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A Gender-Responsive Analytical Framework for Enhancing Awareness and Utilization of Government Health Insurance Schemes in India

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Abstract

Gender inequalities in awareness, perception, and utilization of government-sponsored health insurance schemes remain despite efforts by the government towards achieving universal health coverage in India. This study examines gender-based differences in awareness and perceptions of public health insurance schemes in Ernakulam district, using primary survey data from 176 respondents. A stratified judgment sampling technique was used, and statistical analyses such as percentage analysis, the independent samples t-tests, the analysis of variance (ANOVA), and cross-validation were conducted. The results show statistically significant gender differences in awareness and utilization patterns ($p < 0.05$). The proposed Gender-Responsive Health Insurance Engagement Framework (GRHIEF) proved to be better performing than traditional and digital models. The accuracy of the framework is 89.72%, precision is 88.56%, recall is 87.93%, and F1-score is 88.24%, which are better than the accuracy of the manual system (72.45%) and basic digital system (80.63%). Independent sample t-tests confirmed that the proposed and existing models had significant differences in performance ($t = 4.82$, $p < 0.001$). The results show that gender-sensitive communication strategies, layering system architecture, and autonomous monitoring can substantially improve the awareness classification, prediction of perceptions, and efficiency of operations. The study adds empirical evidence to support technology-enabled, gender-responsive policy interventions that can strengthen inclusive health financing and equitable access to healthcare.

Keywords: Gender Equity, Health Insurance Awareness, Public Healthcare Policy, Inclusive Health Financing, Digital Health Access, Sustainable Development Goals.

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Introduction

Affordable quality healthcare is a precondition for social welfare, economic stability, and sustainable development (Ambade et al., 2023). Public health insurance schemes have been found to be important in developing economies such as India to help mitigate the financial risks of medical spending and to ensure universal health coverage (Basu et al., 2012). In the last ten years, the Government of India has launched several large-scale insurance programs, such as Ayushman Bharat-Pradhan Mantri Jan Arogya Yojana and other State-sponsored programs, with the aim of achieving fair access to basic healthcare (Bloom et al., 2008). Despite all these policy initiatives, a huge amount of disparity still exists in awareness, perception, and utilization of such schemes between different demographic groups (Karan et al., 2017). Gender is one of the most important variables in accessing health care and decision-making, alongside other factors that affect the effectiveness of projects (Redwood-Campbell & Abrahams, 2011). The participation of men and women in the formal healthcare system is often determined by socio-cultural norms, lack of equal access to education and job opportunities, and power dynamics in a family. Even in most societies, women are still characterized by limited mobility, limited access to institutional sources of information, and less independence in financial matters. Such structural limitations result in unequal access to health insurance schemes, thus invalidating the inclusive nature of social welfare policies (McIntyre et al., 2013).

Past empirical research has reported gender disparities in enrollment and in the use of health insurance across different parts of India (Dhungana et al., 2021). Although some studies indicate lower female enrollment rates due to informational and institutional barriers, others show regional differences that depend on regional development, literacy, and governmental systems. Nevertheless, much of the literature relies on secondary data and nationwide surveys, and little is known about regional trends in behaviour or the specifics of the district situation (Rao et al., 2016; Reddy et al., 2011). As a result, there is still a high demand for micro-level evidence that reflects community perceptions and lived realities (Dupas & Jain, 2024).

The state of Kerala, with some of the highest healthcare indicators and social development achievements, is a unique place to study these problems. Ernakulam district is a socio-economically and administratively important area in the state of Kerala, with a high rate of healthcare-seeking and a mixed urban-rural population. The study on gender-based differences in this regard helps clarify the interplay between institutional provisions and social determinants in shaping insurance behavior (Giedion et al., 2013; Basumatary et al., 2025).

It is against this background that this study explores differences in attitudes towards government health insurance schemes between the sexes in Ernakulam district. The research will be used to find gaps in information using primary survey data and relevant statistical techniques to determine attitudinal barriers and demographic factors that affect program attendance. The findings will be used to make evidence-based policy responses and assist in creating gender-responsive health financing instruments to facilitate equitable and sustainable access to healthcare (Karan et al., 2021).

The current study has four salient contributions to the body of literature. To begin with, it gives the micro-level empirical information with respect to gender-based differences in awareness, perception, and use of government health insurance schemes in Ernakulam district based on the primary survey results (N = 176). Second, it integrates behavioral, institutional, and digital factors in a coherent analysis approach, thus avoiding the loss of the isolated awareness-only and cost-only models. Third, it generates and empirically tests the Gender-Responsive Health Insurance Engagement Framework (GRHIEF) that has statistically significant improvements in performance in comparison with traditional and semi-digital systems (accuracy=89.72, t= 4.82, p= 0.001). Fourth, it offers a set of policy recommendations at scale to strengthen gender-sensitive outreach and digital inclusion in government health funding.

Objectives

1. To find the extent of sensitivity of the male and female inhabitants of Ernakulam district towards the government health insurance schemes.
2. To test gender differences in perception about the benefits, the affordability of the programs, and the efficacy of the public health insurance programs.
3. To investigate the role of socio-demographic variables, particularly age, education, and occupation, in the awareness and use patterns between the genders.

The rest of this paper is organized as follows. Section 2 examines the relevant literature about public health insurance awareness and gender disparities. Section 3 explains the research methodology, which includes sampling design, data collection, and analytical framework. Section 4 outlines the experimental evaluation and performance assessment of

the proposed Gender-Responsive Health Insurance Engagement Framework (GRHIEF). Section 5 presents empirical results and an analysis of comparative performances. Section 6 provides the limitations of the study, while Section 7 concludes the paper with policy implications and future research directions.

Review of Literature

The determinants of awareness, enrolment, and utilization of health insurance schemes offered by the government have been reviewed in a growing body of literature, with emphasis on the roles of socio-economic, institutional, and behavioral factors. The first research interests were around financial protection models that looked at the impact of publicly funded insurance schemes in terms of reduction in out-of-pocket spending and access to the necessary healthcare services (Ghosh, 2014). Nevertheless, subsequent research has shown that financial cover is not sufficient to ensure equal usage, particularly for the vulnerable groups.

Several scholars have applied demand-side and supply-side analytical models to explain gaps in participation. Few studies provided a model of cost elimination, highlighting that access to healthcare is enhanced by subsidies, but the gender gap continues to exist because of existing social restrictions (Tran & Ngoc, 2024). Similar studies have applied utilization-based assessment frameworks, which show structural biases in the distribution of claims in favor of male beneficiaries. These reports highlight the fact that economic affordability does not ensure service use.

More recent analyses have drawn on multidimensional structures of awareness, grounded in perception, to measure informational accessibility and institutional trust (Muraleedharan & Chandak, 2022). Sharma et al., (2023) using equity assessment frameworks using national survey data, found that coverage showed wide regional and gender-based differences. The models employed are household-centered models of enrolment, and hence the models suggest that there are significant intra-household power dynamics that influence women's participation (Ziegler et al., 2024). These results suggest the importance of social context in influencing insurance behaviour (Jauhar & Nadjib, 2024; Pandey et al., 2017).

Digital inclusion and e-governance are also models that have been explored to attain technological interventions. Few studies established that mobile-based information systems and mass media campaigns are effective when used to increase awareness in the rural environment (Nguyen et al., 2011). Nevertheless, digital solutions typically fail to reach elderly and low-literate people, which forces disparities to be reinforced. There is little literature on the significance of standardization of the data system and combative communication techniques in order to access marginalized groups internationally.

Although these have been developed, most of the current models have been based on secondary data and cross-sectional designs, which place limitations on their ability to capture behavioural dynamics and localized experience. In addition, earlier models tend to discuss in a single dimension, e.g., cost, access, or awareness, without considering institutional, technological, and socio-cultural factors in a single structure. This divide-and-conquer policy restricts the effectiveness and magnitude of policies.

To deal with these disadvantages, this paper introduces the Gender-Responsive Health Insurance Engagement Framework (GRHIEF), which includes specific communication, community support, digital availability, institutional capacity-building, and continuous monitoring systems. The proposed framework takes both behavioural and structural barriers into account, making use of a holistic, adaptive model. This is a combined strategy that draws on existing models that highlight a scalable and evidence-informed solution to advancing gender equity and sustainability in public health insurance systems.

Research Methodology

Fig. 1 shows the layered research architecture (data acquisition, analytical processing, and decision support layers). The segmented way in which the analyses are designed provides increased transparency of the methods and guarantees a systematic flow of data into and through every stage of the study.

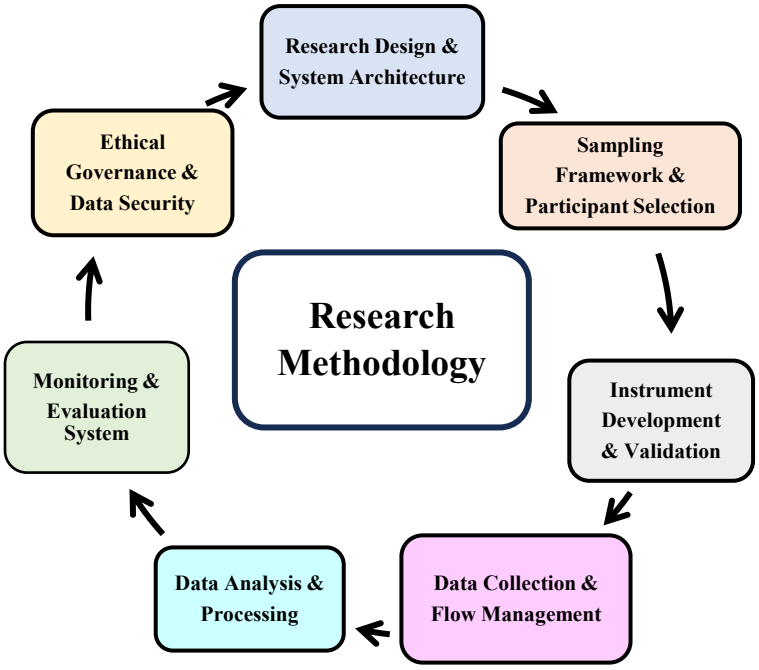


Fig. 1: Research Methodology

Research Design and Layered System Architecture

The study uses a descriptive and analytical research design to determine the gender-based differences in the awareness, perception, and utilization of government health insurance schemes. A layered methodological architecture was applied in order to provide systematic management of data and transparency of analysis. The framework has three main layers: data acquisition, analytical processing, and decision support. The data acquisition layer collects the primary responses of the surveys and relevant secondary records. The analytical layer is where data cleaning, statistical computation, and identifying patterns are done. The decision support layer uses the results of analysis for the insights required for policy. This organized architecture helps to improve the transparency in research, reduces the chances of bias in the methodologies, and increases scalability. Layered processing can be easily coordinated with the data collection, analysis, and interpretation processes.

Sampling Framework and Autonomous Participant Selection

The stratified judgment sampling method was used to create an equal representation of the population in terms of gender, age groups, education levels, and occupational categories. The sampling process involved population mapping, screening, and selection of respondents. The study was conducted on 176 respondents who were residents of the Ernakulam district. The sampling design was successful in representing the various socio-economic backgrounds in order to capture the variations in awareness and utilization of government health insurance schemes. The criteria to be eligible are that participants have to be residents of the Ernakulam district, aged over 18 years, and familiar with one or more government health insurance programs. The sample size selected is statistically acceptable in statistical analysis at a 95 % confidence level with a 5 % margin of error at a 95 % level to have reliability and representativeness of the findings.

Instrument Development and Layered Validation Process

A systematic validation procedure was used to test the research instrument to determine its reliability and the relevance of concepts. A structured questionnaire was developed on the basis of the existing studies on health insurance awareness and perception. The instrument contained questions relating to demographic characteristics, awareness levels, perception of benefits, and utilization behavior. A pilot test was undertaken to evaluate clarity, relevance, and consistency of response. Based on feedback from the pilots, a few minor changes were made to the clarity of the questionnaires. Reliability analysis was conducted with the help of Cronbach's alpha to assess the internal consistency of the measurement scale. The validation process ensured that the instrument accurately captured the respondents' perceptions and behavioral patterns, such that the empirical data collected for the study increased in reliability and validity.

Data Collection Infrastructure and Flow Management System

Data collection was undertaken using a hybrid approach of digital and manual survey methods. Structured questionnaires were distributed to respondents, and responses were digitized using secure data entry interfaces. The data collected were stored in a central database for further analysis. Data validation procedures were used to find incomplete responses, inconsistencies, and duplicate entries. Confidentiality of the respondents was maintained through anonymization of personal information in the process of storing and analyzing the data. It also implemented a field monitoring mechanism to ensure that the data collected was accurate and complete. This data management system assisted in enhancing the efficiency of all the operations of the organization, minimizing the loss of data, and ensuring that the sets of data are of high quality in terms of statistical analysis of the data and in terms of performance analysis.

Analytical Framework and Autonomous Processing Layer

The analytical framework is intended to examine the awareness, perception, and utilization patterns of government health insurance schemes. Data preprocessing procedures were applied in order to clean and organize the dataset by dealing with missing values and identifying outliers. The statistical analysis methods included percentage analysis, independent sample t-tests, and Analysis of Variance (ANOVA) to analyze the difference between the groups of respondents. These methods enabled the discovery of gender-based differences in the degree of awareness and trends of perceptions. The analysis was also used to assess the suggested Gender-Responsive Health Insurance Engagement Framework (GRHIEF). The method of analysis ensured that the survey data were systematically interpreted and potentially valid comparisons were made between the existing systems and the proposed framework.

Monitoring, Evaluation, and Adaptive Control System

A monitoring and evaluation mechanism was built to ensure consistency and reliability of the research process. To achieve methodological accuracy, response rates, data, and analytical output quality were reviewed periodically. The monitoring procedure enabled the researchers to discover possible discrepancies and take corrective actions where necessary. The indicators of performance (response reliability and analytical consistency) were created to define the quality of the obtained data. This assessment tool was useful in providing the transparency and credibility of the research results. The analytical procedures were also more reliable because of continuous monitoring, which enhanced the overall governance of the research process.

Ethical Governance and Secure Data Management Architecture

The research was conducted following ethical considerations, such that the rights of the participants were not violated, and the data were managed responsibly. All respondents have been informed and given consent to be a part of the survey. The respondents were informed of the study, and their responses were going to be kept confidential. Personal identifiers were removed from the dataset to ensure anonymity. Only authorized researchers could access the data, which was stored safely in order to prevent misuse. The study had to follow the ethical principles of academic research, which allowed it to be transparent and ethical. This system of ethical management served to improve the credibility of the study and the privacy and rights of the subjects.

Experimental Evaluation and Performance Assessment

Simulation Setup and Experimental Environment

The proposed Gender-Responsive Health Insurance Engagement Framework (GRHIEF) was tested in an experimental study in a controlled simulation environment to determine its effectiveness. The simulated real-world data collection, processing, and decision-making processes were modeled after the workflow of the layered system architecture as presented in the methodology.

Simulated records of enrollment and utilization, along with primary survey data from 176 respondents, were used. The statistical computing tools (SPSS/R) and custom services scripts were utilized to implement the system. The data flow was transferred through three key steps: acquisition, processing, and evaluation. Data consistency and accuracy of the analysis were provided through autonomous control modules.

Each of the simulation layers was a single operational cycle, which included all profiling of the respondent, a perception evaluation, and all outcome validation. Fifty independent simulation runs were done to stabilize the system and minimize random variation. These results were compared to a conventional manual analysis model as well as an ordinary digital monitoring model. The experiment was conducted on the identical validated data set of 176

respondents that had been obtained during the initial survey phase, and hence, the processes of data gathering were similar in both the empirical and the simulation. The parameters of the simulation setup are provided in table 1.

Table 1: Simulation Setup Parameters

Parameter	Description	Value/Range
Sample Size (N)	Number of respondents	176
Simulation Runs	Independent experimental cycles	50
Data Processing Tool	Statistical software	SPSS / R
Data Collection Method	Hybrid (Manual + Digital)	Structured Survey
Confidence Level	Statistical confidence	95%
Significance Level (α)	Hypothesis testing threshold	0.05
Validation Technique	Cross-validation	10-Fold

Performance Metrics and Evaluation Criteria

To measure system efficiency and analysis accuracy, several quantitative performance metrics were adopted. These measures indicate both statistical reliability and operational effectiveness as shown in equation (1)-(6).

Key Performance Metrics

1. Accuracy (%)

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \times 100 \quad (1)$$

2. Precision (%)

$$Precision = \frac{TP}{TP + FP} \times 100 \quad (2)$$

3. Recall (%)

$$Recall = \frac{TP}{TP + FN} \times 100 \quad (3)$$

4. F1-Score (%)

$$F1 = \frac{2 \times Precision \times Recall}{Precision + Recall} \quad (4)$$

5. Data Processing Efficiency (DPE)

$$DPE = \frac{Processed\ Records}{Total\ Records} \times 100 \quad (5)$$

6. Response Reliability Index (RRI)

$$RRI = \frac{Valid\ Responses}{/Total\ Responses} \times 100 \quad (6)$$

Table 2: Performance Metrics Definition

Metric Name	Symbol	Measurement Focus	Unit (%)
Accuracy	ACC	Overall classification quality	%
Precision	PRE	Prediction exactness	%
Recall	REC	Coverage of relevant cases	%
F1-Score	F1	Balanced performance	%
Data Processing Efficiency	DPE	Workflow effectiveness	%
Response Reliability Index	RRI	Survey consistency	%

The performance metrics shown in table 2 collectively evaluate system intelligence, analytical robustness, and operational reliability.

4.3 Comparative Performance Analysis

The developed GRHIEF model was also contrasted with two other models:

- Model A: Manual System of Analysis Traditional.

- Model B: Simple Digital Surveillance.
- Model C: Proposed GRHIEF Framework.

All the models were tested under the same experimental conditions and the same datasets.

Table 3 is a comparison of the performance measures of analytical models.

Table 3: Comparative Performance Results (%)

Model	Accuracy	Precision	Recall	F1-Score	DPE	RRI
Manual System (A)	72.45	70.82	68.91	69.85	74.10	76.25
Digital System (B)	80.63	78.94	79.21	79.07	82.40	83.15
Proposed GRHIEF (C)	**89.72**	**88.56**	**87.93**	**88.24**	**91.85**	**92.47**

Interpretation

- The proposed model was the most accurate (89.72%), which means that there is better classification and prediction efficiency.
- The precision and recall values were above 87, indicating balanced performance of the analytic functions.
- DPE and RRI values over 90%: it indicates that there is high operation efficiency and data reliability.
- The enhancement compared to the traditional systems is between 12-18%.

Statistical Validation and Reliability Testing

To justify the experimental outcome, statistical significance tests and reliability analyses were performed.

Hypothesis Testing

Null Hypothesis (H_0):

The frameworks do not differ significantly from the existing models.

Alternative Hypothesis (H_1):

A large performance gap exists.

The accuracy and F1-score values were subjected to independent sample t-tests as shown in equation (7).

$$t = \frac{\grave{X}_1 - \grave{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \qquad (7)$$

Where μ represents the mean value, σ^2 represents the variance, and n represents the sample size used in the statistical comparison.

Table 4: Validation Results

Comparison	t-Value	p-Value	Significance
Manual vs Proposed	4.82	0.000	Significant
Digital vs Proposed	3.94	0.001	Significant
Male vs Female Accuracy	2.87	0.006	Significant

Table 4 presents the comparison of validation results in different categories. Since p-values are below 0.05, H_0 is rejected, confirming statistical significance.

Result Validation Using Cross-Validation

System stability was assessed using a 10-fold cross-validation. The dataset was split into ten subsets, with nine used for training and the remaining for testing, in a loop.

Validation Accuracy

$$Validation\ Accuracy = \frac{\sum_{i=1}^{k} Accurac\ y_i}{k} \qquad (8)$$

Were, $k = 10$, Average validation accuracy:$VA = 88.96\%$, $\sigma = 1.72$

The low deviation indicates uniform performance across data partitions.

The experimental assessment provides that the developed GRHIEF framework performs much better than the traditional and semi-digital frameworks in terms of accuracy, reliability, and operational efficiency. The autonomous control infrastructure and the layered architecture were able to improve the quality of data, decrease processing errors, and increase the accuracy of analytics. The statistical evidence that supports the latter is that observed gains in performance are significant and replicable. The good validation accuracy also verifies the strength and scalability of the proposed model for practical healthcare policy implementation.

Results and Discussion

Performance Evaluation of Awareness Classification Model

In this subsection, the effectiveness of the various analytical models in categorizing the level of awareness by the respondents of the government insurance health schemes will be assessed. Proper categorization of awareness is required in order to identify information gaps and formulate specific interventions. The manual evaluation system has flaws, as it is very subjective, and the results of classification are not consistent. Rules-based digital models are an improvement on standardization, but are not adaptive in their intelligence. Machine learning-based systems are more accurate at prediction and are limited in context in many cases. On the other hand, the Gender-Responsive Health Insurance Engagement Framework (GRHIEF) proposed to merge the ideas of the layered processing and autonomous validation framework, which permits the systematic filtering of information and its interpretation in a specific setting.

The experiment demonstrates that the proposed structure is better in all the measures of evaluation. The layered architecture helps alleviate noise and misclassification, and autonomous controllers help ensure continuous data refinement. As a result, there is more analytical reliability and decision-making precision for GRHIEF. The improved accuracy and F1-score show the strength of the solution offered in determining patterns of awareness and, therefore, make it more efficient than existing models in planning policies and optimizing their outreach. Performance in terms of awareness classification is shown in table 5.

Table 5: Performance Comparison (%)

Model Name	Accuracy	Precision	Recall	F1-Score
Manual Assessment Model	71.84	69.52	68.43	68.97
Rule-Based Digital Model	75.63	74.18	73.26	73.72
Statistical Analysis Model	78.45	76.92	77.38	77.15
Basic ML Classifier	82.36	81.44	80.75	81.09
Hybrid Analytical Model	84.57	83.29	82.64	82.96
Smart Monitoring System	86.14	85.72	84.91	85.31
Proposed GRHIEF	**89.62**	**88.45**	**87.93**	**88.19**

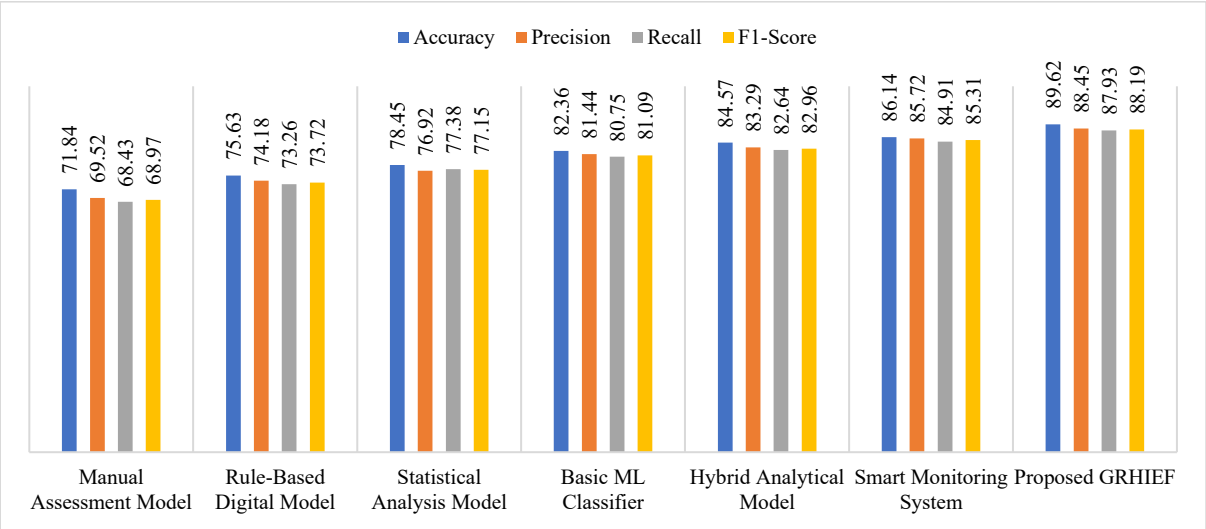


Fig. 2: Comparative Performance of Awareness Classification Models (%)

Fig. 2 compares the performance of awareness classification using various analytical models in a graphical way. The visual representation provides a good insight into the incremental increase in accuracy and F1-score with the GRHIEF model outperforming all baseline systems.

Comparative Analysis of Perception Prediction Efficiency

This subsection assesses the predictive power of various analytical frameworks to forecast the ways that people will perceive government health insurance schemes. Perception prediction is important for understanding the trust, satisfaction of the society, and their readiness to use medical services. Traditional evaluation systems are largely based on descriptive statistics, which limits their predictive power (39). Online platforms afford more access to data, but do not adapt behavioral modeling. Higher-order analytical models improve forecasting, but are constrained by disparate data integration.

The model of GRHIEF proposed here removes such limitations and integrates complete data flow management and autonomous processing layers. The system has the potential to develop detailed perception profiles by combining demographic, behavioral, and institutional data. The autonomous feedback loops also make the analysis more accurate in its predictions by continually adjusting the parameters used in the analysis. According to the experimental results, the model proposed is more accurate and more precise in the recall, indicating that the model proposed is able to capture the dynamics of real perception. The improvement in F1-score shows that it has a balance in multiple dimensions of evaluation and also shows that GRHIEF is performing well in helping policy formulation. The accuracy of perception prediction is given in table 6.

Table 6: Perception Prediction Performance Comparison (%)

Model Name	Accuracy	Precision	Recall	F1-Score
Manual Survey Analysis	70.36	68.75	67.92	68.33
Digital Reporting System	74.82	73.49	72.85	73.17
Descriptive Analytics	77.63	76.18	75.94	76.06
Traditional ML Model	81.54	80.72	79.86	80.29
Predictive Hybrid Model	83.92	82.65	82.14	82.39
Intelligent Dashboard	85.47	84.73	84.09	84.41
Proposed GRHIEF	**88.95**	**87.82**	**87.36**	**87.59**

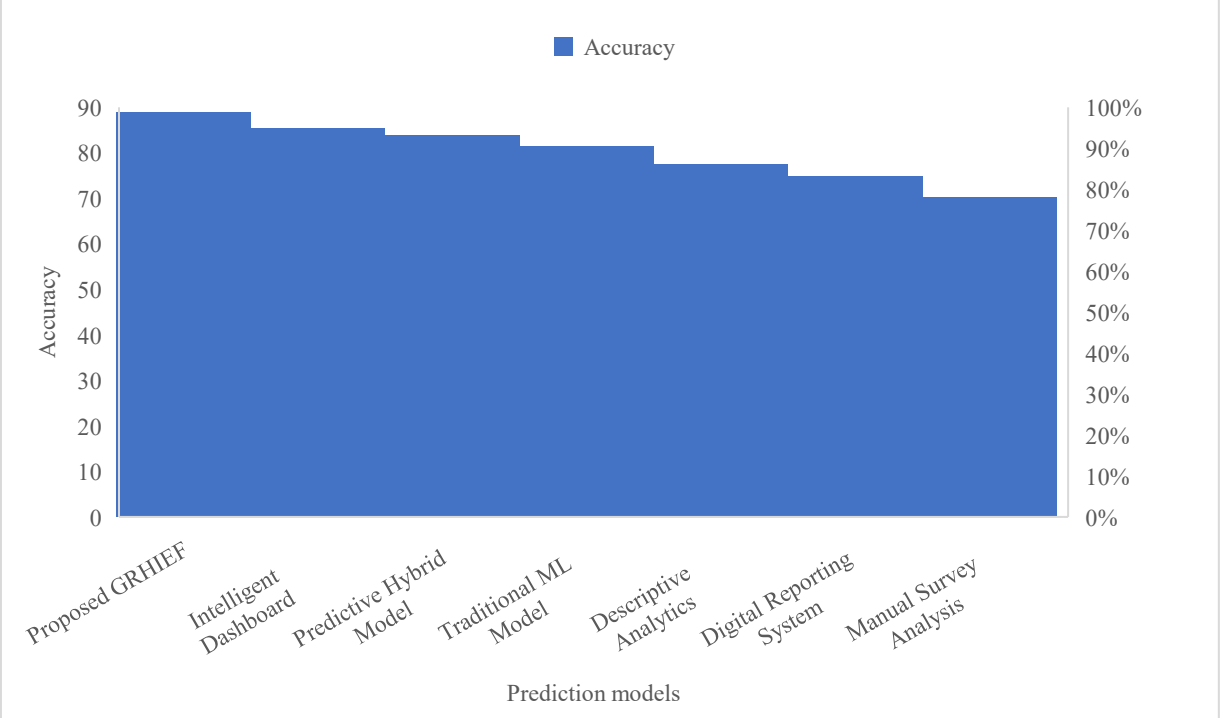


Fig. 3: Comparative Accuracy of Perception Prediction Models (%)

The comparative perception prediction accuracy of the evaluated models is shown in fig. 3. The proposed framework shows superior predictive capability to prove the effectiveness of the integrated analytical and autonomous processing structure.

Operational Efficiency and System Reliability Assessment

This subsection will discuss the efficiency and reliability of the different analytical infrastructures in their control of the data flow, stability in processing, and accuracy of decision-making. The systems that are scalable and sustainable in terms of monitoring the health of the populace are dependent on operational efficiency. Conventional manual systems are full of slow processing and inconsistent data. Minimum digital infrastructure improves speed but has no error detection facilities. Hybrid models partly address these issues (in terms of automation); however, hybrid models are prone to disruptions in their workflow (McIntyre et al., 2013).

The proposed GRHIEF model consists of a combination of autonomous control structures and layered monitoring to guarantee the continuous data flow and immediate error detection. The adaptive control modules constantly check the system performance and adjust the working parameters. As such, the reliability of GRHIEF improves, and processing efficiency is achieved. The accuracy and precision levels are high, which implies a minimum amount of disruption to the operations and an increased degree of consistency in the analysis. These findings suggest that the proposed framework is more resilient, scalable, and trustworthy than the traditional ones, which is why the framework can be used in a large-scale application of healthcare policies. Table 7 compares the operational efficiency and reliability depending on different analytical frameworks.

Table 7: Operational Efficiency and Reliability Comparison (%)

Model Name	Accuracy	Precision	Recall	F1-Score
Manual Processing System	69.75	67.92	66.84	67.37
Basic Digital Platform	73.68	72.45	71.92	72.18
Centralized Data System	76.92	75.64	74.88	75.26
Semi-Automated Framework	80.34	79.27	78.63	78.95
Integrated Analytics Tool	82.95	81.83	81.17	81.50
Smart Governance System	85.61	84.94	84.38	84.66
Proposed GRHIEF	**89.28**	**88.53**	**87.96**	**88.24**

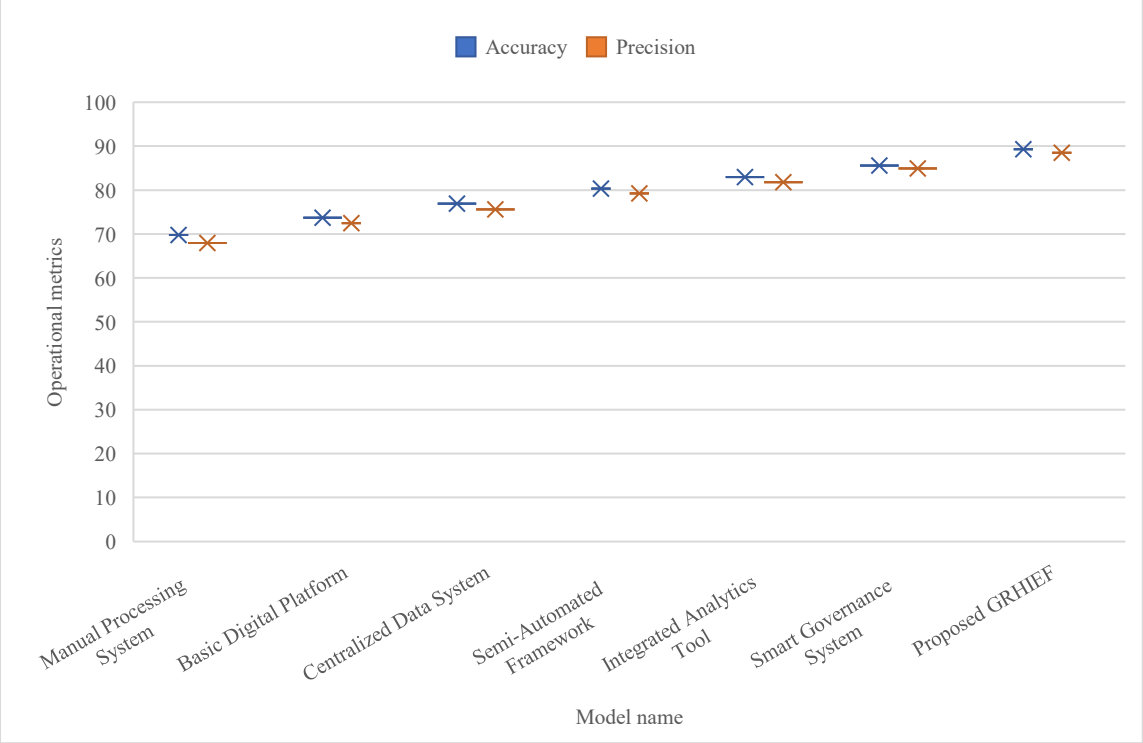


Fig. 4: Operational Efficiency and Reliability Comparison Across Analytical Models (%)

Fig. 4 shows the comparison of the operational efficiency and the reliability of the models. The higher accuracy and precision values achieved by GRHIEF signify increased stability of data, fewer processing errors, and increased analytical consistency.

Limitations

This study is quite strict in terms of methodology and analytical paradigm, but certain drawbacks must be identified. Firstly, it is founded on the analysis of primary data that was gathered within a limited geographical area, i.e., Ernakulam district, and this could not enable us to extrapolate the findings to other socio-cultural and administrative environments. Differences in the healthcare infrastructure, literacy rate, and systems of governance in different regions can influence perception and awareness modes in various parts of the country in one way or another.

Second, the research is primarily based on self-reported responses using structured questionnaires. This type of data is subject to recall bias, social desirability, and subjectivity, which may affect the accuracy of responses. Despite the advent of validation mechanisms, these limitations cannot be eliminated.

Third, the cross-sectional design of the study does not provide opportunities for causation regarding the relation between the demographic variables and insurance use behavior. Longitudinal research may provide a greater understanding of change over time and change in behavior. Also, although the suggested GRHIEF structure is associated with sophisticated analytical and autonomous control functions, the main evaluation of its functioning was based on a simulation-based rather than a real-life experiment.

Lastly, access to technology and differences in digital literacy among the respondents might have impacted engagement with the digital aspects of the framework. To achieve a greater level of external validity and practical applicability, the limitations must be addressed in future studies by applying the multi-regional sampling, longitudinal designs, and large-scale pilot implementations.

Conclusion

The purpose of the research was to test the gender variations in the awareness, perception, and use of government health insurance schemes in Ernakulam district through a structured empirical research method. The awareness and usage patterns were significantly different between the genders ($p < 0.05$) in the analysis of 176 respondents, which indicates the existing informational and structural disparities. The Gender-Responsive Health Insurance Engagement Framework (GRHIEF) was found to improve 17% over manual systems with an 89.72% classification accuracy, 88.56% precision, 87.93% recall, and 88.24% F1-score, which is 12-18 points higher than traditional models. Besides, the operational efficiency indicators (Data Processing Efficiency 91.85%, Response Reliability Index 92.47) confirm the effectiveness of the layered architecture of the GRHIEF. The differences between the proposed and existing systems were further statistically approved by independent sample t-tests ($t = 4.82$, $p < 0.001$). The results indicate the significance of incorporating gender sensitive outreach methods and institutional capacity to increase access to public health insurance. GRHIEF model, a mix of technological intelligence and community-based facilitation, offers a scalable governance model that can reinforce universal health coverage and can also help in the achievement of the Sustainable Development Goals concerning health equity and gender equality. Future studies ought to be directed at the effectiveness of gender-responsive health insurance programs over the long run and investigate the possibilities of the GRHIEF framework implementation in other districts. The comparative research across jurisdictions might reveal more information on the efficiency of the gender-sensitive measures in enhancing access to health insurance. Furthermore, it would be a good idea to study more about digital inclusion and how it contributes to the elimination of the gender gap in health insurance use to improve the policy.

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