An Adaptive Smart Business Intelligence Model Based on Enhanced HGO Discovery for Real-Time in Inpatient Care

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***Abstract*—The complexity and dynamics of inpatient care require advanced decision support systems that are fast, adaptive, and capable of real-time execution. This study proposes a novel Smart Business Intelligence (SBI) model developed through an enhanced Hierarchy Governance Outlook (HGO) Discovery approach to achieve high-precision inpatient service prioritization. Unlike conventional frameworks, the proposed model combines an adaptive weighting mechanism, a sustainability optimization process, and real-time data integration from heterogeneous clinical and operational sources. The enhanced HGO Discovery model allows for dynamic adjustment of decision parameters in response to evolving hospital conditions, thereby maximizing patient care. The results demonstrate that the proposed model consistently outperforms baseline approaches in predictive accuracy, stability, and computational efficiency. These findings highlight the potential of the proposed framework to support data-driven decision-making and enhance the quality and efficiency of inpatient care delivery in modern healthcare environments. Experimental results show that the proposed model provides more accurate patient prioritization, faster identification of critical conditions, and improved operational efficiency compared to conventional approaches. Therefore, the proposed system offers an effective intelligent healthcare solution to support real-time inpatient care and data-driven medical decision-making in modern hospitals.**

***Keywords*—Smart business intelligence; decision support systems; HGO discovery; inpatient care; hospital**

I. Introduction

Advances in smart business intelligence and decision support systems have significantly driven the adoption of advanced data analytics and intelligent optimization techniques in the sustainable healthcare domain. The combination of heterogeneous data, governance, and big data facilitates more informed, rapid, and data-driven decision-making in real-time, particularly in the highly complex and fast-paced hospital environment [1]. However, existing implementations are largely conventional and often lack the ability to effectively respond to the next steps and the increasing demand for timely and accurate decision-making [2].

Smart Business Intelligence in hospitals represents a complex ecosystem where clinical services, operational processes, and information systems continuously interact. As core entities within these systems, hospitals face challenges in optimizing limited resources, managing performance, and maintaining high standards of patient safety and comfort in care [3]. Despite these demands, many current systems lack integration and tend to produce fragmented information, limiting the ability to achieve comprehensive, evidence-based decision-making [4].

Within this framework, Business Intelligence (BI) should be viewed not simply as a set of analytical tools, but as a strategic paradigm to support complex decision-making processes, particularly in patient care management [5]. Although previous studies have highlighted the effectiveness of BI in improving the efficiency and quality of healthcare services, critical research gaps remain in the development of models that can seamlessly integrate heterogeneous data in real time, dynamically adapt to changing clinical conditions, and optimize patient prioritization mechanisms [6]. Consequently, there is an urgent need for new approaches that combine adaptive modeling, dynamic weighting strategies, and continuous optimization techniques to enable more accurate, responsive, and context-aware decision support systems [7].

In inpatient care, the accuracy and complexity of decision-making are crucial factors because they directly impact the quality of care, patient safety, the effectiveness of medical procedures, and the efficiency of hospital operations [8]. Delays in detecting changes in a patient's condition can increase the risk of complications and death, prolong the length of stay, and even potentially increase mortality rates. Therefore, a technology-based approach is needed that not only provides historical information but also offers real-time predictive and adaptive analytics capabilities to support more precise decision-making [9].

A technological innovation phenomenon experiencing rapid development in supporting the digitalization of healthcare services is Smart Business Intelligence (SBI) [10]. SBI is believed to implement strategic operations that integrate data sets, analytical techniques, and data dashboard visualizations to transform systematic data processing into valuable, precise information that can be used as a basis for data-driven decision-making. Through the implementation of SBI, technology-based healthcare services can gain more comprehensive insights into operational conditions and clinical services in a systematic and integrated manner, thereby improving the effectiveness of overall healthcare management [11].

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Based on the problems described, this study proposes an Adaptive Smart Business Intelligence model based on Enhanced HGO Discovery for Real-Time Precision in Inpatient Care. The designed model focuses on the integration of clinical data and hospital operational data into a Smart Business Intelligence system that has the capabilities of real-time data processing, adaptive analysis, patient condition prediction, and the provision of strategic information precisely and accurately [12]. The implementation of this approach is expected to support medical personnel and hospital management in improving the quality of decision-making, accelerating the handling of changing patient conditions, increasing the efficiency of health services, and reducing mortality rates [13].

II. Related Works

The development of Smart Business Intelligence (SBI) and the latest data-driven health analytics has had a significant impact on the transformation of the modern healthcare system towards a smarter, more integrated, and responsive environment [14]. Recent studies have shown that the integration of Artificial Intelligence (AI) technology with SBI has great potential to increase hospital operational efficiency, improve the quality of patient care, and support clinical decision-making processes more accurately, quickly, and in real-time [15]. However, previous studies still face several challenges, particularly in integrating heterogeneous data, improving the system's ability to adapt to dynamic changes in patient conditions, and implementing intelligent optimization methods that can work adaptively in the complex and ever-evolving inpatient care environment [16].

The role of Smart Business Intelligence in the transformation of modern healthcare services is increasingly significant with the integration of artificial intelligence through the use of predictive analytics and intelligent clinical decision support systems [17]. Numerous research studies have shown that the application of artificial intelligence can accelerate diagnosis, analyze patient risks, and improve the overall effectiveness of patient care. Therefore, most existing research focuses on general AI implementation and has not yet integrated the concept of Smart Business Intelligence, supported by adaptive optimization mechanisms, into a real-time inpatient care environment [18].

Developing a real-time patient monitoring system based on Artificial Intelligence (AI) and the Internet of Things (IoT) to support continuous patient condition monitoring [19]. The designed system is capable of integrating primary health data with clinical data to detect changes in patient conditions more quickly and accurately. The results of this study demonstrate the effectiveness of the patient monitoring process, but the research still has limitations in supporting strategic decision-making based on Smart Business Intelligence (SBI) and has not implemented an intelligent optimization mechanism to determine adaptive patient care priorities [20].

The Smart Hospital Framework, which integrates Business Intelligence technology into hospital analytics, was developed to improve operational efficiency and the quality of healthcare services for inpatients [21]. Research results show that the use of a BI-based analytical dashboard can help hospital management monitor service performance and resource utilization more effectively and in a structured manner. However, the applied approach tends to be static, thus not being able to support adaptive analysis or predict patient conditions in real time [22].

In the context of developing patient prediction systems in hospital settings, various studies have developed inpatient condition prediction models using deep learning algorithms. The results show that this approach can improve the accuracy of predicting critical patient conditions compared to conventional methods. However, the implemented models still focus on simple analyses and have not yet integrated comprehensive Business Intelligence mechanisms to support clinical and operational decision-making processes in hospitals [23].

Developing a hybrid optimization technique approach to improve the performance of an artificial intelligence-based healthcare analytics system. The study demonstrates that a combination of heuristic algorithms and adaptive optimization can improve the accuracy of healthcare data classification while accelerating the process of finding optimal solutions for complex datasets. Despite making significant contributions to the development of healthcare optimization, the study has yet to implement the optimization method within an Adaptive Smart Business Intelligence framework to support real-time inpatient care [24].

Based on the latest research, it is understood that the application of Business Intelligence (BI), Artificial Intelligence (AI), and optimization techniques in the healthcare sector has had a significant impact on improving the quality of hospital services. The integration of these technologies can support a more efficient, accurate, and data-driven decision-making process. However, there are still a number of research gaps that have not been fully addressed, especially related to the integration of clinical and operational data in real time, the system's ability to adapt to dynamic changes in patient conditions, optimization of service priorities, and the implementation of adaptive heuristic methods in Smart Business Intelligence systems. Therefore, this study proposes an Adaptive Smart Business Intelligence Model Based on Enhanced HGO Discovery for Real-Time Precision in Inpatient Care as an innovative approach that combines adaptive analytics, real-time heuristic optimization, and intelligent prediction mechanisms to support more precise, responsive, and efficient inpatient care.

III. Research Methodology

This research object uses a quantitative approach based on system development (system development approach) to design an Adaptive Smart Business Intelligence Model Based on Enhanced HGO Discovery for Real-Time Inpatient Care. The research process begins with the collection of clinical data and hospital operational data sourced from Electronic Health Records (EHR) and a real-time patient condition monitoring system where the total patient data used was 2,780 samples. Next, the data processing stage is carried out which includes three main components, namely Hierarchy (H), Governance (G), and Outlook (O), to support the process of data integration, information management, and adaptive analysis in improving the effectiveness of inpatient services. The implementation stages of the Enhanced HGO Discovery Framework in this study are carried out through several systematic processes in Fig. 1.

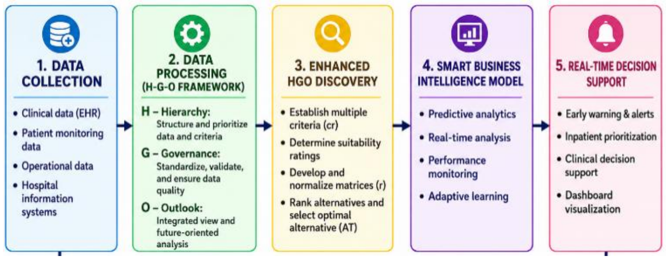

Fig. 1. Methodology framework.

The first stage involves defining multiple decision criteria (criteria/cr) that serve as the primary basis for evaluating inpatient service conditions and supporting clinical decision-making. These criteria are designed to represent important aspects of patient conditions, hospital operations, and healthcare service priorities within the Smart Business Intelligence framework.

The second stage focuses on determining the suitability rating for each alternative based on the established criteria. In this process, the evaluation values are represented through the components of Hierarchy (H) and Governance (G), which are used to classify data structures, prioritize patient conditions, and manage healthcare information systematically. This stage enables the model to identify the relevance and importance of each alternative in supporting adaptive decision-making.

The next stage involves constructing several decision matrices derived from the defined criteria. These matrices are subsequently processed using a normalization procedure based on positive and negative attribute consensus values to produce balanced and standardized data representations. The normalization process generates normalized matrix values symbolized as (*r*), which are utilized to improve analytical consistency, reduce data bias, and enhance computational efficiency in the optimization process.

Finally, the ranking and selection process is performed by calculating the weighted aggregation of the normalized matrix values. Each alternative is evaluated based on its calculated risk and performance score, where the alternative with the lowest risk value and highest optimization performance is selected as the optimal alternative (*AT*). This process enables the proposed model to support real-time adaptive decision-making in inpatient care through accurate prioritization and intelligent analytical recommendations.

IV. Result and Analysis

This study develops an Adaptive Smart Business Intelligence model based on Enhanced HGO Discovery, designed to support real-time decision-making in inpatient care services in hospitals. The proposed model integrates various hospital data sources, namely Electronic Health Records (EHR), patient monitoring data, and hospital operational data, all combined into a single adaptive Business Intelligence platform. Implementation results show that the system is capable of processing data quickly and continuously, thus supporting a more effective and accurate decision-making process in a dynamic healthcare environment.

The research phase begins with the Data Collection process, which serves as the primary foundation for developing a Smart Business Intelligence system. In this phase, various types of data are collected from several sources that serve as reference points for the hospital. The collected data includes Electronic Health Records (EHR), operational data, and information originating from the hospital. Information in the EHR includes patient health histories, medical diagnoses, treatment procedures, and medication administration history. Furthermore, this study utilizes not only clinical data but also hospital operational data, such as bed availability, patient emergencies, healthcare provider schedules, and patient queue data to support a more comprehensive and accurate decision-making process. We look at five key processes: (A) Data Collection, (B) Data Processing HGO Discovery, (C) Enhanced HGO Discovery, (D) Smart Business Intelligence Model, (E) Real Time Decision Support.

A. Data Collection

The initial stage of the research began with the Data Collection process, which serves as the primary foundation for developing an Adaptive Smart Business Intelligence system. This stage involved data collection from hospitals to generate comprehensive and accurate information. The data collected included Electronic Health Records (EHR). This study utilized 2,780 datasets, consisting of inpatient data, patient condition monitoring data, and hospital operational data collected during the study period. The characteristics of the dataset can be seen in Table I.

TABLE I. Characteristics of the Dataset

Specifications	Description
Total number of datasets	2,780
Time slot	2023-2026
Attribute of positive value	Insurance Provider, Room Class, Admission Type, Severity Score, Test Result
Attribute of negative value	Surgery

The EHR datasets utilized in this study contained a wide range of essential information regarding patient conditions, including medical histories, laboratory examination results, clinical diagnoses, treatment procedures, and medication administration records. In addition, the system collected real-time data directly from patient monitoring devices. Beyond clinical information, the research also incorporated hospital operational data, such as inpatient room capacity, bed occupancy availability, and patient queue information, to facilitate a more comprehensive and effective decision-making process.

B. Data Processing HGO Discovery

HGO Discovery is a multidimensional data processing method that integrates: priority structure (Hierarchy), control and decision rules (Governance), and strategic prediction and insight (Outlook). Table II shows implementation of HGO Discovery.

TABLE II. IMPLEMENTATION PROCESSING HGO DISCOVERY

Model	Category	Interpretation
Priority structure (Hierarchy)	Level 1	Main objective
	Level 2	Decision criteria
	Level 3	Sub-criteria
	Level 4	Decision alternatives
Control and decision rules (Governance)	Data validation	Rule-based filtering
Strategic prediction and insight (Outlook)	Prediktif	Intelligence forecasting

After an agreement is reached regarding the weight of each attribute or criterion determined by the experts, the next stage is to assign CRISP values to the data based on the previously determined hierarchy. There are six criteria (Cr) used in the assessment or decision-making process. The first criterion, Cr1 (Insurance Provider), is a benefit criterion with a weight of 0.10, meaning the better the insurance provider, the higher the score. The second criterion, Cr2 (Surgery), is a cost criterion with a weight of 0.20, so a lower score is considered better. Next, Cr3 (Room Type) has a benefit characteristic with a weight of 0.175, where a better room type gives a higher score. Cr4 (Admission Type) is also a benefit criterion with a weight of 0.125. Then, Cr5 (Severity Score) is a benefit criterion with the highest weight along with several other criteria, namely 0.20, indicating a high level of importance in the assessment. Finally, Cr6 (Test Result) is a benefit criterion with a weight of 0.20, so a better test result will increase the final score. All of these criteria's weights are used to determine the priority or overall evaluation results based on their respective levels of importance. Fig. 2 shows specification and value attributes of the characteristic dataset.

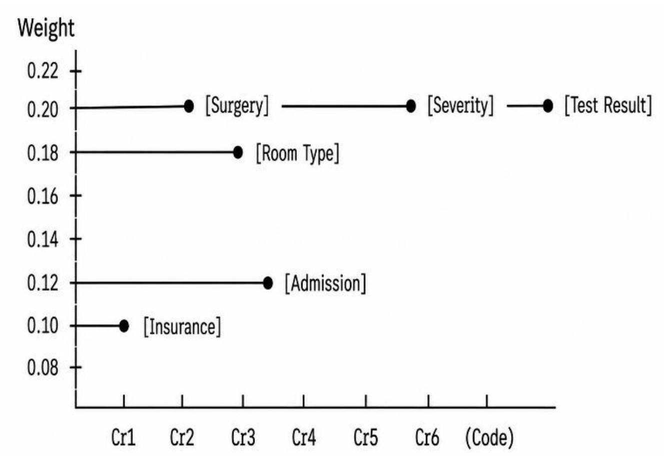

Fig. 2. Specification and value attribute.

C. Enhanced HGO Discovery

Enhanced HGO Discovery demonstrates superior performance in finding optimal solutions compared to conventional methods. Improvements to the HGO algorithm are made through the addition of optimization mechanisms and parameter adjustments to make the exploration and solution exploitation processes more efficient. Based on testing results, this method is able to provide more precise, stable, and consistent preference values in selecting the best alternative based on the criteria of Insurance Provider, Surgery, Room Type, Admission Type, Severity Score, and Test Results.

This stage also shows a faster convergence rate in the calculation process, resulting in more efficient computing time. By considering the weight and type of criteria (benefit and cost), the Enhanced HGO Discovery model successfully provides more objective evaluation results and supports more accurate decision-making, Fig. 3 shows HGO Discovery process.

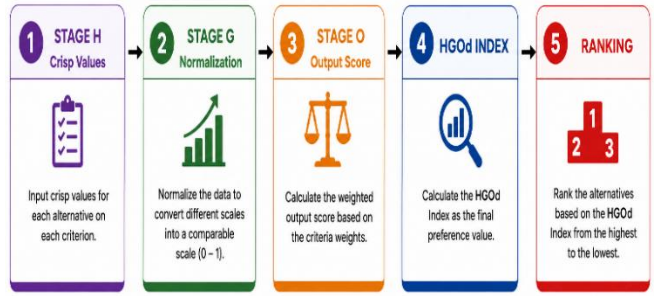

Fig. 3. HGO discovery processes.

Therefore, this model is considered effective for application in decision support systems, especially in the process of analyzing and selecting the best alternative in the healthcare sector. Table III shows the stage enhanced HGO Discovery.

TABLE III. ENHANCED HGO DISCOVERY METHOD

Stage	Description	Formula
Crisp Values	Input crisp values for each alternative on each criteria	Cr = criteria (Cr1 to Cr..n)
Normalization	Normalize the data to convert different scale into a comparable scare (0-1)	Value scale between 0 to 1
Output Score	Calculate the weighted output score based on the criteria weights.	Total weight =1.00
HGO Discovery Index	Calculate the HGO Discovery index as the final preferenced value	HGO Discovery index or HGOD Index, the highest priority value is 0.000, and the lowest priority value is 1
Ranking	Rank the alternative based on the HGO Discovery index from the higest to the lowest	Alternative are ranked from the highest to the lowest HGOD index.

The crisp data representing the criteria values contains information about each criterion and its weight. These crisp values are optional and serve as a reference limit for determining the value range for each criterion. Each crisp value has a specific weight derived from the conversion process, which is then applied to the HGO Discovery model calculations. The weighting process also influences the nature of the criteria, which are divided into two categories: positive and negative factors. Meanwhile, alternative values are used to store the evaluation results of each alternative based on all available criteria data.

Normalization attributes must be carried out so that the important process in compiling data in the stage model that occurs in HGO Discovery. Next stage is output score, where the weighted output score based on the criteria weights is calculated.

The output and HGOD Index have different scales, but each serves a different purpose in the decision support framework of this model, where the higher value output is the best value, while with the HGOD index, the lower value is better. Ranking is based on the HGOD index, where the lowest value = rank 1. This is useful for prioritizing patients based on the HGO discovery metric. Table IV shows different output score and HGOD Index.

TABLE IV. DIFFERENT OUTPUT SCORE VS HGOD INDEX

Interpretation Output	Value
Output Score (Simple Additive Weighting)	Higher output score indicates better patient condition overall. Range: 0–1. Calculated via weighted sum of normalized criteria.
HGOD Index	Lower HGOd index = higher inpatient priority. Formula: $1 / \Sigma(Wj \times Xj)$. Patients in top-left scatter quadrant need immediate attention.

D. Smart Business Intelligence Model

After patient data is collected, processed using the HGO Discovery, and analyzed using the Enhanced HGO Discovery method, the system then enters the Smart Business Intelligence stage to generate more adaptive and strategic insights.

At this stage, the system utilizes previous calculation results, such as normalization values, output scores, and the HGOd Index, to perform predictive analytics. This analysis is used to estimate patient conditions, risk levels, service priorities, and potential changes in a patient's health status during the inpatient process. With this approach, hospitals can take faster and more accurate action based on data automatically analyzed by the system.

This Smart Business Intelligence Model applies the concept of adaptive learning, which is the system's ability to adjust its analysis process based on the latest data patterns. The system can learn from previous patient data, making recommendations and prioritization more accurate over time. This adaptive approach makes the model more flexible in responding to changing patient conditions and hospital operational dynamics. The Smart Business Intelligence Model serves as the center of intelligent analysis in this study because it integrates data, Enhanced HGO Discovery, and real-time analytics to produce faster, more accurate, and more efficient decisions in inpatient care services.

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CODE	NAME	AGE	GENDER	OUTPUT	HGOD INDEX	RANK	PRIORITY
P000011	Patient A	24	Male	0.6225	0.013841	326	• Critical
P000010	Patient B	89	Female	0.6575	0.017937	2201	• Medium
P000009	Patient C	45	Female	0.6850	0.017094	1808	• Medium
P000008	Patient D	52	Male	0.5925	0.014440	549	• Critical
P000007	Patient E	63	Male	0.5125	0.016327	1487	• High
P000006	Patient F	55	Male	0.6850	0.012739	86	• Critical
P000005	Patient G	66	Male	0.5625	0.021622	3025	• Low
P000004	Patient H	66	Male	0.7000	0.016667	1626	• High
P000003	Patient I	18	Male	0.6575	0.017937	2200	• Medium

Fig. 4. Smart business intelligence output score and HGOD index.

E. Real Time Decision Support

Real-Time Decision Support is the final stage in the Adaptive Smart Business Intelligence model based on Enhanced HGO Discovery, which functions as a direct and automated decision support system in inpatient care. At this stage, all analysis results from the previous process—from data processing, Enhanced HGO Discovery calculations, to the Smart Business Intelligence Model—are used to generate fast, accurate, and adaptive decision recommendations based on real-time patient conditions.

Inpatient prioritization is used to determine the priority of inpatient services based on the HGOd Index and patient data analysis. Patients with higher risk levels receive priority treatment over lower-risk patients. This mechanism helps hospitals manage service queues, treatment room utilization, and medical resource allocation more efficiently and objectively.

This stage also supports clinical decision support, which provides data-driven recommendations to assist doctors and healthcare professionals in making medical decisions. The system can provide insights into patient severity, health condition analysis results, and prioritized action recommendations based on automatically processed data. This way, medical decisions no longer rely solely on manual observation but are also strengthened by intelligent data analysis.

Another feature is the visualization dashboard, an interactive visual display that presents patient information, priority scores, risk status, and analysis results in real time. This dashboard makes it easier for hospital management and medical personnel to quickly and comprehensively monitor patient conditions. Clear data visualization also contributes to more effective monitoring and evaluation of healthcare services. Fig. 5 show dashboard interactive visual that priority score.

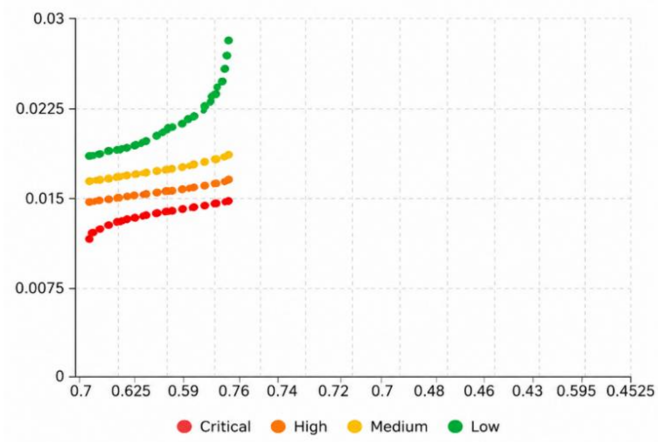

Fig. 5. Dashboard interactive visual for the priority score.

V. Conclusion

An HGO Discovery-based model supports real-time decision-making in inpatient care. The proposed model integrates data collection, the HGO Discovery model, and a Smart Business Intelligence system to generate more adaptive, accurate, and efficient analysis. Implementing this method can improve the patient evaluation process by calculating preference scores and the HGOd Index based on various criteria.

The integration of predictive analytics, real-time analysis, adaptive learning, and real-time decision support features enables the system to provide early warnings, dashboard visualizations, and automated patient service priority recommendations. Enhanced HGO Discovery has also been shown to increase the effectiveness of the solution exploration and exploitation process compared to conventional methods, resulting in more stable and consistent decisions. Thus, this research provides an important contribution to the development of a modern healthcare business intelligence system that can improve hospital service quality, operational efficiency, and rapid response to inpatient conditions dynamically and in real-time.

For further research, it is hoped that the Adaptive Smart Business Intelligence model based on Enhanced HGO Discovery can be developed by adding more variables and more complex health data sources, such as electronic health records (EHRs), health IoT sensor data, and continuous patient monitoring data. Further development can also be done by integrating machine learning and deep learning technologies so that the system can produce more accurate patient condition predictions and adapt to real-time data changes. In addition, further research is expected to test this model on a larger hospital scale and different health environments to determine the level of effectiveness, stability, and flexibility of the system in real conditions.

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