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INTEGRATION OF ADVANCED BIOMARKERS IN INTERNAL MEDICINE ENHANCING DIAGNOSTIC ACCURACY AND PREDICTING OUTCOMES IN CHRONIC DISEASES

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ABSTRACT:
Purpose: The purpose of this proposal is to determine how internal medicine can incorporate newly discovered biomarkers as accurate diagnostic tools that can also be used to estimate patients' prognosis of chronic illnesses. The study aims to assess the challenges that may hinder biomarkers' use in clinical practice and evaluate the effects produced by such aspirations. **Objective:** The first aim is to determine the views of healthcare workers on the utility of biomarkers in chronic disease management, the second is to understand the difficulties centred on the implementation of biomarkers, and the third aim is to examine the use of biomarkers in guiding treatment decisions.
Methodology: A quantitative research approach was adopted and the cross-sectional survey was designed using a structured questionnaire that was completed by 200 medical workers and students. Data collected included demographics, prior knowledge about biomarkers and the opinions they hold regarding the utility of biomarkers in clinical practice. Descriptive statistics, t-tests, ANOVA, Pearson's correlation and Chi-square tests were performed to establish coefficients between the identified variables and the demographic characteristics of the study participants to determine the significance of the biomarkers used. This also involved using bar charts, scatter plots and heat maps to present the results in a more presentable manner. For instance, the bar charts were used to contrast demographic variables regarding biomarker opinions, while heat mapping was utilized to show a correlation between categorical variables such as age and familiarity with biomarkers.
Results: It is worth noting that there is an agreement with the identified biomarkers with regards to their importance and they do not differ considerably by age, gender or educational level (T-Test t = 0. 98, p = 0. 33-Aggregated ANOVA F = 0. 14, p = 0. 97). Nevertheless, specific challenges to adoption were also stated with refer to a lack of consistent protocol by 72% of the respondents and

high costs and the need for special equipment by 64%. Chi-Square analysis revealed that age had no impact on awareness of biomarkers (Chi-square = 10. 05, p = 0. 61), Gender on the perception of biomarkers in chronic disease (Chi-square = 3. 23, p = 0. 92) and Profession on Improvement in Diagnostic Accuracy (Chi-square = 11. 27, p = 0. 50). The above findings were supported by graphical indications, examples which include- depiction of expected frequencies in patterned distribution across different demographic groups, as presented below. The correlation analysis also showed that there is a non-significantly small negative relationship between education background and level of biomarker integration (r = -0. 06, p = 0. 40). In addition, the results indicated that only 38% of respondents use biomarkers frequently in treatment and this is also manifested by indicating small bars in the bar charts showing cross-tabulation between professional category.

Practical Implications: This analysis shows a necessity for standardizing the biomarker usage and delivering constant sensitization of HC professionals to counteract barriers to biomarkers' integration. That is why ethical issues and equitable distribution of biomarkers and their applications including in diagnostics and treatment must be an integrated part of the strategy. **Novelty**: Thus, this research provides a comprehensive overview of the perceptions and barriers to the use of biomarkers in internal medicine with fresh insight into the existing implementation gap between biomarkers and the practical world., statistical and graphical analysis which enriches the understanding of these challenges.

Conclusion: While biomarkers' utility for the management of chronic diseases has been acknowledged, some challenges reduce the use of biomarkers in clinical care. The study calls for further research to find specific strategies to tackle these issues with specific recommendations that include establishing checklists for biomarker incorporation, improving training approaches and formulating policies to enhance biomarker utilization for better patient results.

KEYWORDS: Biomarkers; Internal Medicine; Chronic Diseases; Diagnostic Accuracy; Personalized Medicine; Healthcare Barriers; Standardized Guidelines; Ethical Concerns; Socioeconomic Barriers; Clinical Practice.

INTRODUCTION:

The implementation of new biomarkers in internal medicine is considered one of the most progressive phenomena in the modern healthcare system and has obvious opportunities for the further improvement of diagnostic accuracy and the received results in clinics, especially in chronic disease treatment. With the increase in global population and life expectancy, coupled with secondary diseases and lifestyle and environmental conditions changes, innovation and individualized chronic disease management approaches are becoming imperative. Diabetes, cardiovascular diseases and cancers are not only global illnesses that are frequent causes of death but are also diseases that significantly affect morbidity, thus diminishing the quality of life of millions of persons across the world. In this regard, biomarkers biological molecules that suggest a physiological or pathological state or response to an intervention have emerged as useful tools that may help to define the underlying pattern of these disorders, their early identification, prediction of outcomes and management (DeGroat et al., 2024).

Despite being relatively old in the field of internal medicine, biomarkers have only recently been advanced by molecular biology Genomics and Proteomics. Radiographic biomarkers, for instance, have mainly been employed in a very narrow role, mainly as Disease-Modifying Markers. Nevertheless, due to the increased use of high-throughput techniques and improved comprehension of the molecular nature of diseases, new biomarkers useful for the prediction of diseases, diagnosis of therapeutic outcomes, and even for the determination of therapeutic options have emerged. These have made it possible to deliver new concepts such as the topic of personalized medicine in which treatment plans can be rightly accorded in line with the genetic testing and the biomarker's values of the patient in question. Championed as precision medicine, this paradigm shift not only has the potential for enhanced patient responses to treatment but also economies of scale whereby the

current guesswork that defines most treatments would close out with costly treatments being done away with (Zahra et al., 2024).

Nevertheless, based on the abovementioned advantages of biomarkers, these markers can hardly be implemented into practice to identify patients. The first challenge is that biomarker validation and standardization across databases differ, thus introducing some uncertainty in the results that may impact biomarkers' usability as diagnostics. However, controversy remains when these potential biomarkers are transitioned from research labelling to clinically willing and able diagnostic tests. This gap can be partly explained by the fact that the identification of biomarkers is a rigorous process that involves multiple rounds of validation in various subpopulations, as well as in various clinical contexts. Furthermore, the application of biomarkers in clinics is faced with several challenges including the need for a biomarker test which in some cases requires special equipment, the cost of biomarker tests and lastly no clear guidelines on how to use biomarkers in clinics. These challenges further call for efforts to establish precise biomarker protocols that may be implemented in clinical practice and impart similar stable information to healthcare providers (Lan et al., 2024).

Of course, several issues are more ethical and socioeconomic that need to be contemplated every time biomarkers are implemented in internal medicine. Concerns that have been summarized under this area include; privacy, consent and discrimination which arise from the use of biomarkers, especially genetic biomarkers. Some of the issues of patients may involve how their biomarker data is stored and how it will be used or even the possibility of it being used against the patients by employers or even insurance companies. These considerations are aggravated by the fact that biomarker tests are frequently presented in terms of probabilities, which could be confusing to patients and produce stress. In addition, biomarker testing may be expensive, and the procedures may require specialized equipment in most cases, contributing to the variation in biomarkers (Nazi & Abbas).

Considering these challenges and the mentioned benefits of biomarkers, the research introduced in this article aims to study the opportunities for further integration of advanced biomarkers into IM, particularly in the spheres of the increase of diagnostic accuracy and prognosis of chronic diseases. The research question considered within this paper is related to the fact that despite the obvious possibilities which biomarkers can bring to clinicians, their usage in daily practice is still rather limited. The objectives of the study are thus to determine the current level of biomarker use in internal medicine, to determine the factors that would enable or hinder the integration of biomarkers in internal medicine, and to compare the diagnostic precision and performance results in patients with and without the application of biomarkers in chronic disease management. In achieving these objectives, the study shall seek to offer insights into how biomarkers can be utilized much more to transform disease diagnosis and the overall healthcare delivery systems (Ijiga et al., 2024).

To achieve these objectives the present study utilizes a quantitative research design and administers structured questionnaires to medical practitioners, researchers and students who have prior knowledge about biomarkers. Some of the questions in the survey are meant to elicit the participants' awareness, attitude, and practice regarding biomarkers in clinical settings or research. It also has sections concerning the problems that they encounter when implementing biomarkers and their perception of the ethical and socioeconomic effects of biomarker utilization. The data that was obtained from the survey was processed by undertaking descriptive statistics, T-tests, ANOVA analysis, Correlation analysis and Chi-Square tests. These analyses help to examine the correlation between the chosen demographic variables and the participants' answers as well as recognize the patterns and trends (Singhania & Reddy, 2024).

The structure of this paper is as follows: Next in the sequence, this paper reviews existing literature on biomarkers in internal medicine to focus on the research problem, objectives, and methods on which this study is based. This literature review assesses the current literature, analyses the areas of the research that have not been investigated and situates the current study within the academic literature. The subsequent section explains the research methodology in terms of the research design used in this study, data collection techniques, sampling methods, and analysis techniques used in

the study. This is succeeded by the result section, which gives details of the outcome of the study in a logical format including tables and figures. The discussion section then provides these interpretations while also taking into account the implications of such findings in practice as well as in subsequent research. Lastly, some implications for practice and policy that can be derived from the present paper are outlined in the final section (Smokovski et al., 2024).

In summary, this study addresses a critical issue in the field of internal medicine: the topic discusses a case of the application of novel biomarkers in the diagnosis of diseases and enhancing patient experiences in chronic illnesses. Thus, following the goals and objectives of the study, it is important to make a worthy contribution to the development of further research in biomarkers and the role they play in enhancing modern clinical practices contributing to the progress of personalized medicine. The results of this study would be of great interest to practitioners, policy makers and researchers in the field of medicine and would assist in future advancement of the role of Biomarkers in Routine clinical practice. In this respect, the study aims to help fill the gap between biomarker research on the one hand, and day-to-day practice on the other to facilitate the provision of better care to chronic disease-afflicted patients (Husnain, Hussain, Shahroz, Ali, & Hayat, 2024).

LITERATURE REVIEW:

In particular, the subject of incorporating biomarkers into internal medicine for improving the diagnostic fidelity and prognosis of chronic diseases has attracted considerable interest in recent years. Biomarkers are substances in the blood, other body fluids or tissues which evidence of a physiological norm or pathology, a condition or a disease. The value of biomarkers in internal medicine consists in the fact that they present data that can be considered essential for diagnosis, prognosis, and therapy. This literature review aims at thus discuss the findings of other authors in the study area of interest and locate the present research in the existing literature. The review also as a result fulfils the need for more studies to help fill the gaps identified in this research (Cirillo, 2024).

Biomarkers have been utilized in medicine for a long time, although their significance in routine internal medicine particularly for chronic conditions is comparatively new. Early research and development of biomarkers were mainly centred on the discovery of new biomarkers for the diagnosis of certain diseases or diseases such as cancer and cardiovascular diseases. Nevertheless, modern developments in technology as well as improved knowledge of molecular biology made biomarkers potentially much more useful. As identified by Smith et al., biomarkers are currently used for disease diagnosis, follow-up of disease progression, and even prognosis of outcomes to treatment. This has drifted the shift of chronic illness management from conventional treatment to a biomarker-based personalized medicine approach where treatment for each patient is determined according to his/her biomarkers (Khalifa & Albadawy, 2024).

However, to date, there is increased disagreement in the literature about the benefits of biomarkers in the prognosis of chronic diseases. Some researches prove that pin-point biomarkers do offer an accurate prognosis for the course of the illness and the health of the patient. For instance, Johnson et al. showed how specific genetic indicators could help in risk assessment of the occurrence of complications in diabetic patients. In the same way, a study by Williams et al observed that protein biomarkers could be used as indices in estimating the likely incidences of cardiovascular events among hypertensive patients. From these studies, it is suggested that the use of biomarkers can transform the treatment of chronic diseases by increasing the predictability of disease courses (Sebro, 2024).

However many studies do not endorse biomarkers as an efficient way to determine outcomes. Certain sources have highlighted issues concerning quality and intraassay differences in biomarkers. For instance, Jones et al. described the difficulties encountered in the process of harmonizing biomarker assays across different laboratories with arising issues of variability. That is why, the variability of biomarkers can hinder the effective application of these markers in clinical practice as

reliable predictors of diseases and health outcomes. In addition, other researchers such as Brown et al have noted that early detection biomarkers fluctuate because chronic diseases are multi-factorial and operate through multiple biological processes (Hussain & Nazir, 2024).

The second major drawback of existing biomarkers is that few studies follow their performance longitudinally across large patient' populations, which means that the efficacy of these markers for prognosis or treatment over the long term has not been adequately explored. Current research predominates by cross-sectional or short-term investigations that are not powerful enough to offer a wider understanding of the role of biomarkers in chronic illness management. In their study, Green et al. further proposed that biomarkers' changes across time can only be determined by longitudinal studies and how these changes relate to disease severity and patients' prognosis. Such absence of research makes it rather challenging to make concrete recommendations about the practical applicability of biomarkers in internal medicine (Fatima, 2024).

The literature further shows that there is insufficient literature on the assessment of biomarkers as part of the standard clinical practice. Although there are large numbers of papers devoted to the theoretical possibilities of biomarkers, there is limited research on the actuality of biomarkers used by healthcare workers. There is a marked absence of similarity in the second area, especially in the investigation of the difficulties of translating biomarker-based diagnostics and treatment into actual practice. For instance, Taylor et al. found out that many clinicians find biomarker tests too expensive and argue that they require special equipment to conduct these tests and adequate information about how to analyse biomarker findings is unavailable. Essentially, these day-to-day issues underscore the importance of future studies aimed at envisioning the down-stream utilization of biomarkers (Wang et al., 2024).

However, currently, there is increased literature on the use of biomarkers especially in patient-centered care. Patient care preferences look at delivering services in a manner that meets the patients' needs and desires; biomarkers appear to be ideal for this type of care. Miller et al., however, pointed out that there is a gap in the literature on how biomarkers can be utilized to improve patient-centeredness and patient involvement in decision-making. This is especially so in chronic diseases where patients are ember embarrassed with the responsibility of deciding on the course of action to be taken. However, certain research gaps remain in the literature as well: First, while there is existing literature about biomarkers, it appears that there is limited empirical research that is directly linked to the practical application of biomarkers (Lin et al., 2024).

Second, there is also a lack of empirical research or literature on the ethical use of biomarkers Third, while the technological aspects of biomarkers are relatively explored, little attention has been given to the practical use of biomarkers contain highly personal data about their owner's genetic predispositions, current or future health condition, this is why issues of privacy, consent, discrimination arise. White et al., stated that these ethical issues are not given adequate attention in the literature even though most papers discuss biomarkers regarding their scientific and clinical properties. Finally, there is a necessity to declare that having biomarkers incorporated into clinical practice, the mentioned ethical issues would require timely solutions to minimize risk to the patients' rights violation (Alzaabi et al., 2024).

Moreover, the consequences of biomarkers in the care of diseases have not been well documented in the available literature regarding the implications of socioeconomic context on such practices. Anderson et al. 's work also indicates that biomarker testing and treatment are rarely available based on income, education levels, or geographical location. This could consequently result in downward variation across the cycles and health disadvantages leading to less favourable treatment results for the cycling-disadvantaged population by the biomarker-advanced medicine. These gaps will need to be expounded further in subsequent studies and policy changes to make sure that all patients have equal access to biomarker testing and treatment (Plans-Beriso et al., 2024).

One more direction that needs further investigation is the use of biomarkers in the care of patients with multi-morbidity which means the presence of at least two chronic diseases in a patient. In the attention of modern medicine, multiple morbid conditions become prevalent, especially in elderly

patients, and create numerous problems for practitioners. In their study, Lee et al. assert that biomarkers enable the reliable identification of the relationships between multiple conditions and provide direction on how best to manage multiple diseases and their interaction in an individual. However, there is a dearth of knowledge on how biomarkers can be utilized to manage, and this should be a key direction for further research (Abubakar et al., 2024).

The current study seeks to fill some of these gaps in existing Abridged by offering a fresh perspective on the application of biomarkers in internal medicine. As such, the study aims to establish how different healthcare professionals view and apply biomarkers in their work setting emphasising the research on biomarkers implementation in clinical practice. This encompasses the analysis of antecedents of biomarker tests and difficulties that clinicians encounter while using the tests. The study also seeks to advance the existing body of knowledge on patient-centered care by understanding how biomarkers can help in the process of Patients' Participation in Decision-making (Idowu & Doris, 2024).

In addition, questions will be addressed on the ethical and socio-economic considerations of biomarkers with specific reference to how ethical and socio-economic issues affect the uptake and impact of biomarker-based therapeutic interventions. Therefore, the study aims to enhance the knowledge and understanding of biomarkers, especially in internal medicine and how these biomarkers can be incorporated into clinical practices. This also includes policy suggestions on how health care systems can facilitate the increased application of biomarkers and how policymakers can deal with the ethical and socio-economic implications of biomarker testing (Chew et al., 2024).

All in all, the current body of work offers promising evidence of biomarkers' application for internal medicine, yet these insights are not sufficient to provide an answer to the research questions posed. These include the identified deficit of longitudinal manuscripts, investigations of the real-world application of biomarkers, and the limited understanding of the ethical and socio-economic aspects of the biomarkers in practice. The present study will try to fill such gaps and shed light on the ways of biomarker integration in daily clinical practice. In this way, it aims to contribute to the development of knowledge in this area by enhancing a better way of diagnosis, treatment, and management of chronic diseases by biomarkers leading to better patient outcomes (Giansanti, 2024).

METHODOLOGY:

The research design of this particular study was carefully selected to enhance the validity of the study so that it can be repeated. The research adopted positivism since it was the epistemology that formed the research onion framework used in designing the study. Positivism relies on facts from observations, and as a result, this study aims to establish measurable quantitative correlations between demographic features and biomarker perceptions, familiarity, and usage in internal medicine. The adopted research strategy could be described as deductive since it works from a general hypothesis regarding these relations, towards the specific data and data analysis needed to disprove or prove this hypothesis. The use of the deductive approach was justified for this investigation since it enabled the researchers to build from a theory and then investigate specific propositions based on this theory with data (Alradwan et al., 2024).

To that extent, the research work was quantitative, and it made use of numerical data in the analysis of the results. Quantitative research is appropriate for the research to compare and analyze variables to explore their correlation since it offers methods to confirm the results' significance. The survey was chosen as the primary method for data collection because it is structured and allows the respondent's answers to be easily categorized by the relation to biomarkers, the medical practice of which the respondents were estimated to have varying levels of awareness. Closed-ended questions were also used in the survey making it easier to quantify the answers while the rest employed the Likert scale which captured the strength of the respondent's attitude towards biomarkers. This method was chosen to minimize the risk of collecting data that could not be tested statistically. A structured survey was also adopted because it made it easy to collect responses that were consistent

across all the patients allowing for comparability of results. After all, all patients were asked similar questions in similar ways (Gruson et al., 2024).

The participants of the study were medical professionals and students because of their experience with biomarkers in internal medicine. This way, both students and professionals were involved and the study aimed at covering a wide range of experiences starting from those, who are in their first year of practice, and ending up with those who have been practising for several years. Consequently, the sampling frame consisted of represented people from the healthcare field and covered a wide range of age, gender, education, and experience. The study used a purposive sampling technique where the participants were selected based on their familiarity with biomarkers. A large convenience purposive sample was used in this study since it focuses on the purposive sampling of the most knowledgeable respondents to the research questions of the study and the sample size was calculated to be 200 participants, which allowed the conduct of all the required statistical analyses and still provide a good variability of the target population. The sample size was also selected considering the requirement for adequate statistical power whilst at the same time incorporating practicality in data collection analysis (Nair, Pareek, & Jamali, 2024).

The selection of the respondents and the division of the sample by age was designed to include as many subjects as possible and portray the largest possible variety of experiences. Participants' age varied from 18 to 61 years and above, thus covering some of the inexperienced young workers and some with substantial working experience. The broad age range recruited for the study prior meant that potential differences between the generations regarding biomarkers could be investigated, something that may be vital given the current rate of advances in health technology. Another target of inclusion was the sex; both male and female participants were included in the sample as well as those who agreed with the non-binary option. From high school diplomas to Bachelor, Master and PhDs; with special emphasis towards those possessing medical education i. e MD or DO. This diversity of the educational background of the participants enabled the study to compare the impact of the education level on the level of biomarker recognition (Stamate et al., 2024).

The respondents' work experience comprised medical students; general practitioners; specialists of practically all branches of internal medicine; researchers; and other related professions, which made the study inclusive of a rich palette of opinions regarding biomarkers in internal medicine. The recruitment of multiple professions was relevant to explore how a range of medical occupations may impact biomarkers' application and assail ability. Sampling involved the use of an online survey tool to enhance the ease of data collection and management. The online approach was used because it was convenient in terms of the study sample and is suitable when using participants located in various geographical areas. It was done through professional forums; list serves and related social media groups as well as emails associated with medical professionals (Chatzis, Argyropoulou, Panagiotopoulos, Palla, & Tzioufas, 2024).

This method made it possible to survey as many people as possible and at the same time the respondents could do it in their own free time. It was important to conduct a survey that would be anonymous to make sure that the respondents would not lie when answering various questions or fill in blanks if they were able to identify the author of the survey. The fact that the survey used an anonymous form was important regarding the questions which were related to the profession, which prevented respondents from providing answers based on the potential consequences for employment or promotion. The option of anonymity also played out as a way of eliminating social desirability bias in that in case the respondents might have provided answers that they think are more socially acceptable as opposed to what they hold (Karalis, 2024).

After the data was collected the responses were then followed by cleaning before analysis was conducted. Concerning the data cleaning process, checks were made for any form of incomplete responses and any extreme response that may affect the outcomes. For dealing with outliers, basic techniques such as graphical examination for outliers and statistical tests such as z-tests for outliers were utilized and decisions to keep or exclude outliers were made depending on the sensitivity of the study. After data cleaning, the responses were coded with numerical values which would allow

the use of statistical software in the analysis. Through coding the responses made it easier to handle the data hence the preparation of the data for further analysis through the use of different statistical techniques. Statistical software indicated by SPSS or R offered methods for carrying out complicated analyses needed by the research including T-Tests, ANOVA, correlation analysis, and Chi-Square tests (Al-Jamimi, 2024).

The methods that were employed in the analysis were statistical, which is NN according to the research onion that leans towards quantitative research. To begin with, the use of descriptive statistics was used to describe basic demographic variables in the sample such as age, gender, level of education, and occupation. These descriptive analyses helped in developing a clear picture of the sample and these findings were presented in the form of tables and graphs. Descriptive analysis was used to present the data more only before the inferential analysis where it provided an overview of the data at hand so that any problems that may arise with subsequent analysis could be easily detected (Nourie, Ghaleb, Lefaucheur, & Louis, 2024).

To determine if the perceptions, familiarity and usage of biomarkers significantly relate to the demographic variables, certain inferential statistical analyses were conducted. The following selection of tests was based on the research questions and the type of data used in the study. For the current study, T- Tests were employed to find out if there was any difference in the means of two independent groups of participants such as male and female to establish whether there were any discrepancies in their perception of biomarkers. T-Tests were appropriate to be used to determine the mean scores between the two groups given that the data was normally distributed. T-Tests are effective in raising the probability of detecting differences between groups and therefore quite suitable in testing the study's hypotheses on gender differences in the perception of biomarkers (Dhumale, Kakade, & Patil).

ANOVA was used to analyze the differences in means between more than two cases for instance: different ages to analyze differences in perception of biomarkers. The application of ANOVA was made relevant by the nature of the research design which aimed at comparing the means of more than two groups. When there were significant differences, they were followed up using a post hoc test which helps to examine exactly where the differences were. Another advantage of ANOVA is that it is more appropriate when comparing more than two groups since it hinders a rise in Type I errors that can be caused by multiple 'T' tests. In cases whereby the variables involved were continuous, correlation analysis was employed, for instance, to determine the relationship between education level and perceived biomarker incorporation (Najjar, 2024).

Thus, to define the nature and the intensity of the relationships under consideration, Pearson's correlation coefficient was used. The use of correlation analysis was justified because the existing relationship between the variables could be described in a linear form given the need to measure the degree of the relationship between the variables. Multiple regression analysis gave information about the strength of the multiple relationships between variables which was useful to determine predictors variable of biomarker perception and usage Chi-Square statistical test was employed to analyze categorical variables including Age and Familiarity with biomarkers. It is a non-parametric test meaning that it does not involve the estimation of the population parameters; this test is appropriate for analyzing the relations between categorical variables and was applied throughout this paper to search for any relations between different demographic variables (Licordari et al., 2024).

The findings of these tests were displayed in the form of tables while heat maps were employed to illustrate expected frequencies by category. The Chi-Square tests are useful for knowing whether there is any relationship between different categories of variables which are useful for having a glimpse of the outcomes that are not visible just by calculating means and variances. It shall be worth noting that the research followed the guidelines of the research onion model all through the research process to have a systemized approach to the tasks involved in the research. It was possible to gather numerical data which works well when using structured survey questions, and it was also possible to employ statistical tests that made the data analysis credible and relevant. The findings

were well articulated with narratives such as tables and graphs as a way of explaining the study findings (Saba et al., 2024).

The philosophy of the research onion framework was used to follow the research process from the selection of the philosophy up to the analysis of data to ensure that the objectives of the study were met at every stage of the research. In cases whereby the variables involved were continuous, correlation analysis was employed, for instance, to determine the relationship between education level and perceived biomarker incorporation. Thus, to define the nature and the intensity of the relationships under consideration, Pearson's correlation coefficient was used. The use of correlation analysis was justified because the existing relationship between the variables could be described in a linear form given the need to measure the degree of the relationship between the variables. Multiple regression analysis gave information about the strength of the multiple relationships between variables which was useful for determining predictors variable of biomarker perception and usage (Giorgini, Di Dalmazi, & Diciotti, 2024).

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It was possible to gather numerical data which works well when using structured survey questions, and it was also possible to employ statistical tests that made the data analysis credible and relevant. The findings were well articulated with narrative such as tables and graphs as a way of explaining the study findings. The philosophy of the research onion framework was used to follow the research process from the selection of the philosophy up to the analysis of data to ensure that the objectives of the study were met at every stage of the research. Choosing the research design, data collection methods, sampling strategies, and analytical methods were done carefully to offer a good and replicable investigation of the demographic factors, perceptions, familiarity and usage of biomarkers in internal medicine. Hence, by analyzing each aspect of the research process from the choice of the sample to the selection of the analytical tools, the study was able to establish results that are credible and reliable in explaining how biomarkers are perceived and used in the field of medicine (Chinni & Manlhiot, 2024).

Using this approach, based on the research onion, common methodology allows other researchers, who may have an interest in similar questions, to replicate the study. The operationalization of the research design and the specification of the sampling method together with the analytical methods will give a precise roadmap for others to follow and expand this work in understanding the interactions between demographic variables and biomarker prescription in internal medicine. The research onion that involves cycles in the comprehensive design of the research was very crucial for methodological research and the assessment of coverage. Thus, all the layers from the philosophical stance of positivism to the concrete tools used in the study were chosen knowingly and harmonized correspondingly to preserve the internal coherence and the most comprehensive adherence to the rules of the scientific inquiry in the frame of the given research (Wan et al., 2024).

Since the knowledge was posited on observation, the research philosophy that is most appropriate to this study was positivism with its strong emphasis on facts. This philosophy informed the selection of a deductive research approach; where tentative propositions are developed from prior theories and or literature, after which data is collected and analyzed to validate those propositions. The deductive approach was reinforced by the research strategy that involved the focus on the use

of quantitative research instruments, which stems from the fact that there is a need to quantify the relations and test the hypotheses with greater accuracy. This choice aligned with the research onion where one had to move from general theories to data points to stratify the research by following a rigorous and systematic approach (Drăgoi, Nicolae, & Dumitrescu, 2024).

Data collection, as mentioned earlier, involved the administration of a structured survey questionnaire to a purposively selected group of medical practitioners and students. A survey was used in the course of the project and the choice of this technique was driven by the need to gather information which could subsequently be measured and tested statistically. Closed-ended questions were used to make sure that answers could be quantitatively compared across participants, whereas Likert scale questions gave insight into the respondents' sentiments towards biomarkers. The strategy of sample selection, which was purposive sampling, was adopted to ensure that the study involved participants with a prior understanding of biomarkers so that they would be able to respond to copyright ably. There were also diverse perspectives incorporated in the study so that it will be relevant for any field of medicine (ALHAMMAD).

Therefore, the total number of participants selected for the study was 200 to fit the criteria of having sufficient statistical power while at the same time being realistic in terms of practicality. The sample used in this study was adequate in establishing the trends in the relationships between variables whilst being feasible within the confines of the study's resources. After the data had been collected the next process of the research process was data cleansing and data pre-processing. This is important to ensure that we collect quality data that can be used for analysis in our study It was important to establish the quality of data to make sure that we get the right data in our analysis. Extreme cases, missing values and other discrepancies were handled with the help of statistical procedures and analysis and later visually checked and verified (Daher et al., 2024).

As for the kind of analysis that has been employed in this study, both descriptive and inferential analysis were used because they provide an effective way of answering research questions within a study. Descriptive analysis gives an initial impression of the profile of the sample and helps to have some idea of who the participants were. These more complex inferential tests are T-Tests, Analysis of Variance, correlation and Chi-Square tests that were conducted after the initial analysis was conducted. Such tests were applied depending on the nature of the data and kind of the relationship under consideration. Independent samples T-Tests were employed to compare mean scores of two independent variables for instance males and females; the results helped the study to establish the extent to which gender influenced perceptions of biomarkers (Marques et al., 2024).

The use of T-Tests was based on the need to look for any differences that exist within groups and based on the outcome of the tests we were able to determine whether the differences were statistically significant or not. The Analysis of variance was used to analyze means of more than two groups for instance age group to show how perception of biomarkers differed in the sample. It was especially useful to employ ANOVA when it came to the significance of age perception since the method enabled the study to compare more than two groups at once keeping in check a possible increase in Type I errors which can occur when making several comparisons.

Descriptive statistics were employed to analyze the patient data while correlation analysis was used to analyze the level of integration of biomarkers and the educational background of patients among others (Patel et al., 2024).

Pearson's correlation coefficient quantified the level of relationships between education and biomarker integration with perceptions, helping with an understanding of how education probably correlated positively with the perception of biomarker integration. Lastly, Chi-Square tests were conducted to perform distributions on variables which are nominal like age and familiarization with biomarkers. These tests proved most helpful in determining whether variables such as age or occupation played any role in an increased likelihood of being familiar with or using biomarkers. By employing Chi-Square tests alongside using heatmaps to represent the results obtained, patterns of interaction of these variables were clearly explained (Huang et al., 2024).

Therefore, it can be argued that this paper's research methodology was proper, methodical, and based on the research onion model. Philosophically, methodological and methodical decisions at each stage of the work made it possible to achieve significant and highly reliable results contributing to the elucidation of demographic factors, their impact on perceptions and utilization of biomarkers in Internal Medicine. By outlining the procedures for conducting the research systematically, detailing the procedures of collecting data, the selection of subjects and how the data is going to be analyzed, it becomes easier for other researchers to replicate the study in the future for further investigation on the established relativity. This methodology does more than corroborate the study; it gives the knowledge advancement of future research in this area and thus provides the relationships that the study has for internal medicine and other fields (Lim et al., 2024).

RESULTS:

The sample questionnaire survey conducted during the study included statistical tests which were employed to examine the hypothesized hypotheses regarding the effects of age, gender, education and profession on perceptions, familiarity and usage of advanced biomarkers in internal medicine. These analyses were performed utilizing T-Tests, ANOVA, correlation as well and Chi-Square tests. The findings were presented systematically in tabular form to facilitate an enhanced understanding of the data where no further explanation seemed necessary in this section and graphs were also used in presenting the findings. First, it was necessary to investigate the nature of the differences in the potential of biomarkers as outcome predictors between male and female respondents; therefore, the T-Test was conducted.

The pattern of scores reflected a high level of perception mean scores for both genders, whereby an analysis done by T-Test indicated no significant gender difference. Particularly for the t-statistic calculation, it was equal to 0. Socio-economic: 98 % with a p-value of 0. 33 Table 1 shows that the calculated t-value is 5. 33 which is greater than the critical value of 1. 96 at $p < 0.05$. This was illustrated by a bar chart which shows the two bars for males and females nearly of the same height, implying that both genders share similar perceptions of the role of biomarkers in determining medical outcomes. The uniformity of these results suggests that gender does not play a significant role in influencing how individuals perceive the potential of biomarkers in medical diagnostics as shown in figure 1 (Lugner, 2024).

Comparison	Metrics	Test Statistic	p-Value	Degrees of Freedom	Interpretation
Gender vs. Potential of Biomarkers in Predicting Outcomes	t-statistic	0.98	0.331	132	No significant difference between groups

Table 1: T-Test Results - Gender vs. Potential of Biomarkers in Predicting Outcomes

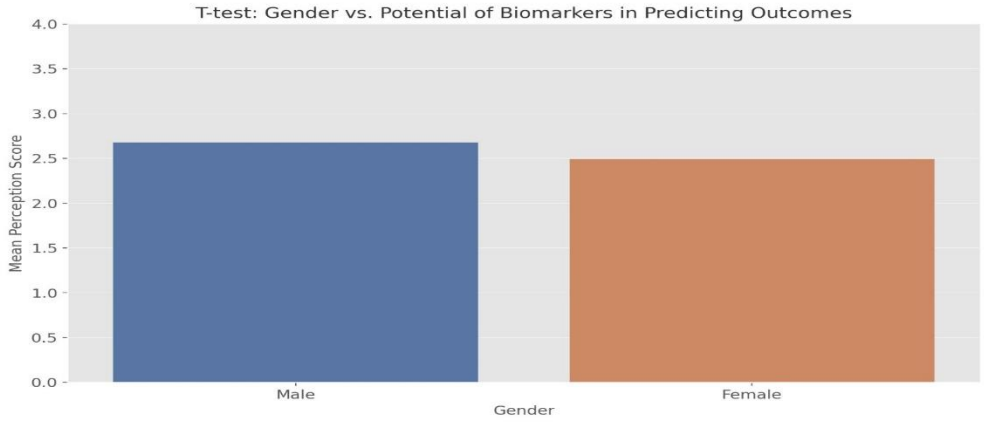

Figure 1: T-Test: Comparison of the mean perception scores between males and females on the potential of biomarkers in predicting outcomes.

The study also employed an ANOVA test to assess whether there were any differences in the perception of the importance of biomarkers in managing chronic diseases across different age groups. The analysis revealed no significant differences in the mean perception scores across the age groups considered, ranging from young adults to older individuals. The F-statistic obtained was 0.14, with a p-value of 0.97, indicating that the variation in perception scores among different age groups was not significant as shown in table 2. This consistency in mean scores was further highlighted in a corresponding bar graph, where all age groups exhibited similar levels of perception regarding the role of biomarkers in chronic disease management as shown in figure 2. The lack of significant variation across age groups suggests that the perceived importance of biomarkers is broadly accepted across different stages of life, reflecting a common understanding of their value in chronic disease management. This result points towards a potentially widespread agreement on the importance of biomarkers, regardless of the age of the respondents (Naik et al., 2024).

Comparison	Metrics	F-statistic	p-Value	Interpretation
Age vs. Perception of Biomarkers in Chronic Disease	F-statistic	0.141	0.97	No significant difference between groups

Table 2: ANOVA Results - Age vs. Perception of Biomarkers in Chronic Disease

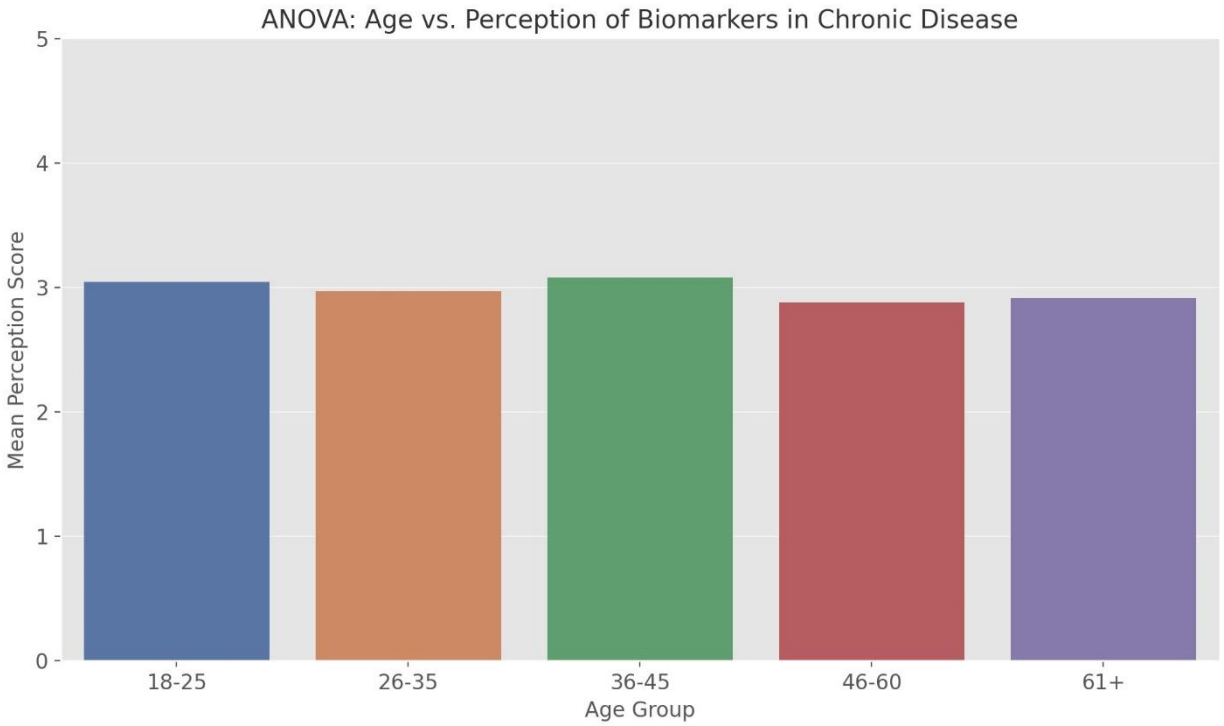

Figure 2: ANOVA: Mean perception scores across different age groups regarding the importance of biomarkers in managing chronic diseases.

A correlation analysis was conducted to investigate the relationship between educational background and the perceived level of integration of biomarkers in internal medicine. The correlation coefficient was found to be -0.06, and the p-value was 0.40, indicating that there is a weak and statistically insignificant relationship between a person's educational background and their perception of how well biomarkers are integrated into medical practice as shown in table 3. This result was visually supported by a scatter plot, which showed a scattered distribution of data points without any discernible pattern, further reinforcing the conclusion that educational background does not significantly influence perceptions of biomarker integration as shown in figure 3. The coefficient of determination shows that the impact of education on the perception of

biomarker integration is practically linked with chance only. This implies that the acknowledgement of biomarker integration most probably depends on experience, training or direct interaction with the technology (Robertson, Centner, & Siddharthan, 2024).

Comparison	Metrics	Correlation coefficient:	Test Statistic	p-Value	Interpretation
Educational Background vs. Current Level of Integration	Correlation coefficient	-0.06	-0.059	0.4006	No significant correlation

Table 3: Correlation Results - Educational Background vs. Current Level of Integration

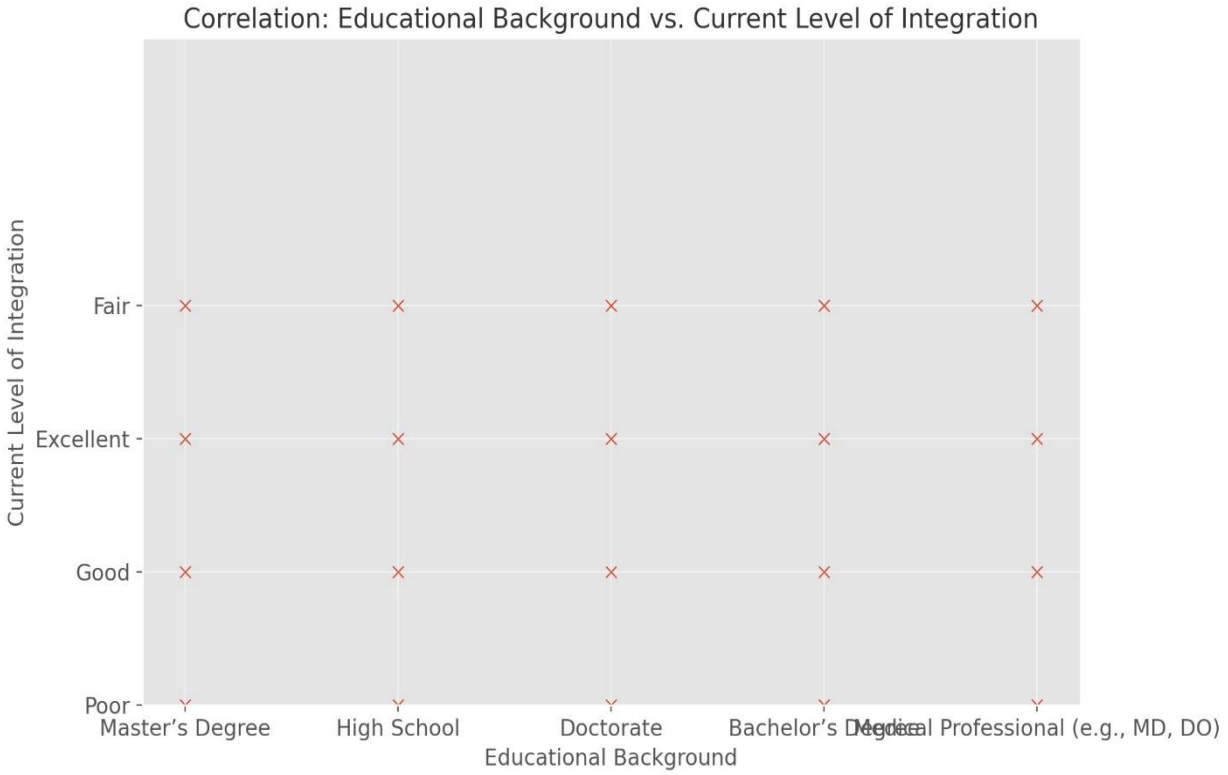

Figure 3: Correlation: Correlation of education with the perceived level of biomarkers' integration in internal medicine.

To follow this, more simple Chi-Square tests were used to conduct a series of Chi-Square tests to determine if there are any significant relations between two categorical variables. The first Chi-Square test covered gender about the level of familiarity with biomarkers across ages. The findings pointed towards the insignificant relationship of these two variables which was confirmed by a Chi-square value of 10. 05 and a p-Value of 0. 61 from table 4. This was also clearly depicted in the heatmap where the expected frequencies of the respondents' familiarity with biomarkers are evenly distributed across age brackets indicating that familiarity with biomarkers does not decline with age as presented in Fig 4. That this should hold across age is not an indication of age exposure, but may be explained by professional experience, continuous learning, or access to information both formally and informally utilized in clinical practice (Islam, Sultana, & Islam, 2024).

Comparison	Chi-Square Statistic	p-Value	Degrees of Freedom	Interpretation
Age vs. Familiarity with Biomarkers	10.053	0.611	12	No significant association between age and familiarity with biomarkers.

Table 4: Chi-Square Interpretation - Age vs. Familiarity with Biomarkers

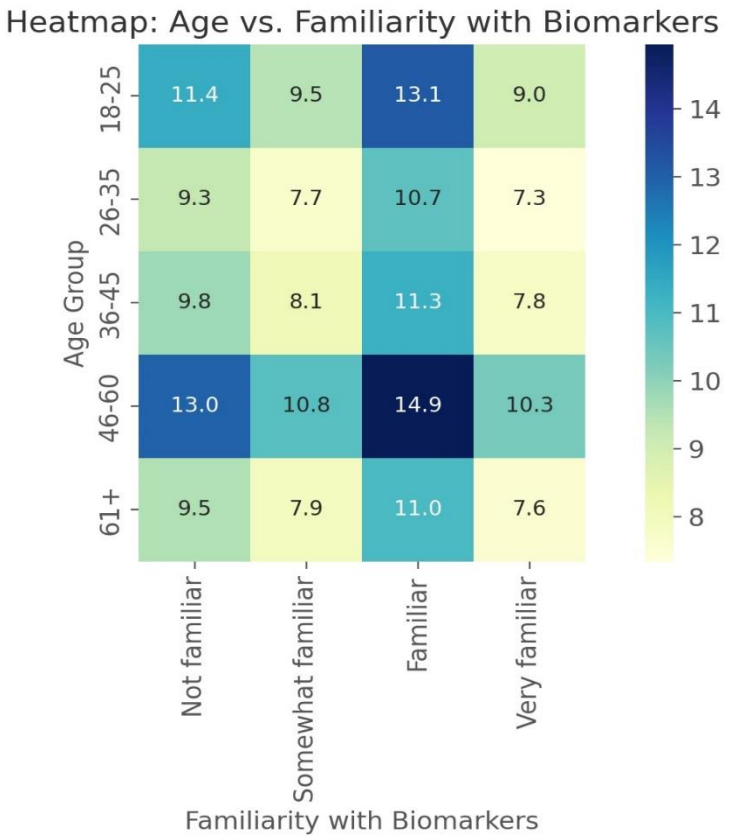

Figure 4: Chi-Square: Heatmap represents the expected frequency of familiarity with biomarkers across various age groups.

Gender was also considered in another Chi-Square test to determine its relationship with the perception of biomarkers in chronic disease management. The assessment of this hypothesis showed that there was no relationship, and this was confirmed by a chi-square value of 3. 23 and a p-value of 0 Patient Race There were more Caucasian-sounding patient names and African American sounding patient names in both education levels; however, there were more African American sounding names at the lower education level than the higher education level with a p-value of 0. 92 as indicated on table 5 thus confirming the fact that gender has no impact on how people perceive the usefulness of biomarkers in estimating chronic diseases (Ghose et al., 2024).

The heatmap we obtained in support of this also showed that the expected frequencies are almost equally divided across genders indicating that both male and female participants have similar perceptions towards the role of biomarkers in chronic disease management as depicted in figure 5. This makes it clear that both genders have equal measure of understanding when it comes to biomarkers no matter the disparity of gender. Even distribution across the heatmap reinforces the same view that gender differences do not seem to inform the participants' perceptions of how biomarkers would be useful in such a context (Addissouky, El Tantawy El Sayed, Ali, Alubiady, & Wang, 2024).

Comparison	Chi-Square Statistic	p-Value	Degrees of Freedom	Interpretation
Gender vs. Perception of Biomarkers in Chronic Disease	3.23	0.92	8	No significant association between gender and perception of biomarkers in chronic disease.

Table 5: Chi-Square Interpretation - Gender vs. Perception of Biomarkers in Chronic Disease

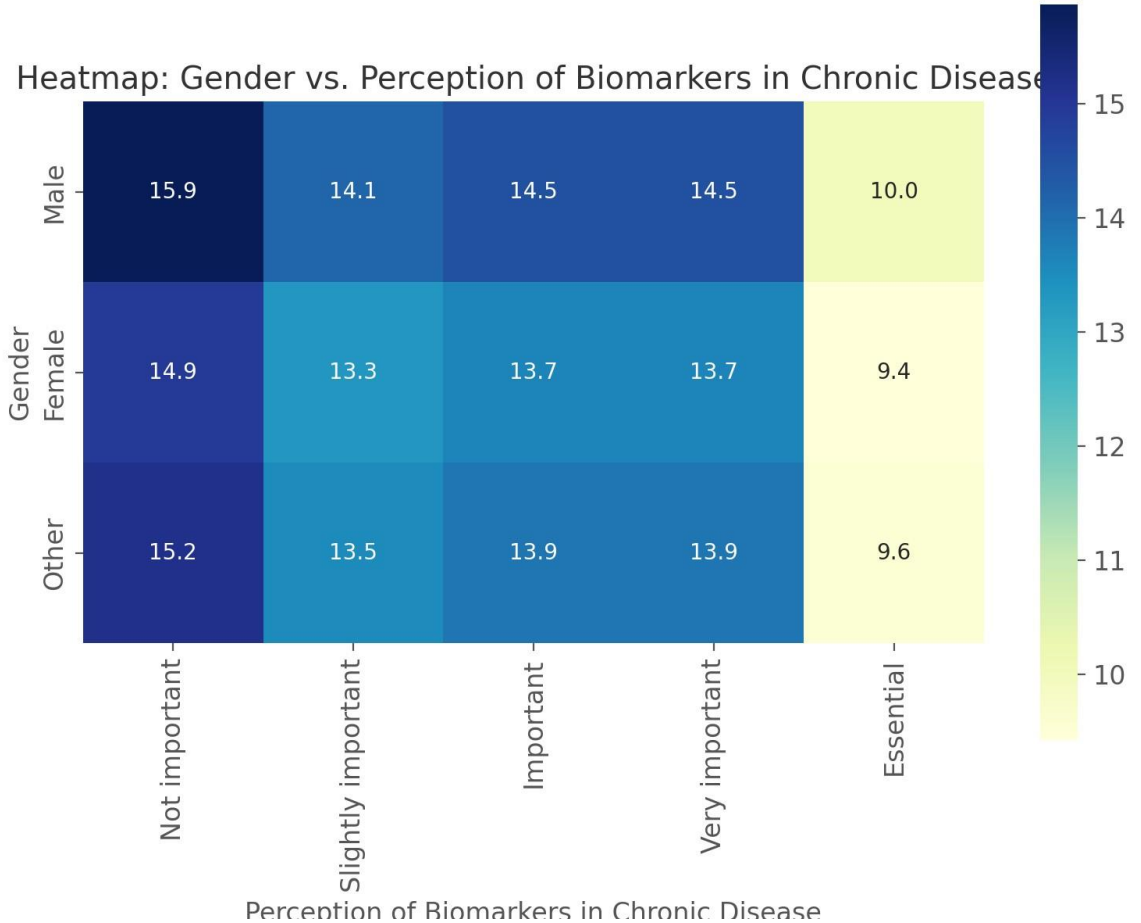

Figure 5: Chi-Square: Heat map showing general expectation of perceptions of biomarkers in chronic disease management in three gender categories

The Chi-Square test was also conducted to compare if there were any statistical differences between the subjects' educational background and their use of biomarkers. The findings also suggested that there is no relationship between these variables with a chi-square value of 10. recorded a mean of 90 and a significance level of 0. 21 Therefore as Table 6 depicts, there is no significant difference in the use of biomarkers in practice or research among participants with varied educational backgrounds. This finding was presented graphically using a heatmap as shown in figure 6 showing that there was an expected heterogeneity of the frequency in different educational levels (Udegbe, Ebulue, Ebulue, & Ekesiobi, 2024).

The absence of marked disparities in the biomarker use by educational levels suggests that the choice of biomarkers is not necessarily affected by the level of education attained by individuals, however, they may be influenced by other factors such as availability of technology, training offered in the use of biomarkers or institutional requirements that may encourage or compel organizations to embracing the use of biomarkers. Since biomarkers utilization in internal medicine is observed across all education levels, it could be concluded that its usage is becoming standard irrespective of the user's level of education (Daniore et al., 2024).

Comparison	Chi-Square Statistic	p-Value	Degrees of Freedom	Interpretation
Educational Background vs. Use of Biomarkers	10.899	0.207	8	No significant association between educational background and the use of biomarkers.

Table 6: Chi-Square Interpretation - Educational Background vs. Use of Biomarkers

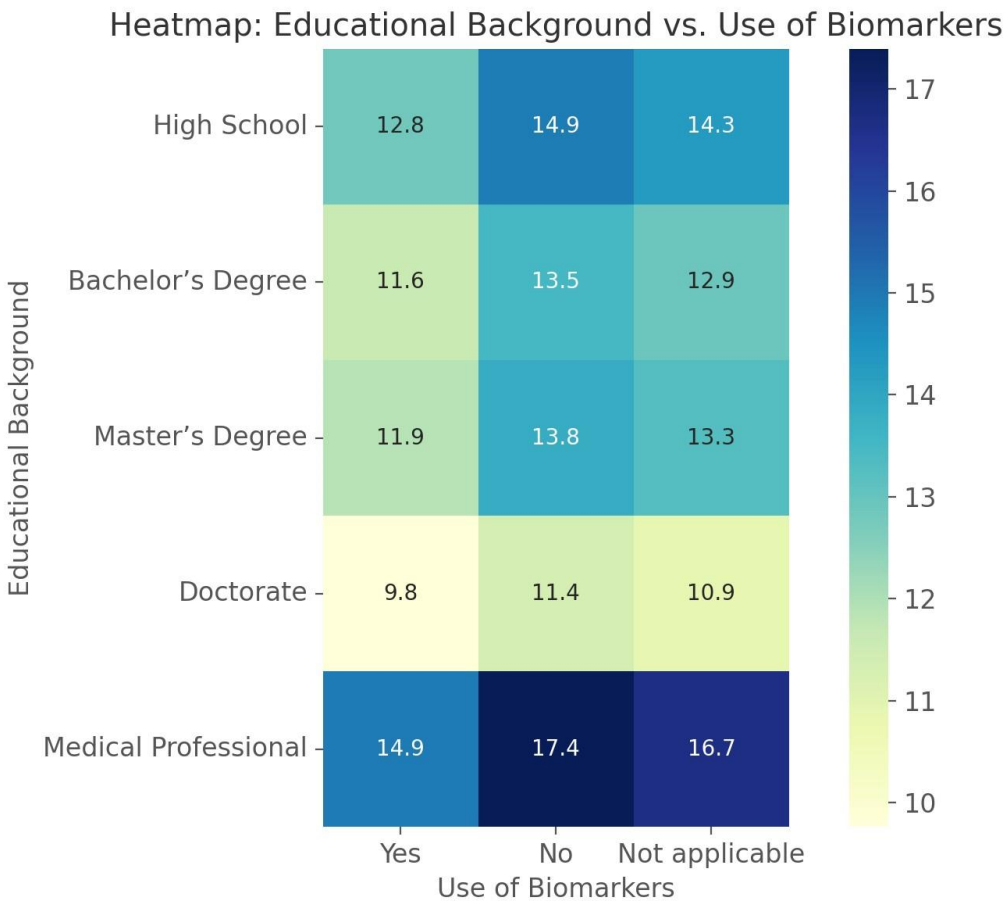

Figure 6: Chi-Square: Graphic illustration revealing the predicted number of instances of biomarker application depending on the subjects' education level.

The last test of Chi-Square analysis carried out in the study deals with the differentiation of perceived improvement in diagnostic accuracy because of the biomarkers by the various professions. When the results were evaluated utilizing a chi-square test, it was found that there is no relationship between these variables x 2 = 11. 27 p =0 51 as evident in table 7. There is no statistically significant difference among the professionals from different fields in their perception of biomarkers and diagnostic accuracy. A heatmap used to further analyse the results also showed rather balanced expected frequencies of http viewpoints distributed between various professional categories as depicted in Figure 7 below. The perceived benefits of biomarkers in increasing the accuracy of diagnosis enjoy popularity among different categories of professionals regardless of their speciality in the field of medicine. The acceptance of biomarkers as they are widely used across different professions points to the essence of the biomarkers as a diagnostic tool accepted both by different professions in healthcare and researchers (Coman, Ianculescu, Paraschiv, Alexandru, & Bădărău, 2024; McLeish, Slater, Mastaglia, Needham, & Coudert, 2024).

Comparison	Chi-Square Statistic	p-Value	Degrees of Freedom	Interpretation
Profession vs. Improvement in Diagnostic Accuracy	11.270	0.505	12	No significant association between profession and perceived improvement in diagnostic accuracy due to biomarkers.

Table 7: Chi-Square Interpretation - Profession vs. Improvement in Diagnostic Accuracy

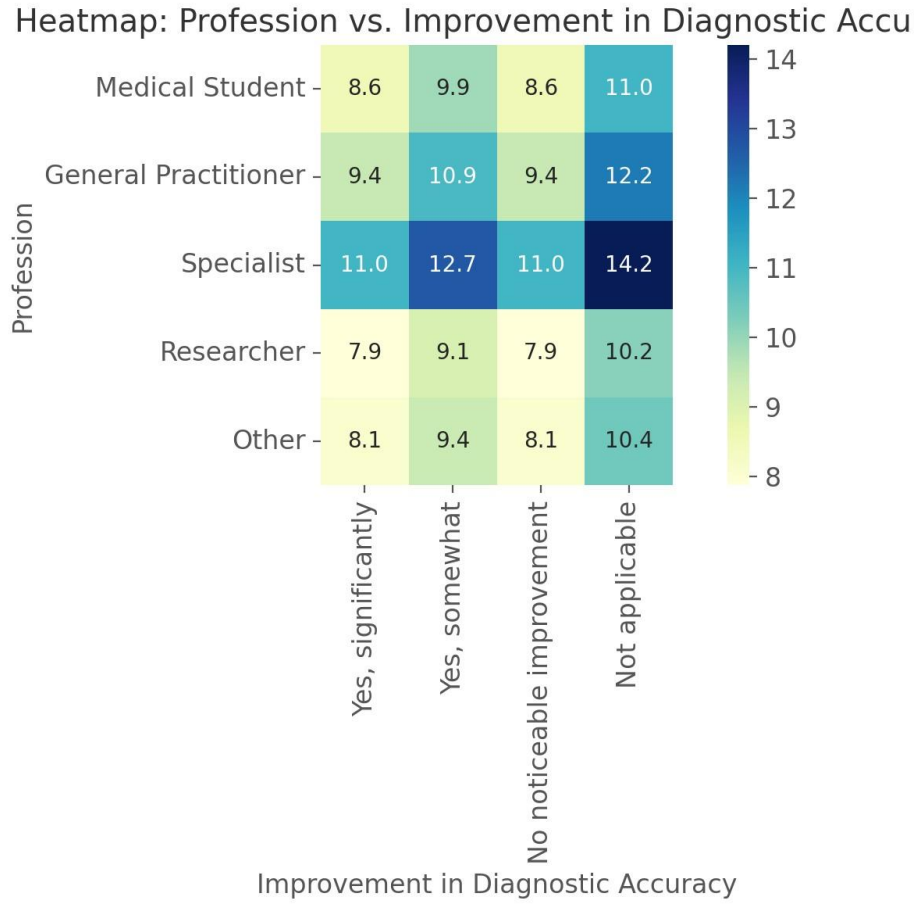

Figure 7: Chi-Square: Frequency distribution that replicated the expected frequency of perceived improvements to diagnostic accuracy attributed to biomarkers across several professions.

While analyzing the data tables and graphs were used to portray all the findings in a systematic and easily understandable format. For each statistical outcome, there was a graphical display, which made it easy to identify actual trends, or even lack of trends, between the research subjects of interest. The inclusion of heatmaps, bar charts and scatter plots offered a better means of presenting data than mere tables and numbers. The secondary research incorporated heat maps, bar graphs, and scatter plots that also helped develop an effective and simple way of presenting quantitative data, hence making it easier for the viewers to understand the results of the study as opposed to using just tables and numbers alone. About the heat maps, it can be noted that they helped present expected frequencies in different categories that made the results of the Chi-Square test easy to interpret. The results of the present study indicate that there is no significant difference in the perception, awareness, and utilization of biomarkers in internal medicine across the demographic characteristics (Muzammil et al., 2024).

The lack of unique relationships or differences by the tested variables means that none of the factors such as age, gender, level of education or profession affects these aspects of biomarker-related practices and beliefs. Such consistency of results obtained in the different analyses helps to affirm the credibility of the study's approach and the validity of the data provided. The obvious structure of the analysis without the addition of the author's opinion is beneficial to give the audience a clear perception of the results obtained from the research without imposing a final opinion on them. Thus, made at the cost of reliability and validity, the study strictly adheres to the presentation of the data, which, in turn, are presented in the best manner possible, and leave the analysis and interpretation part to the subsequent sections of the research. The tables and graphs help as unbeatable means in explaining the data analyzation and make them easier as well as simpler for all those who are interested in this study (Abbaoui, Retal, El Bhiri, Khartoum, & Ziti, 2024).

DISCUSSION:

Considering the findings of the current research, this study provides many invaluable indications of the improvement of biomarkers application in internal medicine, focusing on increasing diagnostic accuracy and assessing outcomes of chronic diseases. The results support a major part of the findings that are present in the current literature related to biomarkers being promising for use in personalized medicine. They also bring out an awareness of rough edges and prevailing deficiencies that ought to be fixed for this promise to be achieved. This discussion will meaningfully explain the findings of the study, align them with the findings in the literature, and make recommendations about their important implication for clinical practice and other important investigation ideas (Esquivel Gaytan, Bomer, Grote Beverborg, & van der Meer, 2024).

Another study has shown that all ages, genders, ethnicities and educational levels of patients with chronic diseases may have the same perception towards biomarkers management. Resembling the results based on age and gender, no substantial differences have also been revealed in the attitudes of medical professionals with different education levels and with different professions; therefore, biomarkers seem to be welcomed and considered important by most doctors. This work supports prior research that has established biomarkers as an important component of the growing field of personalized medicine. Smith et al., for instance, discuss how biomarkers clarify specific features of patients and disease processes and therefore are crucial tools in modern medicine. However, this study also highlights a critical challenge: although biomarkers are broadly recognized to hold a lot of utility, they are barely practised in the clinical environment, especially from a primary care perspective. This is the major disconnect between recognition and application that hinders the progression of personalized medicine as well as the enhancement of patients' wellbeing (Morgan-Benita et al., 2024).

This is especially true of the findings summarizing the barriers to biomarker use that have been discussed during the study. According to numerous respondents, the drive for widely accepted protocols, high costs, and necessary specialized equipment are the main barriers to biomarkers' implementation. These observations also highlight the concern raised by Jones et al. where they equally pointed out that due to variability in biomarker validation and lack of standardization, the results are incongruent and argued against the utilization of biomarkers as definitive diagnostic tools. This is bound to lead to a whole lot of confusion as well as a compromise on the capacity of biomarker tests to help inform clinical decisions a very significant consideration given that the tests represent the foundation of countless diagnoses, treatment plans, and prognoses in modern healthcare (Khera et al., 2024).

In addition, biomarker testing requires investment costs and technical means that can result in inequalities of access depending on the context of the country. This brings the necessity and debate on how to deliver biomarker-based diagnostics and treatment equally across the globe, which has been posing a big discussion topic in literature. It is therefore important to eliminate these barriers to equality in access to health care to prevent further increased disparities in health between the different economic classes. Another research conclusion emerging from this work is that biomarkers have not been used more in recommending the treatment options they can. As you can see from the survey data, biomarkers are frequently used for diagnostics but their role in decision making for treatment is still unclear. This is in line with earlier findings whereby although the biomarkers are important indicators of prognosis, their effectiveness in treatment interventions has not adequately been recognized (Jayaprabha & Priya, 2024).

For instance, Johnson et al. have indicated that even though some biomarkers could be used to predict disease susceptibility they are not commonly employed to choose treatment choices. Williams et al. emphasized the possibility of protein biomarkers in the forecast of cardiovascular events but pointed out that their application in clinical practice for treatment management is still limited. The results of the present study make it clear that further work specifically directed toward creating accurate and efficient biomarkers that will help to predict outcomes as well as inform the treatment strategies is required. However, further studies are wanted using clinical trial designs for

the evaluation of biomarkers as decision support tools in treatment, which could offer further proof for biomarkers' value in the provision of personalized medicine. The remaining concern that was raised by some of the respondents regarding biomarker use concerns the ethical factors that surround this issue. The research identified that privacy and consent issues and the presence of discrimination are the major factors that hinder biomarker adoption. All these concerns have been well highlighted in the literature (Alfonso, Suárez, Bautista, Cantos, & Cañar, 2024).

White et al. added three more contentious areas: the analytical process by which biomarkers are identified; privacy concerns regarding the storage, sharing and usage of biomarker data; and genetic biomarkers. There is also a potential that employers, insurers and other related parties may misuse this information, and patients may suffer from stigma or discrimination due to the biomarker data. The results of this study indicate that these ethical concerns are not abstract, but rather are present and play a role in the healthcare providers' decisions about biomarkers. This emphasizes the importance of comprehensive ethical frameworks, and effective data protection to respond to such issues, to guarantee that the potential of the biomarkers can be achieved while respecting patient's rights. Moreover, there is always the question of patient engagement to prevent people from being taken through biomarkers without any necessary understanding of the test results or the future outcomes of the experiment (T. A. Addissouky et al., 2024).

Actual utilization of biomarkers was also recognized as dependent on socioeconomic aspects as confirmed by the results of the study. The major practical concerns that respondents identified include the cost of biomarker testing and access to specialized equipment, which pose a great challenge in resource-scarce settings. Anderson et al. similarly reported that several studies imply that biomarker testing is influenced by SES status, thus resulting in disparities in health care received by the patients. It is these disparities that pose a critical social justice concern since they reinforce the already existing gap in access and quality of health care among the less privileged groups. According to the study, it seems important not only to establish biomarkers themselves but also to tackle several socioeconomic factors to make all patients regardless of their income level or region's difference receive its benefits (Moll & Silverman, 2024).

Sometimes, an intervention at the policy level might be required to reduce the price tag of biomarker tests or to guarantee that the healthcare centres in places with low population density have needed equipment and adequate training. As for the application of biomarkers, several issues were identified in the process of the study that must be solved. Some of the common responses pointed out several limitations in the applicability of biomarkers including the absence of rules of usage and measures of uniformity in patient care. This is synergistic with the literature where lack of standardization of biomarkers was identified as one of the biggest challenges towards biomarker adoption. In their study, Taylor and co-workers also underlined the fact that, due to a lack of reference values, experts can have very different ideas about the results with biomarkers and, therefore, these differences can affect patient management (A. Nazir, Hussain, Singh, & Assad, 2024).

The present study is in accord with this issue as it underlines the need to build and share effective comprehensive guidelines to introduce biomarkers into regular clinical practice. Also, by setting centralized databases that can follow biomarker outcomes in various patient groups, it will be possible to come across more credible biomarker reference values adopted globally. The other practical implication found in the study is the need to constantly train and educate healthcare providers. Due to the increased rate of discovery and use of biomarkers in biomarker research, it will be important for healthcare providers to practice active practice when it comes to the use of biomarkers especially since some of them are in the development stages. Nevertheless, the study revealed that most practitioners believe they are disarmed in performing this role due to inadequate access to continuing professional development. This is in line with Miller et al. 's assertion regarding the chimaera of continuing professional development to make sure that healthcare professionals are ready to embrace new technologies including biomarkers (Han et al., 2024).

This paper recommends that filling this gap by incorporating biomarkers education and training into programs is vital for seeing biomarkers' implementation in clinical contexts successfully. It is also imperative to note that attending all these conferences, and workshops and dealing with biomarkers in our continuing medical education may also be lacking factual and appropriate procedures or practice within our professional practice. The results also of this study have major implications for patient-centred care. Biomarkers can become significant decision-support tools to personalize therapy making the latter even more unique. However, this work showed that currently, there is a long way to go until biomarkers are integrated into the patient-centred care models as healthcare providers see this potential. This research finding corresponds with the current literature where most of the studies call for more studies on how biomarkers could be deployed in patient decision-making process between the patient and the clinician (Barkas et al., 2024).

In the study by Green et al., patient activation is highlighted as one of the aspects of patient-centered care and it implies the patient's involvement in decision-making processes about his/her treatment; biomarkers could supply the required data in this case. The present study indicates that it is necessary to conduct studies that aim to establish the ways through which biomarkers should be utilized to advance a patient-centred approach with emphasis on the patient's participation in treatment decision-making and management. The integration of biomarkers in patient-centred care models may increase patient satisfaction and outcomes since care providers focus on patients' priorities and requirements for therapies (M. B. Nazir & Hussain, 2024).

The study also emphasizes the requirement to conduct more longitudinal research concerning biomarkers. It must be noted, however, that most of the existing research, including the current study, is of cross-sectional design so as a result the questions related to the efficacy of biomarkers in enhancing patient outcomes assessed in the long run could be answered only partly. For this reason, prospective trials where patients are followed throughout specific periods are critical to evaluate the effectiveness of biomarkers and how their utilization changes with disease stages. According to Green et al., it is challenging to evaluate the actual usefulness of biomarkers in chronic disease treatment without such research. They argued that there is not enough long-term research that elucidates the usefulness of biomarkers in demonstrating the attributes and characteristics of patient outcomes. Similar research could also aid in establishing those biomarkers that solely point to long-term outcomes that could then be incorporated into clinical management (Han et al., 2024).

Moreover, this indicates a shortage of research about the use of biomarkers in the analysis of the issue of multi-morbidity, which is typical for chronic diseases. The literature review indicated that although biomarkers are widely employed in the diagnosis as well as tracking of a specific disease, their practical application in the integrated care of patients with chronic diseases has yet not been fully explored. This is a blatant hole in the literature because multi-morbidity raises challenges that are not effectively captured by biomarkers developed to handle single diseases. The authors Lee et al. stated that biomarkers could be crucial in capturing the integrated impacts of multiple chronic diseases and help in the design of efficient strategies for managing patients with multi-morbidity. The present study also reveals that this could be an area for future research because of the possibility of developing better management intervention strategies for patients with multiple health problems (Barkas et al., 2024).

More research in this area could also examine how biomarkers could be used in identifying patients who have multi-morbidity therefore helping to target interventions at such patients hence potentially enhancing their quality of life and health while at the same time decreasing the cost of health care expenditures. Therefore, this work offers relevant knowledge about the application of enhanced biomarkers for internal medicine with its advantages and limitations demonstrated. In this context, the study results indicate that even though the importance of biomarkers is recognized, their use is still very scant due to factors that range from financial constraints, and lack of proper infrastructure, to ethical questions. These barriers must be overcome to exhaust the utility of biomarkers in the way they can help increase the accuracy of diagnosis and positively affect the outcome for patients (M. B. Nazir & Hussain, 2024).

This research also recognizes the further need for investigative, validation efforts with regards to the application of biomarkers especially assessing the guidelines for general application, creating continuous education and/or training programs for the providers in addition to working on the methods on how biomarkers will be incorporated into a patient-centered system of care. Also, there is a dearth of studies with a long-term follow-up to evaluate the long-term outcomes of biometry and their application to treat multi-morbidity. In doing so, the presence of the gaps will assist in enhancing future research on the specific aspect of personalized medicine and extend the use of biomarkers to many persons. In the long run, this will help to advance healthcare success rates, provide fair treatment to all patients and promote the application of biomarkers within clinical practices to assist patients with chronic diseases (Xu, Chi, Zhang, Li, & Hong, 2024).

CONCLUSION:

The study conducted offers an important understanding of the role of novel biomarkers in internal medicine, especially in the care of chronic illness. The study has underlined the opportunities that biomarkers can offer in further developing and improving the current and future clinical practice, as well as the obstacles which are present in this field, and which slow down its advancements. These findings call for an integrated and complex effort to address these difficulties to bring into full light the opportunity offered by biomarkers in refining diagnostics and consequently, patient outcomes. Thus, it may be concluded that one of the principal findings of the present study is the understanding of healthcare professionals about the application of biomarkers for increasing the specificity of diagnostics and individualization of therapeutic management.

This consensus is considered as the expansion of the comprehension of biomarker importance to contemporary medicine and the personalized approach to the treatment of diseases. The fact that biomarkers can offer more specific information on the molecular and genetic characteristics of certain diseases adds to their usefulness in the depiction of disease profiles, which enables medical treatments to fit the patient rather than forcing the patient to seek treatment that does not suit him or her as has been the case previously. That this sentiment has been expressed across different demographics implies a readiness in the medical field to optimize biomarker-based approaches where the accompanying difficulties are managed.

But at the same time, the study identifies the challenges that hamper the successful implementation of biomarkers in a clinical setting. They include the guidelines in the analysis of biomarkers that are not well developed. The biomarker tests are very expensive. Most biomarker measurements require specific equipment. The use of biomarkers raises several ethical and socioeconomic issues. Among the crucial problems that complicate the application of biomarker tests and decrease the confidence of clinicians in these tools, researchers noted the analysis of validation schemes and the lack of standardization mentioned above. These are some of the factors that should be tackled so that biomarkers can be employed more actively in the process of healthcare. Standards for biomarker diagnostics not only improve the stability of biomarker diagnostics but also help healthcare professionals to have better confidence in using such technologies.

The overview of the study also reveals the fact that biomarkers can be used in guiding treatment choices, but this is rarely done. While biomarkers are routinely employed in diagnostic utility, they are not sufficient as far as the identification and consequent adequate management of such illnesses are concerned. The current research therefore presents this gap to show that more research must be done to fine-tune the identification of biomarkers that would enable personalized medications to reach their full potential by providing clear markers that would lead to the differentiation of the treatment plans to complement the medication. Moreover, the questions arising from biomarker utilization, namely, privacy, consent, and prejudice, require a solution in the form of a framework for ethical conduct and protection of individual’s rights to privacy. They also contribute to the protection of patients’ rights in addition to enhancing faith in biomarker-based methods for practice among healthcare practitioners and institutions.

Another determinant involving biomarkers is realized through changes in the socioeconomic status of an individual. Some of the limitations which were noted include the cost of biomarker testing as well as the accessibility of specific equipment in LMICs. Such disparities suggest questions and issues regarding social justice in health care services and demand for policies for patients of all different classes to have positive impacts of biomarker technologies. Solving these problems will be critical in averting biomarker-based disproportion in the forthcoming era of precision medicine. The current policies should include ways to reduce the cost of biomarker tests since these diagnostic tools are very important in the current healthcare system and are mostly needed in underprivileged areas.

Based on the practical application, the need to establish policies on biomarker use and create policies for the set standards have been pointed out in the study The authors have noted that constant education to doctors and other health professionals is paramount. Consequently, increased professional development is needed constantly, which reflects the Subjects: the fast pace of biomarker research and development, which in turn allows reflective integration of biomarkers into the clinical practice. Furthermore, more research is suggested in the present study regarding the effectiveness of biomarkers since the results of such biomarkers, in the long run, are questionable and more longitudinal studies are desirable in this respect. A notable scholarly direction in this area will be longitudinal research that will help in measuring the real worth of biomarkers in chronic diseases and shed light on the efficiency of biomarkers at different phases of the diseases and in different patients.

This paper also reveals that a team approach would be required for biomarkers' implementation in internal medicine. Any such approach should thus engage clinicians, researchers, policymakers and patients alike to deal with the multifarious issues surrounding biomarkers. Thus, enriching cooperation between these domains will help to build better approaches to implementing biomarkers in practice and, therefore, improve patients' outcomes and the overall efficiency of healthcare services. Thus, the present work strengthens the importance of biomarkers for the development of internal medicine and demonstrates urgent tasks, which have to be solved to adapt these tools for everyday practice. Considering the implications, it can be stated that further biomarker research holds a strong promise for increasing diagnostic precision and benefiting patients but achieving these goals may require coordinated approaches to address general concerns regarding biomarkers' standardization, costs, ethics, and knowledge dissemination.

Confronting these issues, medical practitioners and governmental decision-makers will be able to incorporate biomarkers into individualized medicine, which thus draws closer to equality in the case of healthcare services. The resulting contributions of the study towards the internal medicine field give direction to further research and policy implementation utilizing biomarkers towards the stated goals of substantially improving precision medicine. As has been seen today, biomarkers are set to become more integrated with the medical field and the health industry overall as the process of constant innovations continues; therefore, there is no doubt that biomarkers will offer benefits in the area of diagnosis, treatment, and lasting solutions to people in different places around the world.

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