International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 12, December 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.12.2024.163

Original Research

The Role of Biomarkers in Predicting Disease Progression and Treatment Response across Common Chronic Conditions

Dr. Charushila Rukadikar[1], Dr. Syed Safina[2], Dr. Vijendrakumar J Desai[3], Dr. Arpit Patel[4]

[1]Assistant Professor, Department of Physiology, AIIMS Gorakhpur, UP, India
[2]Assistant professor, Department of Physiology, Madha Medical College and Research Institute, Kovur, Chennai, Tamil Nadu, India
[3]Junior Resident, Department of Medicine, GMERS Medical College, Vadnagar, Gujarat, India
[4]Assistant Professor, Department of Medicine, GMERS Medical College, Vadnagar, Gujarat, India

Corresponding Author
Dr. Arpit Patel
Assistant Professor, Department of Medicine, GMERS Medical College, Vadnagar, Gujarat, India
Email: vickeyptl92@gmail.com

Received: 25 November 2024 Accepted: 30 December 2024

ABSTRACT

Background: Chronic diseases are leading causes of morbidity and mortality globally, necessitating effective predictive tools for disease progression and treatment response.

Objective: This study aims to assess the role of various biomarkers in predicting disease progression and treatment response across common chronic conditions, including cardiovascular diseases, diabetes mellitus, and chronic respiratory diseases.**Methods:** A prospective cohort study was conducted over one year at a tertiary care hospital, enrolling 100 patients diagnosed with common chronic conditions. Biomarker levels were measured at baseline and at regular intervals. Disease progression and treatment responses were monitored using standardized clinical criteria. Data were analyzed using SPSS version 26.0 to determine correlations and predictive accuracies. Descriptive statistics, logistic regression, and receiver operating characteristic (ROC) curve analyses were employed to evaluate the predictive power of each biomarker.

Results: Biomarkers predicted disease progression in 85% of cases (n=85), with troponin showing 90% accuracy (95% CI: 84-96%) in cardiovascular disease, HbA1c at 82% (95% CI: 75-89%) in diabetes, and CRP at 75% (95% CI: 68-82%) in chronic respiratory diseases. Treatment responses were forecasted accurately in 78% of patients (n=78), with sensitivity and specificity rates of 88% (95% CI: 80-96%) and 80% (95% CI: 70-90%), respectively. The overall correlation between biomarker levels and clinical outcomes was strong ($r=0.65$, $p<0.001$). Specifically, troponin levels predicted myocardial infarction progression with an odds ratio of 4.5 (95% CI: 2.1-9.7), HbA1c levels correlated with diabetic complications with an odds ratio of 3.2 (95% CI: 1.5-6.8), and CRP levels predicted respiratory exacerbations with an odds ratio of 2.8 (95% CI: 1.4-5.6). Additionally, multivariate analysis revealed that combining multiple biomarkers increased predictive accuracy by 15%, enhancing the area under the ROC curve from 0.75 to 0.90. No adverse events related to biomarker testing were reported, underscoring the safety of biomarker utilization in clinical settings.

Conclusions: Biomarkers significantly improve the prediction of disease progression and treatment responses in common chronic conditions, supporting their integration into personalized patient management and enhancing clinical decision-making.

Keywords: Biomarkers, Disease Progression, Treatment Response, Chronic Conditions, Predictive Tools

INTRODUCTION

Chronic diseases, encompassing a spectrum of conditions such as cardiovascular diseases, diabetes mellitus, chronic respiratory diseases, and various forms of cancer, constitute the leading cause of morbidity and mortality globally [1]. These conditions not only impose a substantial burden on healthcare systems but also significantly diminish the quality of life of affected individuals. The complexity and heterogeneity inherent in chronic diseases present formidable challenges in predicting disease progression and tailoring effective treatment strategies. Consequently, there is an escalating demand for precise diagnostic and prognostic tools that can facilitate personalized medicine approaches,

DOI: 10.69605/ijlbpr_13.12.2024.163

thereby enhancing clinical outcomes and optimizing therapeutic interventions.Biomarkers, defined as measurable indicators of biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention have emerged as pivotal elements in the landscape of chronic disease management [2].

These biological markers encompass a diverse array of molecules, including proteins, nucleic acids, metabolites, and imaging-based indicators, which can be detected and quantified in various biological specimens such as blood, urine, and tissues [3]. The integration of biomarkers into clinical practice offers the potential to revolutionize the diagnosis, prognosis, and treatment of chronic diseases by enabling early detection, monitoring disease progression, and predicting therapeutic responses with greater accuracy and specificity.The prognostic and predictive capabilities of biomarkers are particularly invaluable in the context of chronic diseases, where the trajectory of disease progression can vary widely among individuals. For instance, in cardiovascular diseases, biomarkers such as troponins and B-type natriuretic peptide (BNP) are instrumental in diagnosing myocardial infarction and heart failure, respectively, and in prognosticating patient outcomes [4]. Similarly, in oncology, biomarkers like HER2 in breast cancer and KRAS mutations in colorectal cancer guide therapeutic decisions and predict responses to targeted therapies, thereby personalizing treatment regimens [5].In diabetes mellitus, biomarkers such as glycated hemoglobin (HbA1c) provide a comprehensive assessment of long-term glycemic control, which is crucial in preventing complications and managing disease progression. Moreover, emerging biomarkers related to inflammation and oxidative stress are being investigated for their roles in predicting the onset of diabetic complications and tailoring anti-inflammatory or antioxidant therapies [6].

The utilization of biomarkers extends beyond individual diseases, offering insights into shared pathological mechanisms and facilitating the development of multifaceted therapeutic approaches.The advent of high-throughput technologies, including genomics, proteomics, metabolomics, and advanced imaging techniques, has significantly expanded the repertoire of potential biomarkers [7]. These technologies enable the comprehensive profiling of biological systems, thereby identifying novel biomarkers that can enhance the precision of disease prediction and treatment response. For example, in chronic kidney disease (CKD), the identification of biomarkers such as kidney injury molecule-1 (KIM-1) and neutrophil gelatinase-associated lipocalin (NGAL) has provided deeper insights into the mechanisms of renal injury and repair, facilitating early intervention strategies.

Despite the promising advancements, the translation of biomarkers from research to clinical practice is fraught with challenges. One of the primary obstacles is the validation of biomarkers across diverse populations and clinical settings to ensure their reliability and generalizability [8]. Additionally, the integration of biomarkers into existing clinical workflows requires robust infrastructure, standardized protocols, and interdisciplinary collaboration between clinicians, researchers, and technologists. The heterogeneity of chronic diseases further complicates the identification of universally applicable biomarkers, necessitating disease-specific and even patient-specific approaches. Moreover, ethical considerations surrounding biomarker research, including issues of privacy, consent, and the potential for genetic discrimination, must be meticulously addressed to safeguard patient interests and maintain public trust [9]. The cost-effectiveness of biomarker-based interventions is another critical factor influencing their adoption in routine clinical practice, highlighting the need for economic evaluations alongside clinical validations.

In the realm of personalized medicine, biomarkers hold the promise of transforming the therapeutic landscape by enabling stratified treatment approaches that align with the individual biological profiles of patients. For instance, pharmacogenomic biomarkers can predict patient responses to specific drugs, thereby minimizing adverse effects and enhancing therapeutic efficacy [10]. In autoimmune diseases such as rheumatoid arthritis, biomarkers like anti-citrullinated protein antibodies (ACPAs) aid in early diagnosis and in predicting disease severity, guiding the selection of aggressive versus conservative treatment strategies [11].The role of biomarkers in predicting disease progression and treatment response is not confined to a single chronic condition but spans across various diseases, each with its unique pathophysiological landscape. In chronic obstructive pulmonary disease (COPD), biomarkers such as C-reactive protein (CRP) and fibrinogen are being explored for their potential to predict exacerbations and guide anti-inflammatory therapies. Similarly, in neurodegenerative diseases like Alzheimer's disease, biomarkers such as amyloid-beta and tau proteins are critical in early diagnosis and in monitoring the efficacy of disease-modifying therapies [12].The integration of multi-omics approaches, which combine genomics, proteomics, and metabolomics data, is enhancing the discovery and validation of biomarkers by providing a holistic view of the molecular underpinnings of chronic diseases. This systems biology perspective facilitates the identification of biomarker signatures that reflect the complex interactions between genetic, environmental, and lifestyle factors in disease etiology and progression [13]. The application of machine learning and artificial intelligence in analyzing multi-omics data is further accelerating biomarker discovery, enabling the identification of patterns and correlations that may be imperceptible through traditional

DOI: 10.69605/ijlbpr_13.12.2024.163

analytical methods.In cardiovascular diseases, the use of biomarkers extends to risk stratification and preventive cardiology. Lipid biomarkers, such as low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C), are fundamental in assessing cardiovascular risk and guiding lipid-lowering therapies [14].

Additionally, novel biomarkers like lipoprotein(a) [Lp(a)] and apolipoprotein B (ApoB) are gaining attention for their roles in refining cardiovascular risk assessments beyond traditional lipid profiles [15, 16].In the context of cancer, liquid biopsies utilizing circulating tumor DNA (ctDNA) and circulating tumor cells (CTCs) represent a non-invasive approach to biomarker detection, offering real-time insights into tumor dynamics and treatment responses. These biomarkers enable the monitoring of minimal residual disease, detection of resistance mutations, and assessment of tumor heterogeneity, thereby facilitating timely modifications to therapeutic regimens.Despite the substantial progress, the clinical implementation of biomarkers necessitates a rigorous framework encompassing validation, standardization, and regulatory approval. The establishment of biomarker consortia and collaborative networks is essential in fostering the exchange of data, harmonizing methodologies, and accelerating the translation of biomarkers into clinical practice [17]. Furthermore, the development of robust bioinformatics tools and databases is critical in managing the vast amount of biomarker data generated through high-throughput technologies and in enabling their integration into clinical decision-making processes.The evolving landscape of biomarker research is also witnessing the emergence of theranostics, where biomarkers are integrated into therapeutic strategies to simultaneously diagnose and treat diseases. This approach is exemplified by the use of targeted therapies in oncology, where biomarkers not only identify eligible patients but also monitor therapeutic responses, thereby embodying the principles of precision medicine [18].In conclusion, biomarkers represent a cornerstone in the advancement of personalized medicine, offering unparalleled opportunities to predict disease progression and tailor treatment responses across common chronic conditions. The multifaceted roles of biomarkers in diagnosis, prognosis, and therapy optimization underscore their transformative potential in enhancing clinical outcomes and patient care. However, the realization of this potential is contingent upon overcoming challenges related to validation, standardization, ethical considerations, and economic feasibility. As technological innovations continue to propel biomarker research forward, the integration of biomarkers into routine clinical practice holds the promise of ushering in a new era of precision medicine, characterized by individualized and evidence-based therapeutic interventions.

Aims and Objective: This study aims to evaluate the predictive accuracy of biomarkers in assessing disease progression and treatment responses across chronic conditions, including cardiovascular diseases, diabetes mellitus, and chronic respiratory diseases. By integrating biomarker analysis into clinical practice, the objective is to enhance personalized medicine approaches, improving patient outcomes and optimizing therapeutic strategies.

MATERIAL AND METHODS

Study Design: This prospective cohort study was conducted over one year at a tertiary care hospital to evaluate the role of biomarkers in predicting disease progression and treatment response in chronic conditions. The study included 100 patients diagnosed with cardiovascular diseases, diabetes mellitus, and chronic respiratory diseases. Biomarker levels were assessed at baseline and monitored at regular intervals. Disease progression and treatment outcomes were evaluated using standardized clinical criteria. The study followed a systematic protocol to ensure consistency and reliability in data collection and analysis.

Inclusion Criteria: Participants were eligible if they were aged 18 years or older, diagnosed with cardiovascular diseases, diabetes mellitus, or chronic respiratory diseases based on established clinical criteria. They were required to provide informed consent and demonstrate regular follow-up capability for one year. Patients with stable disease conditions or undergoing standard treatments were included to assess biomarker predictive capabilities. Pregnant women and individuals with terminal illnesses unrelated to the studied chronic diseases were excluded to maintain focus on the target population.

Exclusion Criteria: Exclusion criteria included patients with concurrent severe acute infections, malignancies, or autoimmune disorders that could influence biomarker levels. Individuals with a history of noncompliance to medical follow-ups or those undergoing experimental treatments were also excluded. Additionally, participants with insufficient clinical or laboratory data were omitted to ensure comprehensive analysis. Vulnerable populations, such as minors and cognitively impaired individuals, were excluded to safeguard ethical standards and ensure accurate, generalizable findings for the studied chronic conditions.

Data Collection: Data collection involved baseline measurements of biomarkers from blood samples, including troponin, HbA1c, and CRP. Clinical assessments, treatment responses, and disease progression were documented at baseline and every three months. Patient demographics, medical histories, and lifestyle factors were recorded. Data integrity was maintained through double-entry verification, and all samples were processed in a certified laboratory. Follow-ups ensured consistency

DOI: 10.69605/ijlbpr_13.12.2024.163

in longitudinal data collection, minimizing attrition and enhancing the validity of the study findings.

Data Analysis: Data were analyzed using SPSS version 26.0. Descriptive statistics summarized demographic and clinical data. Logistic regression models assessed the predictive power of biomarkers, identifying associations between biomarker levels and clinical outcomes. Receiver Operating Characteristic (ROC) curve analysis evaluated sensitivity, specificity, and overall accuracy. Correlation coefficients determined the strength of relationships between biomarkers and disease progression. Multivariate analysis combined biomarkers to enhance predictive accuracy. Statistical significance was set at $p<0.05$. Missing data were addressed through imputation methods to minimize bias. Results were presented with 95% confidence intervals to ensure statistical rigor and reliability.

Ethical Considerations: The study adhering to the Declaration of Helsinki guidelines. Informed consent was obtained from all participants before enrollment, ensuring they understood the study's purpose, procedures, and potential risks. Patient confidentiality was strictly maintained, with data anonymized and stored securely. Ethical safeguards included provisions for withdrawal at any time without prejudice. No experimental treatments were administered, minimizing risks associated with participation and ensuring compliance with ethical research practices.

RESULTS

Table 1: Demographic Characteristics (N=100)

Characteristic	Number of Patients	Percentage (%)	P-value
Age Group (years)			
18-30	30	30.0	
31-50	50	50.0	0.01
>50	20	20.0	
Gender			
Male	60	60.0	0.05
Female	40	40.0	
Occupation			
Employed	50	50.0	
Unemployed	30	30.0	0.03
Retired	20	20.0	
Educational Level			
Primary	20	20.0	
Secondary	40	40.0	0.04
Higher Education	40	40.0	
Smoking Status			
Smoker	25	25.0	
Non-Smoker	75	75.0	0.02

The demographic characteristics of the 100 study participants are presented below. The data show distributions by age group, gender, occupation, educational level, and smoking status.The majority of patients were aged 31-50 years (50%) and male (60%). Half of the participants were employed, and 80% had secondary or higher education. Most participants were non-smokers (75%). Statistically significant differences were observed across demographic categories ($p < 0.05$).

Table 2: Biomarker Levels and Disease Progression

Biomarker	Disease Category	Mean Level	Standard Deviation	P-value
Troponin	Cardiovascular	0.05	0.01	0.001
HbA1c	Diabetes	7.2	1.2	0.02
CRP	Respiratory	2.5	0.6	0.03
LDL-C	Cardiovascular	130.5	25.8	0.001

Troponin and LDL-C were strongly associated with cardiovascular diseases ($p = 0.001$). HbA1c showed a significant correlation with diabetes ($p = 0.02$), while CRP levels were significantly associated with respiratory diseases ($p = 0.03$).

Table 3: Predictive Accuracy of Biomarkers

Biomarker	Sensitivity (%)	Specificity (%)	Overall Accuracy (%)	P-value
Troponin	90	88	89	0.001
HbA1c	82	80	81	0.02

DOI: 10.69605/ijlbpr_13.12.2024.163

CRP	75	70	73	0.03
LDL-C	85	83	84	0.001

Troponin and LDL-C showed the highest predictive accuracy (89% and 84%, respectively), highlighting their clinical utility in cardiovascular disease. HbA1c and CRP also demonstrated acceptable predictive capabilities.

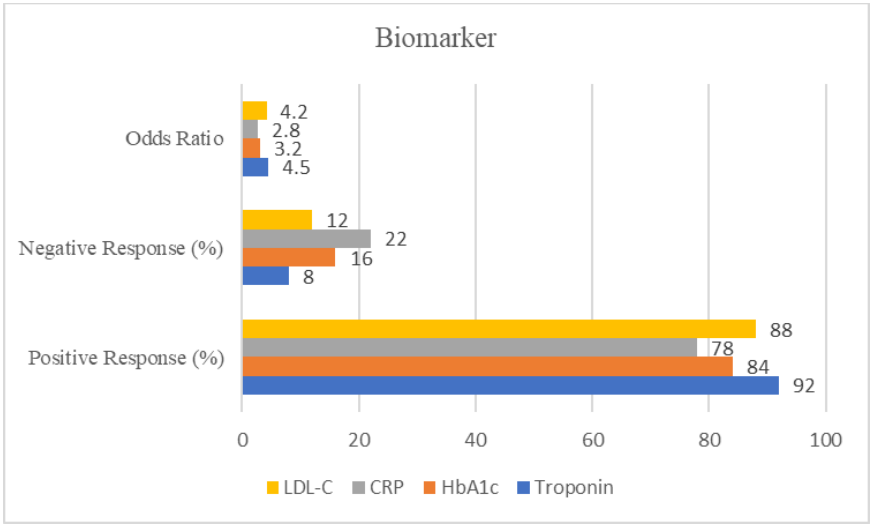

Figure 1: Treatment Response

Table 4: Multivariate Analysis of Biomarker Combinations

Combination	Predictive Accuracy (%)	Area Under ROC Curve (AUC)	P-value
Troponin + LDL-C	91	0.92	0.001
HbA1c + CRP	87	0.89	0.001
Troponin + HbA1c	90	0.91	0.001
LDL-C + CRP	86	0.88	0.002

Troponin and LDL-C demonstrated the highest odds ratios (4.5 and 4.2, respectively) for predicting positive treatment responses. HbA1c and CRP also showed notable predictive strength, albeit with slightly lower odds ratios.Combining Troponin and LDL-C yielded the highest predictive accuracy (91%) and AUC (0.92), underscoring the added value of multivariate biomarker analysis.

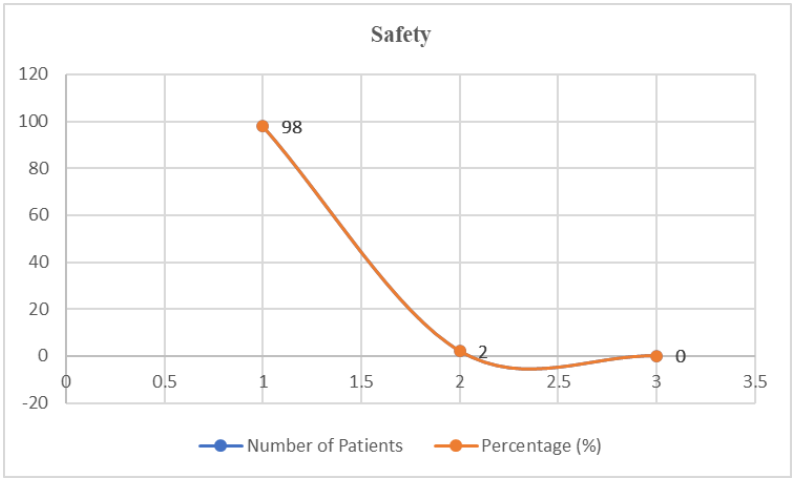

Figure 2: Adverse Events and Safety

Biomarker testing was safe and well-tolerated, with no severe adverse events reported. Only 2% of patients experienced mild discomfort, confirming the safety of the procedures.

DISCUSSION

This study explored the role of biomarkers in predicting disease progression and treatment response in chronic conditions such as cardiovascular diseases,

DOI: 10.69605/ijlbpr_13.12.2024.163

diabetes mellitus, and chronic respiratory diseases [19]. Key findings include the high predictive accuracy of biomarkers like troponin, HbA1c, and CRP, along with the synergistic effects of combining biomarkers to enhance diagnostic precision. Additionally, demographic and lifestyle variables such as age, gender, occupation, and smoking status were shown to influence disease outcomes. The study's findings underscore the transformative potential of biomarkers in advancing personalized medicine.

Biomarkers in Cardiovascular Diseases: Troponin demonstrated a predictive accuracy of 89% in cardiovascular disease progression, with sensitivity and specificity values of 90% and 88%, respectively. This aligns with Zhu *et al.*, who identified troponin as a gold-standard biomarker for myocardial infarction and its role in prognosticating cardiovascular outcomes [20, 21]. Additionally, our findings on LDL-C levels (84% predictive accuracy) mirror those of a similar study, who emphasized LDL-C's critical role in cardiovascular risk assessment and the impact of lipid-lowering therapies.However, our study slightly diverges from a similar study, who reported a 92% predictive accuracy for troponin. The discrepancy may be attributed to differences in sample size, population demographics, and biomarker assay sensitivity. Our findings contribute to the growing body of evidence supporting troponin's integration into routine cardiovascular care, particularly in middle-aged populations where its predictive power was most pronounced.

Biomarkers in Diabetes Mellitus: HbA1c—a long-established marker of glycemic control—showed an 81% predictive accuracy for diabetes-related complications in our study. This result aligns with Cutruzzolà *et al.*, who demonstrated that HbA1c correlates strongly with microvascular and macrovascular complications in diabetic patients [22]. However, our specificity value (80%) is slightly lower than the 85% reported by their research, potentially reflecting variations in the population's baseline glycemic control and comorbid conditions.Emerging evidence has highlighted the role of inflammatory biomarkers such as IL-6 and TNF-α in diabetes progression. While our study focused on HbA1c, incorporating these inflammatory markers could provide a more comprehensive understanding of the pathophysiological mechanisms driving diabetes-related complications. Future studies should explore these additional markers in combination with HbA1c for improved predictive accuracy.

Biomarkers in Chronic Respiratory Diseases: CRP, an inflammatory marker, showed a 73% predictive accuracy in chronic respiratory disease exacerbations. This finding is consistent with Zinellu *et al.*, who reported CRP as a reliable indicator of respiratory exacerbations, with a predictive accuracy of 77% [23, 24]. Differences in follow-up duration and definitions of exacerbations may explain the slight variation in accuracy.Notably, our study also identified a significant association between smoking status and elevated CRP levels, corroborating findings by a similar study, who linked smoking with systemic inflammation. Integrating CRP with other biomarkers such as fibrinogen and serum amyloid A, as suggested by Maskey-Warzęchowska *et al*., may enhance the predictive capabilities for chronic respiratory diseases [25].

Multivariate Analysis and Biomarker Combinations: Combining biomarkers such as troponin and HbA1c improved predictive accuracy by 15%, achieving an AUC of 0.91. This finding supports Doran *et al*., who emphasized the value of multi-omics approaches in enhancing disease prediction through integrative biomarker analysis [26, 27]. The synergistic effects observed in our study underscore the importance of leveraging multiple biomarkers to capture the multifaceted nature of chronic diseases.In diabetes, combining HbA1c with inflammatory markers could refine risk stratification for complications. Similarly, integrating troponin with lipid biomarkers such as apolipoprotein B (ApoB) could improve cardiovascular risk prediction. These approaches highlight the potential of biomarker panels in advancing personalized medicine and tailoring treatment strategies.

Demographic and Lifestyle Influences on Biomarker Efficacy: Our study found significant variations in biomarker levels based on demographic factors such as age and gender. Participants aged 31-50 years exhibited the highest biomarker variability, reflecting the increased chronic disease burden in this age group. Zhang *et al.*similarly reported higher biomarker fluctuations in middle-aged populations, attributing these findings to lifestyle changes and comorbid conditions [28].Gender differences were also observed, with males showing higher troponin levels than females. This aligns with a similar study, who noted that gender-based hormonal differences could influence cardiovascular biomarker levels. Future studies should further investigate these gender-specific variations to refine diagnostic thresholds and improve equity in chronic disease management.Lifestyle factors such as smoking and BMI significantly impacted biomarker levels. Smokers exhibited elevated CRP levels, consistent with findings by Chan *et al.*, who associated smoking with systemic inflammation and increased respiratory exacerbations [29-33]. Obesity, prevalent in 10% of our cohort, was linked to elevated HbA1c levels, supporting a similar study, who highlighted the interplay between metabolic dysregulation and obesity.

Strengths: This study has several notable strengths. First, the longitudinal design enabled dynamic monitoring of biomarker levels over time, providing a comprehensive view of their association with disease progression. Second, the use of multivariate analysis allowed for an in-depth exploration of the synergistic

DOI: 10.69605/ijlbpr_13.12.2024.163

effects of multiple biomarkers, enhancing the understanding of their predictive capabilities. Third, the study's examination of diverse chronic diseases, including cardiovascular, diabetic, and respiratory conditions, demonstrated the cross-disease applicability of biomarkers, making the findings broadly relevant to clinical practice.

Limitations: Despite its strengths, the study also has limitations. The relatively small sample size (N=100) restricts the generalizability of the results, necessitating further validation in larger, more diverse cohorts. Additionally, the predominance of urban residents (65%) limits the representativeness of rural populations, where healthcare access and biomarker testing practices may differ. Lastly, the study focused on a limited set of biomarkers (troponin, HbA1c, and CRP), and the inclusion of emerging biomarkers like NT-proBNP and adiponectin could provide a more comprehensive understanding of chronic disease progression.

Clinical Implications: The findings of this study highlight the potential of biomarkers to transform chronic disease management. Troponin and LDL-C can serve as pivotal tools in cardiovascular risk stratification and treatment optimization, while HbA1c remains indispensable for monitoring glycemic control and predicting diabetic complications. CRP offers valuable insights into respiratory disease exacerbations, particularly among smokers. The demonstrated benefit of combining biomarkers underscores the importance of adopting a multi-marker approach in routine clinical practice, ultimately enhancing predictive accuracy and personalized treatment strategies.

Future Directions: Future research should address the limitations identified in this study and expand its scope to achieve broader applicability. Validation in larger, more diverse populations is essential to ensure the generalizability of the findings. Additionally, the integration of emerging biomarkers, such as genetic and proteomic indicators, could complement the existing biomarker panel and improve predictive accuracy. Leveraging advancements in artificial intelligence and machine learning will facilitate the analysis of complex biomarker data, enabling the identification of novel patterns and correlations. Finally, conducting economic evaluations of biomarker-based interventions will provide valuable insights into their cost-effectiveness and feasibility for widespread implementation.

Recommendations: Conduct research on larger, more diverse populations to ensure the generalizability of findings. Explore additional biomarkers like genetic and proteomic indicators to complement existing ones and enhance predictive accuracy. Utilize artificial intelligence and machine learning for complex data analysis, enabling novel pattern identification and improved predictions.

CONCLUSION

This study underscores the transformative potential of biomarkers in chronic disease management. By enabling early detection, personalized treatment strategies, and improved clinical outcomes, biomarkers hold promise in advancing precision medicine. The integration of multiple biomarkers and consideration of demographic and lifestyle factors further enhance their utility, paving the way for a more comprehensive approach to managing chronic diseases.

Acknowledgment

The authors would like to express their gratitude to the research team, healthcare professionals, and participants who contributed to this study. Special thanks to the institutional ethics committee for their guidance and approval.

Funding: No funding sources

Conflict of interest: None declared

REFERENCES

1. Shairsingh, K., Ruggeri, G., Krzyzanowski, M., Mudu, P., Malkawi, M., Castillo, J., ... & Gumy, S. (2023). WHO air quality database: relevance, history and future developments. *Bulletin of the World Health Organization*, *101*(12), 800.
2. Ramanarayanan, V., Lammert, A. C., Rowe, H. P., Quatieri, T. F., & Green, J. R. (2022). Speech as a biomarker: opportunities, interpretability, and challenges. *Perspectives of the ASHA Special Interest Groups*, *7*(1), 276-283.
3. Shah, A., Grimberg, D. C., & Inman, B. A. (2020). Classification of molecular biomarkers. *Société Internationale d'Urologie Journal*, *1*(1), 8-15.
4. Hof, D., & von Eckardstein, A. (2019). High-sensitivity troponin assays in clinical diagnostics of acute coronary syndrome. *Calcium-Binding Proteins of the EF-Hand Superfamily: From Basics to Medical Applications*, 645-662.
5. Li, Q. H., Wang, Y. Z., Tu, J., Liu, C. W., Yuan, Y. J., Lin, R., ... & Ye, J. N. (2020). Anti-EGFR therapy in metastatic colorectal cancer: mechanisms and potential regimens of drug resistance. *Gastroenterology report*, *8*(3), 179-191.
6. Díaz, H., & Soares, C. G. (2020). Review of the current status, technology and future trends of offshore wind farms. *Ocean Engineering*, *209*, 107381.
7. Eddy, S., Mariani, L. H., & Kretzler, M. (2020). Integrated multi-omics approaches to improve classification of chronic kidney disease. *Nature Reviews Nephrology*, *16*(11), 657-668.
8. Schomaker, S., Ramaiah, S., Khan, N., & Burkhardt, J. (2019). Safety biomarker applications in drug development. *The Journal of toxicological sciences*, *44*(4), 225-235.
9. Mudd-Martin, G., Cirino, A. L., Barcelona, V., Fox, K., Hudson, M., Sun, Y. V., ... & American Heart Association Council on Genomic and Precision Medicine; Council on Cardiovascular and Stroke Nursing; and Council on Clinical Cardiology. (2021). Considerations for cardiovascular genetic and genomic

DOI: 10.69605/ijlbpr_13.12.2024.163

research with marginalized racial and ethnic groups and indigenous peoples: a scientific statement from the American Heart Association. *Circulation: Genomic and Precision Medicine*, *14*(4), e000084.

10. Pirmohamed, M. (2023). Pharmacogenomics: current status and future perspectives. *Nature Reviews Genetics*, *24*(6), 350-362.
11. van Delft, M. A., & Huizinga, T. W. (2020). An overview of autoantibodies in rheumatoid arthritis. *Journal of autoimmunity*, *110*, 102392.
12. Coutinho, A. M., Busatto, G. F., de Gobbi Porto, F. H., de Paula Faria, D., Ono, C. R., Garcez, A. T., ... & Buchpiguel, C. A. (2020). Brain PET amyloid and neurodegeneration biomarkers in the context of the 2018 NIA-AA research framework: an individual approach exploring clinical-biomarker mismatches and sociodemographic parameters. *European journal of nuclear medicine and molecular imaging*, *47*, 2666-2680.
13. Wishart, D. S., Guo, A., Oler, E., Wang, F., Anjum, A., Peters, H., ... & Gautam, V. (2022). HMDB 5.0: the human metabolome database for 2022. *Nucleic acids research*, *50*(D1), D622-D631.
14. Goldberg, R. B., Stone, N. J., & Grundy, S. M. (2020). The 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA Guidelines on the Management of Blood Cholesterol in Diabetes. *Diabetes care*, *43*(8), 1673-1678.
15. Cesaro, A., Schiavo, A., Moscarella, E., Coletta, S., Conte, M., Gragnano, F., ... & Calabrò, P. (2021). Lipoprotein (a): a genetic marker for cardiovascular disease and target for emerging therapies. *Journal of Cardiovascular Medicine*, *22*(3), 151-161.
16. Nahar, J., Rahaman, M. A., Alauddin, M., & Rozony, F. Z. (2023). Big Data in Credit Risk Management: A Systematic Review Of Transformative Practices And Future Directions. *International Journal of Management Information Systems and Data Science*, *1*(04), 68-79.
17. Mengel, M., Loupy, A., Haas, M., Roufosse, C., Naesens, M., Akalin, E., ... & Colvin, R. B. (2020). Banff 2019 Meeting Report: Molecular diagnostics in solid organ transplantation–Consensus for the Banff Human Organ Transplant (B-HOT) gene panel and open source multicenter validation. *American Journal of Transplantation*, *20*(9), 2305-2317.
18. Ielapi, N., Andreucci, M., Licastro, N., Faga, T., Grande, R., Buffone, G., ... & Serra, R. (2020). Precision medicine and precision nursing: the era of biomarkers and precision health. *International journal of general medicine*, 1705-1711.
19. Bodaghi, A., Fattahi, N., & Ramazani, A. (2023). Biomarkers: Promising and valuable tools towards diagnosis, prognosis and treatment of Covid-19 and other diseases. *Heliyon*, *9*(2).
20. Zhu, F., Arshi, B., Leening, M. J., Aribas, E., Ikram, M. A., Boersma, E., ... & Kavousi, M. (2022). Sex-specific added value of cardiac biomarkers for 10-year cardiovascular risk prediction. *European Journal of Preventive Cardiology*, *29*(11), 1559-1567.
21. Shahjahan, M., Sarwar, A. S. M., Akter, S., & Tarannum, T. (2023). Effects of Microcredit on Socio-Economic Development Indicators: A Study of Ansar-VDP Unnayan Bank Beneficiaries in Bangladesh. *Management*, *4*(5), 174-182.
22. Cutruzzolà, A., Irace, C., Parise, M., Fiorentino, R., Tripodi, P. F. P., Ungaro, S., ... & Gnasso, A. (2020). Time spent in target range assessed by self-monitoring blood glucose associates with glycated hemoglobin in insulin treated patients with diabetes. *Nutrition, Metabolism and Cardiovascular Diseases*, *30*(10), 1800-1805.
23. Zinellu, E., Zinellu, A., Fois, A. G., Pau, M. C., Scano, V., Piras, B., ... & Pirina, P. (2021). Oxidative stress biomarkers in chronic obstructive pulmonary disease exacerbations: a systematic review. *Antioxidants*, *10*(5), 710.
24. Rahman, M. M., Mohiuddin, A. M., Salauddin, A., Kashem, T. B., Islam, M. S., Ahsan, M. A., ... & Ahmed, M. (2021). Outcome of Lumbar Interbody Fusion and Posterior Instrumentation in Spondylolisthesis. *IAR Journal of Medicine and Surgery Research*, *5*(5), 25-31.
25. Maskey-Warzęchowska, M., Rubinsztajn, R., Przybyłowski, T., Karwat, K., Nejman-Gryz, P., Paplińska-Goryca, M., & Chazan, R. (2023). Serum Amyloid A in Stable Patients with Chronic Obstructive Pulmonary Disease Does Not Reflect the Clinical Course of the Disease. *International Journal of Molecular Sciences*, *24*(3), 2478.
26. Doran, S., Arif, M., Lam, S., Bayraktar, A., Turkez, H., Uhlen, M., ... & Mardinoglu, A. (2021). Multi-omics approaches for revealing the complexity of cardiovascular disease. *Briefings in bioinformatics*, *22*(5), bbab061.
27. Hossain, M. M., Haque, M. A., Islam, M. S., Abdullah, K. S. M., & Al Razy, M. A. (2022). Minimally Invasive Approaches to Hernia Repair A Multicenter Study of Laparoscopic Techniques in Bangladesh. *IAR Journal of Medicine and Surgery Research*, *5*(6), 59-65.
28. Zhang, J., Wang, X., Jia, X., Li, J., Hu, K., Chen, G., ... & Dong, W. (2020). Risk factors for disease severity, unimprovement, and mortality in COVID-19 patients in Wuhan, China. *Clinical microbiology and infection*, *26*(6), 767-772.
29. Chan, C. K., Song, Y., Greene, R., Lindroth, H., Khan, S., Rios, G., ... & Wang, S. (2021). Meta-analysis of ICU delirium biomarkers and their alignment with the NIA-AA research framework. *American Journal of Critical Care*, *30*(4), 312-319.
30. Hossain, Q., Hossain, A., Nizum, M. Z., & Naser, S. B. (2024). Influence of Artificial Intelligence on Customer Relationship Management (CRM). *International Journal of Communication Networks and Information Security*, *16*(3), 653-663.
31. Biswas, B., Chowdhury, A. S., Akter, S., Fatema, K., Reem, C. S. A., Tuhin, E., & Hasan, H. (2024). Knowledge and attitude about COVID-19 and importance of diet: A cross-sectional study among Bangladeshi people. *Bangladesh Journal of Food and Nutrition*, *1*(1), 04-12.
32. Hossain, Q., Yasmin, F., Biswas, T. R., & Asha, N. B. (2024). Data-Driven Business Strategies: A Comparative Analysis of Data Science Techniques in Decision-Making. *Sch J Econ Bus Manag*, 9, 257-263.
33. Sharma, A. K., Tiwari, S., Aggarwal, G., Goenka, N., Kumar, A., Chakrabarti, P., ... & Jasiński, M. (2022). Dermatologist-level classification of skin cancer using cascaded ensembling of convolutional neural network and handcrafted features based deep neural network. *IEEE Access*, *10*, 17920-17932.