishment of causal relationships through long-term observations.

Declaration of competing interest. The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Availability of data and materials. The data is not publicly available because researchers need to obtain permission from the Korea Centers for Disease Control and Prevention. Detailed information can be found at: http://knhanes.cdc.go.kr.

Author's Contribution. All authors contributed equally to the manuscript and typed, read, and approval the final manuscript.

Acknowledgement. We are thankful to the editors and the anonymous reviewers for many valuable suggestions to improve this paper.

Funding: This research Supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF- RS-2023-00237287, NRF-2021S1A5A8062526) and local government-university cooperation-based regional innovation projects (2021RIS-003).

Ethical approval. The study was conducted in accordance with the guidelines of the Declaration of Helsinki. The protocol for the 2016–2018 KNHANES was approved by the Institutional Review Board (IRB) of the Korea Centers for Disease Control and Prevention (IRB approval numbers for 2016–2018: 2018-01-03-P-A and 2018-01-03-C-A).

## References

1. K. T. Mills, A. Stefanescu, & J. He, The global epidemiology of hypertension, Nature Reviews Nephrology, 16(4) (2020), 223-237.
2. B. Zhou, P. Perel, G. A. Mensah, & M. Ezzati, Global epidemiology, health burden, and effective interventions for elevated blood pressure and hypertension, Nature Reviews Cardiology, 18(11) (2021), 785-802.
3. J. P. Kalehoff, & S. Oparil, The story of the silent killer: a history of hypertension: its discovery, diagnosis, treatment, and debates, Current Hypertension Reports, 22(9) (2020), 72.
4. E. Oliveros, H. Patel, S. Kyung, S. Fugar, A. Goldberg, N. Madan, & K. A. Williams, Hypertension in older adults: Assessment, management, and challenges, Clinical Cardiology, 43(2) (2020), 99-107.
5. M. Gilbert-Ouimet, X. Trudel, D. Talbot, M. Vézina, A. Milot, & C. Brisson, Long working hours associated with elevated ambulatory blood pressure among female and male white-collar workers over a 2.5-year follow-up, Journal of Human Hypertension, 36(2) (2022), 207-217.
6. N. R. Poulter, C. Borghi, G. Parati, A. Pathak, D. Toli, B. Williams, & R. E. Schmieder, Medication adherence in hypertension, Journal of Hypertension, 38(4) (2020), 579-587.
7. M. Burnier, E. Polychronopoulou, & G. Wuerzner, Hypertension and drug adherence in the elderly, Frontiers in Cardiovascular Medicine, 7 (2020), 49.
8. E. A. Mamaghani, E. Hasanpoor, E. Maghsoodi, & F. Soleimani, Barriers to medication adherence among hypertensive patients in deprived rural areas, Ethiopian Journal of Health Sciences, 30(1) (2020).
9. J. González-Bueno, D. Sevilla-Sánchez, E. Puigoriol-Juvanteny, N. Molist-Brunet, C. Codina-Jané, & J. Espaulella-Panicot, Improving medication adherence and effective prescribing

through a patient-centered prescription model in patients with multimorbidity, European Journal of Clinical Pharmacology, 78(1) (2022), 127-137.
10. K. Q. E. Peh, Y. H. Kwan, H. Goh, H. Ramchandani, J. K. Phang, Z. Y. Lim, et al., An adaptable framework for factors contributing to medication adherence: results from a systematic review of 102 conceptual frameworks, Journal of General Internal Medicine, 36 (2021), 2784-2795.
11. X. Chen, L. Du, R. Wu, J. Xu, H. Ji, Y. Zhang, et al., The effects of family, society, and national policy support on treatment adherence among newly diagnosed tuberculosis patients: a cross-sectional study, BMC Infectious Diseases, 20 (2020), 1-11.
12. I. A. Kretchy, M. Asiedu-Danso, & J. P. Kretchy, Medication management and adherence during the COVID-19 pandemic: perspectives and experiences from low-and middle-income countries, Research in Social and Administrative Pharmacy, 17(1) (2021), 2023-2026.
13. R. Whitley, & R. Whitley, Employment, Unemployment, and Workplace Issues in Relation to Men's Mental Health, Men's Issues and Men's Mental Health: An Introductory Primer, 2021, 177-205.
14. K. Kvarnström, A. Westerholm, M. Airaksinen, & H. Liira, Factors contributing to medication adherence in patients with a chronic condition: a scoping review of qualitative research, Pharmaceutics, 13(7) (2021), 1100.
15. H. Byeon, Determinants of blood pressure control in hypertensive individuals using histogram-based gradient boosting: findings from 1114 male workers in South Korea, Journal of Men's Health, 20(9) (2024), 47-55.
16. J. An, Q. Cai, Z. Qu, & Z. Gao, COVID-19 screening in chest X-ray images using lung region priors, IEEE Journal of Biomedical and Health Informatics, 25(11) (2021), 4119-4127.
17. R. Liu, Y. Liu, & J. Gu, Improved AdaNet based on adaptive learning rate optimization, Journal of Computer Applications, 40(10) (2020), 2804.
18. F. Aziz, S. Malek, A. M. Ali, M. S. Wong, M. Mosleh, & P. Milow, Determining hypertensive patients' beliefs towards medication and associations with medication adherence using machine learning methods, PeerJ, 8 (2020), e8286.
19. J. Waring, C. Lindvall, & R. Umeton, Automated machine learning: Review of the state-of-the-art and opportunities for healthcare, Artificial Intelligence in Medicine, 104 (2020), 101822.
20. G. K. Lee, H. H. Wang, K. Q. Liu, Y. Cheung, D. E. Morisky, & M. C. Wong, Determinants of medication adherence to antihypertensive medications among a Chinese population using Morisky Medication Adherence Scale, PLoS One, 8(4) (2013), e62775.
21. Z. Xie, K. Liu, C. Or, J. Chen, M. Yan, & H. Wang, An examination of the socio-demographic correlates of patient adherence to self-management behaviors and the mediating roles of health attitudes and self-efficacy among patients with coexisting type 2 diabetes and hypertension, BMC Public Health, 20 (2020), 1-13.
22. O. O. Ekundayo, O. T. Elegbede, O. E. Gabriel-Alayode, S. M. Agboola, O. M. Shabi, I. S. Bello, et al., Role of perceived spousal social support in medication adherence among hypertensive patients attending family medicine clinic in federal teaching hospital, ido-ekiti, Nigeria, Archives of Clinical Hypertension, 6(2) (2020), 205-212.
23. L. Laranjo, A. Arguel, A. L. Neves, A. M. Gallagher, R. Kaplan, N. Mortimer, et al., The influence of social networking sites on health behavior change: a systematic review and meta-analysis, Journal of the American Medical Informatics Association, 22(1) (2015), 243-256.
24. C. I. Fernandez-Lazaro, D. P. Adams, D. Fernandez-Lazaro, J. M. Garcia-González, A. Caballero-Garcia, & J. A. Miron-Canelo, Medication adherence and barriers among low-income, uninsured patients with multiple chronic conditions, Research in Social and Administrative Pharmacy, 15(6) (2019), 744-753.
25. R. Nakajima, F. Watanabe, & M. Kamei, Factors associated with medication non-adherence

among patients with lifestyle-related non-communicable diseases, Pharmacy, 9(2) (2021), 90.
26. Y. Lee, Y. Ahn, & L. Cucullo, Impact of physical activity and medication adherence on the seizure frequency and quality of life of epileptic patients: a population study in West Texas, BioMed Research International, 2022(1) (2022), 4193664.
27. J. L. Grenard, B. A. Munjas, J. L. Adams, M. Suttorp, M. Maglione, E. A. McGlynn, & W. F. Gellad, Depression and medication adherence in the treatment of chronic diseases in the United States: a meta-analysis, Journal of General Internal Medicine, 26 (2011), 1175-1182.
28. I. G. Chouvarda, D. G. Goulis, I. Lambrinoudaki, & N. Maglaveras, Connected health and integrated care: Toward new models for chronic disease management, Maturitas, 82(1) (2015), 22-27.
29. M. L. Sampaio, & J. P. Bispo Júnior, Towards comprehensive mental health care: experiences and challenges of psychosocial care in Brazil, BMC Public Health, 21 (2021), 1-12.
30. M. Burnier, & B. M. Egan, Adherence in hypertension: a review of prevalence, risk factors, impact, and management, Circulation Research, 124(7) (2019), 1124-1140.
31. L. Steed, K. Heslop-Marshall, R. Sohanpal, S. Saqi-Waseem, M. Kelly, H. Pinnock, & S. Taylor, Developing a complex intervention whilst considering implementation: the TANDEM (Tailored intervention for ANxiety and DEpression Management) intervention for patients with chronic obstructive pulmonary disease (COPD), Trials, 22 (2021), 1-14.
32. C. Schäfer, Reimagining Medication Adherence: A Novel Holistic Model for Hypertension Therapy, Patient Preference and Adherence, 2024, 391-410.
33. H. Jin, Y. Kim, & S. J. Rhie, Factors affecting medication adherence in elderly people, Patient Preference and Adherence, 2016, 2117-2125.
34. S. K. Smith, A. Dixon, L. Trevena, D. Nutbeam, & K. J. McCaffery, Exploring patient involvement in healthcare decision making across different education and functional health literacy groups, Social Science & Medicine, 69(12) (2009), 1805-1812.
35. K. Gow, A. Rashidi, & L. Whithead, Factors influencing medication adherence among adults living with diabetes and comorbidities: a qualitative systematic review, Current Diabetes Reports, 24(2) (2024), 19-25.