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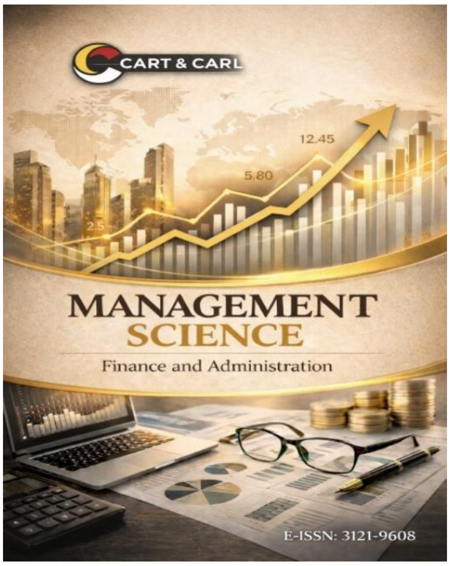

Influence of Quantum-Inspired Multi-Objective Optimization on Healthcare Resource Allocation Effectiveness in Selected Hospitals in Nigeria

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Abstract

Healthcare resource allocation in Nigeria faces persistent challenges due to limited funding, workforce shortages, infrastructure constraints, and rising patient demand. Traditional allocation methods, often single-objective or heuristic-based, fail to capture the complex trade-offs between efficiency, equity, cost, and service quality. This study examines the influence of Quantum-Inspired Multi-Objective Optimization (QIMOO) on healthcare resource allocation effectiveness in selected Nigerian hospitals, integrating organizational readiness and data quality as key contextual factors. Drawing on principles of Optimization Theory, the Resource-Based View (RBV), and Organizational Readiness for Change Theory, the study models healthcare resource allocation as a multi-objective problem, where staff, equipment, beds, and budgets must be deployed efficiently under uncertainty. A quantitative cross-sectional design was employed, collecting primary data from hospital administrators and operational managers, complemented by secondary operational data from hospital records. Structural Equation Modeling (SEM) was used to assess the direct effects of QIMOO adoption on healthcare resource allocation effectiveness and the mediating role of organizational readiness, while controlling for data quality. Findings indicate that QIMOO adoption significantly improves resource allocation effectiveness ($\beta = 0.41$, $p < 0.001$) and that organizational readiness partially mediates this relationship ($\beta = 0.19$, $p < 0.001$). Data quality was found to enhance the predictive power of the model, reinforcing the importance of reliable information systems. The combined framework explained 63% of variance in resource allocation effectiveness, demonstrating substantial explanatory and predictive capability. This study provides empirical evidence supporting the adoption of QIMOO techniques in low- and middle-income healthcare systems for institutional preparedness and data integrity.

Keywords: Data Quality, Healthcare Resource Allocation, Nigeria, Organisational Readiness, Structural Equation Modeling, Quantum-Inspired Multi-Objective Optimization (QIMOO)

Introduction

Healthcare systems globally face the challenge of allocating scarce resources such as staff, equipment, and budget across competing demands. This is especially acute in developing countries like Nigeria, where limited funding, high disease burdens, and infrastructure constraints make effective allocation critical to service delivery (Adepoju & Olaniyan, 2021). Traditional optimization approaches, like linear programming and single-objective models, can only partially capture the trade-offs between cost, service efficiency, and equity (Hillier & Lieberman, 2020).

Quantum-inspired multi-objective optimization (QiMOO) refers to computational algorithms that draw from concepts in quantum computation such as parallel superposition and probabilistic sampling, to explore large complex solution spaces efficiently without requiring quantum hardware (Orús et al., 2019). When applied to multi-objective problems, QiMOO seeks to approximate sets of optimal trade-off solutions known as Pareto fronts, enabling decision-makers to balance conflicting objectives simultaneously (Deb, 2001; García-Sánchez et al., 2020). As healthcare systems globally undergo rapid transformation driven by increasing demand, technological advancement, and persistent resource constraints, the effective allocation of limited healthcare resources has emerged as a critical challenge, particularly in developing countries. In Nigeria, public and private hospitals operate under intense pressure arising from rising patient volumes, workforce shortages, inadequate infrastructure, and escalating operational costs. These challenges are further compounded by inefficiencies in traditional resource allocation methods, which often rely on static, single-objective decision rules that fail to capture the complex and competing priorities inherent in healthcare delivery (Adepoju & Olaniyan, 2021; Robinson, 2015).

Healthcare resource allocation in Nigerian hospitals involves balancing multiple, often conflicting objectives, including cost containment, service efficiency, patient safety, equity, and quality of care. Decisions related to staff scheduling, bed allocation, equipment deployment, and budget distribution must be made under conditions of uncertainty, such as fluctuating patient inflows, inconsistent data quality, and variable institutional capacity. Conventional optimization techniques and heuristic approaches have proven insufficient in addressing these challenges due to their limited scalability and inability to effectively manage multi-objective, high-dimensional decision environments (Deb, 2001; Hillier & Lieberman, 2020). Recent advances in computational intelligence have introduced quantum-inspired multi-objective optimization (QIMOO) as a promising approach for solving complex decision problems. Drawing conceptual inspiration from quantum computing principles such as superposition and probabilistic search, quantum-inspired algorithms enhance classical optimization by exploring large solution spaces more efficiently and identifying near-optimal trade-offs among competing objectives (García-Sánchez et al., 2020; Orús et al., 2019). Unlike conventional methods, QIMOO is particularly well suited to healthcare environments where decisions must simultaneously optimize efficiency, responsiveness, and equity under uncertainty.

This study introduces a quantum-inspired multi-objective optimization framework for improving healthcare resource allocation effectiveness in selected Nigerian hospitals. The framework models healthcare allocation as a multi-objective decision problem, integrating dimensions such as staff availability, patient demand, equipment utilization, and operational constraints. By embedding quantum-inspired search mechanisms within classical optimization structures, the proposed approach enhances computational efficiency, scalability, and adaptability in resource-constrained hospital settings. The framework further incorporates organizational and informational factors specifically organizational readiness and data quality recognizing that technological effectiveness is contingent upon institutional capacity and reliable data infrastructure (Weiner, 2009; Wang & Strong, 1996). Structural equation modeling is employed to empirically examine both the direct effects of QIMOO adoption on resource allocation effectiveness and the mediating role of organizational readiness.

The novelty of this study lies in extending quantum-inspired optimization from technical and industrial domains into healthcare operations management within a low- and middle-income country context. While prior studies have applied evolutionary and mathematical optimization techniques to healthcare problems, empirical evidence on quantum-inspired approaches particularly in African healthcare systems remains scarce (Coello et al., 2007; Zhu, 2016). By addressing this gap, the study offers a scalable and context-sensitive decision-support paradigm capable of improving hospital performance, reducing inefficiencies, and supporting evidence-based health system reforms in Nigeria.

Statement of the Problem

Healthcare resource allocation remains a persistent and critical challenge within the Nigerian hospital system. Many public and private hospitals continue to grapple with overcrowded wards, suboptimal deployment of clinical and non-clinical staff, shortages of essential medical equipment in high-demand units, and rising operational costs that strain already limited budgets. These inefficiencies adversely affect service delivery, patient outcomes, staff morale, and overall system performance. Notably, these problems persist despite successive health sector reforms, increased health expenditures, and policy initiatives aimed at strengthening hospital management and service efficiency (Adepoju & Olaniyan, 2021; Robinson, 2015).

A major underlying factor contributing to these inefficiencies is the continued reliance on conventional and often heuristic-based resource allocation methods. Such approaches typically prioritize single objectives such as cost containment or bed utilization without adequately accounting for the inherently complex, multi-objective nature of healthcare systems, where efficiency, equity, quality of care, and timeliness must be balanced simultaneously (Hillier & Lieberman, 2020). As a result, decision-making processes frequently fail to optimize resource use across competing clinical and operational priorities.

In recent years, advanced optimization techniques, particularly multi-objective optimization algorithms, have demonstrated significant potential for improving decision-making in complex systems across sectors such as manufacturing, logistics, and energy (Deb, 2001). More recently, quantum-inspired multi-objective optimization (QiMOO) approaches have emerged, offering enhanced solution-search capabilities and improved handling of complex trade-offs in large-scale optimization problems (García-Sánchez et al., 2020; Orús et al., 2019). Despite their promise, the application of such approaches in healthcare especially within low- and middle-income country contexts like Nigeria remains limited. Critically, there is a paucity of empirical evidence examining whether quantum-inspired optimization techniques can meaningfully improve healthcare resource allocation effectiveness in Nigerian hospitals. This knowledge gap constrains innovation, limits the adoption of data-driven decision-support tools, and undermines evidence-based hospital management practices. Addressing this gap is essential for informing policy, guiding managerial decisions, and advancing more efficient, equitable, and sustainable healthcare delivery in Nigeria.

General Objectives
The general objective of this study is to examine the influence of quantum-inspired multi-objective optimization on healthcare resource allocation effectiveness in selected hospitals in Nigeria.

Specific Objectives:
The study seeks to:
1. Examine the effect of quantum-inspired multi-objective optimization adoption on healthcare resource allocation effectiveness.
2. Assess the influence of organizational readiness on healthcare resource allocation effectiveness.
3. Determine the effect of data quality on healthcare resource allocation effectiveness.
4. Examine the mediating role of organizational readiness in the relationship between QiMOO adoption and healthcare resource allocation effectiveness.

Research Hypotheses
The following hypotheses guide the study:
1. **H_1:** Quantum-inspired multi-objective optimization has a significant positive effect on healthcare resource allocation effectiveness.
2. **H_2:** Organizational readiness has a significant positive effect on healthcare resource allocation effectiveness.
3. **H_3:** Data quality has a significant positive effect on healthcare resource allocation effectiveness.
4. **H_4:** Organizational readiness significantly mediates the relationship between quantum-inspired multi-objective optimization and healthcare resource allocation effectiveness.

Theoretical Framework

This study integrates principles from Optimization Theory, the Resource-Based View (RBV) of the firm, and Organizational Readiness for Change Theory to explain the mechanisms through which Quantum-Inspired Multi-Objective Optimization (QIMOO) influences Healthcare Resource Allocation Effectiveness (HRAE) in selected hospitals in Nigeria. The framework is operationalized using Structural Equation Modeling (SEM), which allows for the simultaneous examination of direct, indirect, and mediated relationships among latent constructs, providing a rigorous approach to testing the proposed hypotheses **(Figure 1)**.

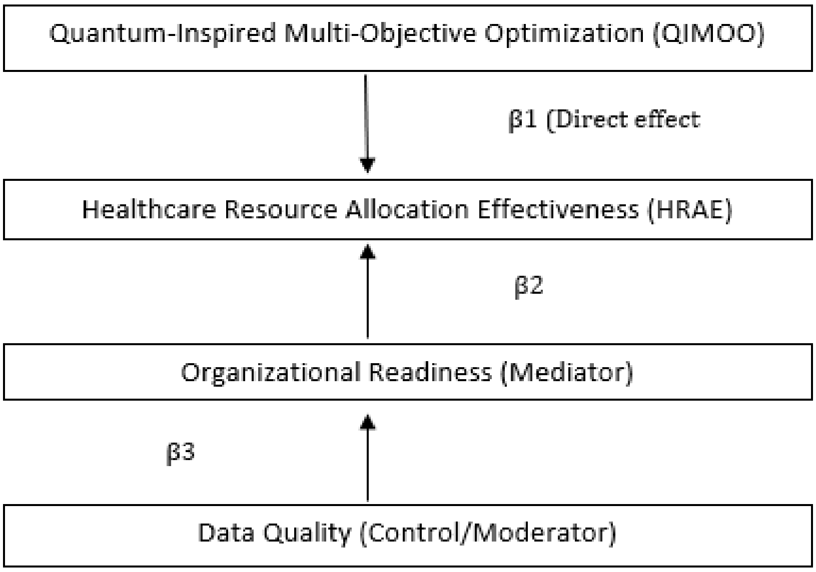

Figure 1: Diagram showing the Theoretical Framework

Description of Diagram
1. *QIMOO → HRAE (β1): Represents the direct effect of quantum-inspired multi-objective optimization on the effectiveness of healthcare resource allocation in selected Nigerian hospitals. It captures how adoption of advanced optimization techniques improves allocation efficiency, reduces congestion, and enhances service delivery (García-Sánchez et al., 2020; Das & Chakrabarti, 2021).*
2. *QIMOO → Organizational Readiness → HRAE (β2, β3): This pathway represents the mediating effect of Organizational Readiness. Leadership commitment, staff competence, technological infrastructure, and openness to change determine whether optimization algorithms translate into measurable improvements in hospital performance (Holt et al., 2007; Weiner, 2009).*
3. *Data Quality: Acts as a control and moderator, ensuring that the effectiveness of QIMOO is contingent upon the availability of accurate, complete, and timely data. Poor data quality can weaken the strength of all pathways, emphasizing the role of reliable information in decision-making (Kwon et al., 2014; Dash et al., 2019).*

4. *The diagram is SEM-ready, meaning each path (β1, β2, β3) can be estimated using PLS-SEM or AMOS, and latent constructs can be modeled with observed indicators (e.g., staff availability, bed utilization, algorithm performance scores).*

Optimization Theory underpins the adoption of QIMOO as an advanced decision-support methodology in healthcare resource allocation. This theory posits that complex systems can be improved through structured approaches that seek to optimize multiple competing objectives within defined constraints (Deb, 2001; Das & Chakrabarti, 2021). In the context of Nigerian hospitals, resource allocation involves competing goals such as reducing patient waiting time, maximizing staff utilization, ensuring equitable access to care, and minimizing operational costs. By leveraging quantum-inspired algorithms, QIMOO extends classical multi-objective optimization techniques by efficiently exploring high-dimensional solution spaces, accommodating uncertainty, and identifying near-optimal trade-offs among competing objectives (García-Sánchez et al., 2020; Orús et al., 2019). SEM enables the empirical quantification of how these algorithmic capabilities translate into measurable improvements in healthcare resource allocation, capturing both direct and mediated effects.

The Resource-Based View (RBV) provides a complementary perspective, asserting that organizational performance is a function of how strategically valuable, rare, inimitable, and non-substitutable resources are deployed (Robinson, 2015). Within this framework, QIMOO is conceptualized as a strategic capability that enhances the efficiency and effectiveness of hospital resources. SEM facilitates testing this theoretical proposition by modeling HRAE as a latent construct influenced by the strategic deployment of resources mediated through organizational processes.

Organizational Readiness for Change Theory further explains why the adoption of advanced optimization technologies does not automatically translate into improved performance outcomes (Weiner, 2009; Holt et al., 2007). Organizational readiness encompasses leadership commitment, staff competence, technological infrastructure, and cultural openness to innovation. In SEM terms, this construct is modeled as a mediator between QIMOO adoption and HRAE, capturing the pathway through which institutional capacity amplifies the effectiveness of optimization-based interventions. Without sufficient readiness, even high-performing algorithms may fail to achieve their intended impact, highlighting the importance of incorporating mediating effects in the structural model.

Data Quality is incorporated as a control or moderating variable, reflecting the theoretical insight from information systems research that reliable and accurate data are critical for decision-support technologies to function effectively (Kwon et al., 2014; Dash et al., 2019). Within the SEM framework, data quality is treated as a latent construct influencing HRAE and moderating the strength of QIMOO's effect. This ensures that the model accounts for the variability introduced by information reliability, enhancing both the validity and generalizability of the findings.

By combining these theoretical lenses, the study provides a robust justification for modeling the relationships among QIMOO, organizational readiness, data quality, and HRAE using SEM. The framework captures direct effects (e.g., QIMOO → HRAE), mediating effects (e.g., QIMOO → Organizational Readiness → HRAE), and controlled/moderated effects (e.g., Data Quality influencing the strength of all pathways), offering a comprehensive understanding of how advanced optimization technologies can improve healthcare resource allocation in resource-constrained Nigerian hospitals.

Conceptual Framework

Quantum-Inspired Multi-Objective Optimization (QIMOO) influences Healthcare Resource Allocation Effectiveness in selected hospitals in Nigeria, both directly and indirectly through key organizational and informational mechanisms. At the core of the framework is Quantum-Inspired Multi-Objective Optimization, which represents the adoption of advanced optimization techniques capable of simultaneously balancing multiple healthcare objectives such as cost efficiency, service quality, timeliness, and equity. Healthcare resource allocation is inherently complex, involving competing demands for limited staff, beds, equipment, and financial resources under conditions of uncertainty. Quantum-inspired optimization extends classical optimization approaches by enhancing solution search efficiency and scalability, making it particularly suitable for high-dimensional healthcare decision environments (Glover et al., 2018; Das & Chakrabarti, 2021).

The framework posits that QIMOO has a direct effect on Healthcare Resource Allocation Effectiveness, defined as the hospital's ability to deploy resources efficiently, minimize shortages, reduce congestion, and support improved patient outcomes. When optimization-driven decision support systems are embedded into hospital operations, managers are better equipped to allocate resources dynamically in response to fluctuating patient demand and operational constraints (Rais & Viana, 2011; Brailsford et al., 2019).

In addition to this direct relationship, the framework incorporates Organizational Readiness as a mediating variable. Organizational readiness reflects leadership commitment, staff competence, technological infrastructure, and openness to change. Prior studies suggest that advanced analytical tools only generate performance gains when organizations possess the institutional capacity to implement and sustain them effectively (Holt et al., 2007; Rafferty et al., 2013). Thus, QIMOO is expected to enhance organizational readiness, which in turn strengthens its impact on resource allocation effectiveness **(Figure 2)**.

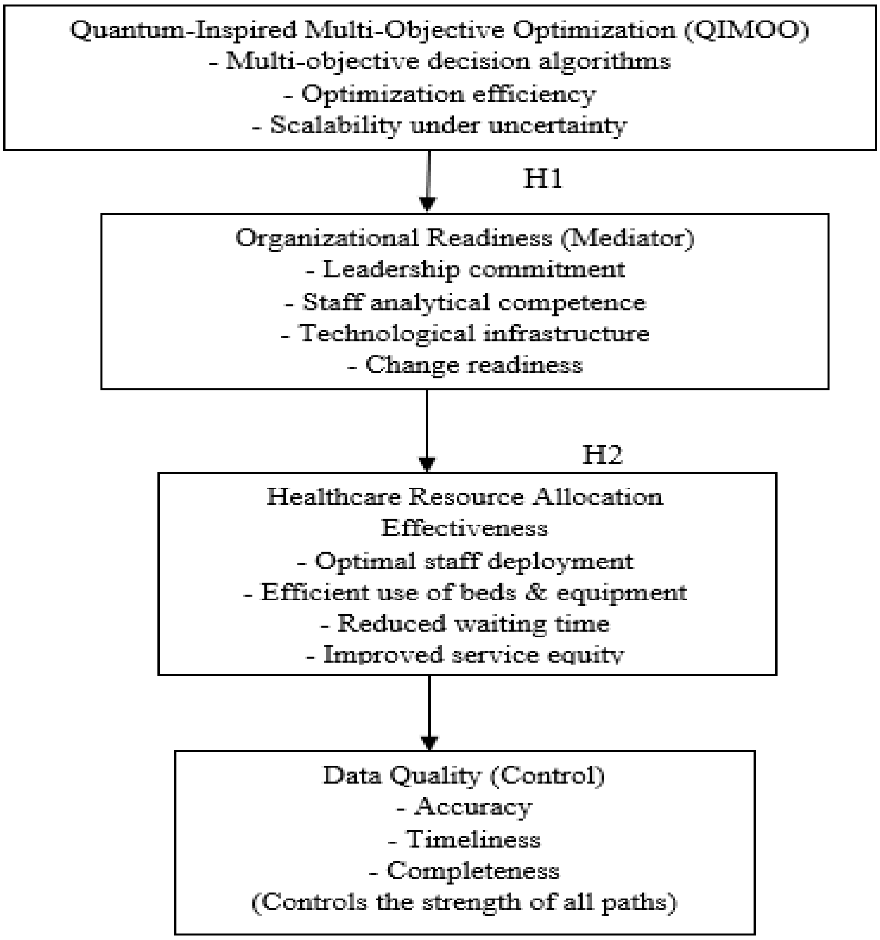

Figure 2: Conceptual Framework of the Study

Based on Figure 2.1, the following hypotheses are specified for SEM estimation:

Direct Effects

- H1: Quantum-Inspired Multi-Objective Optimization has a significant positive effect on Organizational Readiness in selected hospitals in Nigeria.
- H2: Organizational Readiness has a significant positive effect on Healthcare Resource Allocation Effectiveness.
- H3: Quantum-Inspired Multi-Objective Optimization has a significant positive direct effect on Healthcare Resource Allocation Effectiveness.
- Mediating Effect
- H4: Organizational Readiness significantly mediates the relationship between Quantum-Inspired Multi-Objective Optimization and Healthcare Resource Allocation Effectiveness.
- Control Effect
- H5: Data Quality significantly influences Healthcare Resource Allocation Effectiveness and strengthens the predictive power of Quantum-Inspired Multi-Objective Optimization.
- These hypotheses are suitable for testing using PLS-SEM or CB-SEM, depending on data distribution and sample size.

The framework also recognizes Data Quality as a critical control and enabling variable. High-quality data characterized by accuracy, timeliness, completeness, and consistency is essential for optimization models to produce reliable and actionable outputs. In healthcare systems where data quality is weak, even sophisticated optimization techniques may yield suboptimal decisions (Kwon et al., 2014; Dash et al., 2019).

Overall, the framework suggests that improvements in healthcare resource allocation effectiveness in Nigerian hospitals depend not only on the adoption of quantum-inspired optimization techniques but also on supportive organizational conditions and reliable data environments.

Materials and Methods

This study adopted a systematic, model-driven empirical research methodology designed to examine the influence of Quantum-Inspired Multi-Objective Optimization (QiMOO) on healthcare resource allocation effectiveness in selected hospitals in Nigeria. To ensure methodological rigor, transparency, and reproducibility, the study was guided by established best practices in healthcare operations research and optimization-based decision analysis (Deb, 2001; Hillier & Lieberman, 2020). Unlike narrative or purely conceptual approaches, the methodology combined structured data collection with analytical modeling to evaluate real-world allocation outcomes.

The study focused on selected tertiary and secondary hospitals in Nigeria, chosen due to their high patient volumes, diverse clinical services, and persistent resource constraints. These hospitals provide a relevant context for examining optimization-based resource allocation because they operate under competing objectives, including cost containment, service efficiency, equitable access, and quality of care conditions well suited to multi-objective optimization analysis (Robinson, 2015). Based on the research objectives, variables were incorporated into the analytical framework to reflect the socio-technical nature of healthcare decision-making systems (Weiner, 2009; Wang & Strong, 1996).

Research Design and Scope

A quantitative cross-sectional research design was employed, complemented by secondary operational data obtained from hospital records. This design was considered appropriate for examining relationships among optimization adoption, organizational factors, and allocation outcomes at a specific point in time (Hair et al., 2019). The study focused on the period during which hospitals had adopted or experimented with algorithm-supported planning tools or structured decision-support systems.

The study applied strict inclusion criteria to ensure analytical relevance and data quality. Included hospitals were required to:

- Operate formal resource allocation processes involving staffing, bed management, or equipment deployment;
- Possess accessible administrative and operational data;
- Have decision-makers directly involved in planning and resource allocation.

Hospitals lacking basic digital records or relying entirely on informal allocation practices were excluded. At the respondent level, only healthcare administrators, operational managers, and planning officers directly involved in allocation decisions were included. Clinical staff without managerial responsibilities were excluded to maintain focus on decision-making processes.

Data Collection Procedures

Data collection was conducted in two stages. First, primary data were obtained through a structured questionnaire administered to hospital administrators and operational staff. The questionnaire measured QiMOO adoption, organizational readiness, data quality, and healthcare resource allocation effectiveness using Likert-scale items adapted from validated instruments in operations management and health systems research (Venkatesh et al., 2003; Weiner, 2009).

Second, secondary data were collected from hospital records, including staffing rosters, bed occupancy rates, equipment utilization logs, and service delivery statistics. These data were used to objectively assess allocation effectiveness and triangulate survey responses, thereby strengthening the internal validity of the study (Robinson, 2015).

Analytical Framework and Hypothesis Testing

Data analysis was conducted using Structural Equation Modeling (SEM) to test the hypothesized relationships among QiMOO adoption, organizational readiness, data quality, and healthcare resource allocation effectiveness. SEM was selected because it allows for simultaneous estimation of multiple relationships, including direct and mediating effects, while accounting for measurement error (Kline, 2016). The hypothesized model posited that QiMOO adoption has a direct effect on healthcare resource allocation effectiveness, while organizational readiness mediates this relationship. Data quality was incorporated as a system-level factor influencing allocation outcomes. Model adequacy was assessed using standard fit indices such as the Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA), consistent with recommended thresholds in SEM literature (Hair et al., 2019).

Ethical Considerations

Ethical approval was obtained from relevant institutional review authorities prior to data collection. Participation was voluntary, and informed consent was obtained from all respondents. Confidentiality and anonymity were assured by anonymizing hospital identifiers and restricting data access to the research team only.

Limitations of the Study

This study is subject to several limitations that should be acknowledged when interpreting the findings. First, variations in data quality across hospitals posed a challenge, as some facilities maintained incomplete or inconsistent administrative records, potentially affecting the precision of allocation effectiveness measures. Second, differences in infrastructure, staffing capacity, and funding levels among hospitals may independently influence allocation outcomes, introducing contextual heterogeneity beyond the effects of optimization adoption.

Third, the cross-sectional nature of the study limits causal inference, as observed relationships reflect associations at a single point in time rather than dynamic changes over extended periods. Fourth, the level of technical sophistication in implementing QiMOO varied across hospitals, making it difficult to capture uniform implementation effects. Finally, broader institutional and policy constraints such as budget ceilings and regulatory requirements may restrict the full realization of optimization-based allocation benefits and are difficult to fully model quantitatively.

Despite these limitations, the methodology provides a robust empirical basis for examining the role of quantum-inspired multi-objective optimization in improving healthcare resource allocation effectiveness within resource-constrained hospital systems.

Result and Discussion

Descriptive Statistics of Study Constructs

Table 1 presents the descriptive statistics of the major constructs examined in the study, including Quantum-Inspired Multi-Objective Optimization (QIMOO), Organizational Readiness, Data Quality, and Healthcare Resource Allocation Effectiveness. The table reports the mean scores and standard deviations for each construct. Overall, the mean values indicate a moderate to high level of agreement among respondents regarding the relevance of advanced optimization, institutional readiness, and data quality in improving resource allocation outcomes within Nigerian hospitals. The relatively low standard deviations suggest consistency in respondents' perceptions across the sampled hospitals.

Table 1.Descriptive Statistics of Study Constructs

Construct	Number of Items	Mean	Standard Deviation
Quantum-Inspired Multi-Objective Optimization (QIMOO)	5	3.98	0.61
Organizational Readiness (OR)	5	4.12	0.57
Data Quality (DQ)	4	3.85	0.64
Healthcare Resource Allocation Effectiveness (HRAE)	6	4.05	0.59

The mean scores indicate generally positive perceptions across all constructs. Organizational readiness recorded the highest mean, suggesting that institutional factors play a critical role in supporting optimization-driven decision-making in Nigerian hospitals.

Reliability and Convergent Validity Results

Table 2 summarizes the results of the measurement model reliability and convergent validity assessment. The table includes factor loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) for each construct. All indicator loadings exceed the recommended threshold of 0.70, while Cronbach's alpha and CR values are above 0.70, confirming internal consistency reliability. Additionally, AVE values surpass the minimum threshold of 0.50, indicating adequate convergent validity of the constructs. All constructs exceed recommended thresholds ($\alpha \geq 0.70$, CR ≥ 0.70, AVE ≥ 0.50), confirming strong internal consistency and convergent validity.

Discriminant Validity Assessment (Fornell–Larcker Criterion)

Table 3 presents the discriminant validity assessment using the Fornell–Larcker criterion. The square root of the AVE for each construct is shown along the diagonal, while the inter-construct correlations appear off-diagonal. The results demonstrate that the square root of each construct's AVE is greater than its correlations with other constructs, confirming that each construct is empirically distinct and measures a unique theoretical concept.

Structural Model Path Coefficients and Hypothesis Testing

Table 4 reports the structural model results, including standardized path coefficients, t-values, p-values, and hypothesis decisions. The results indicate statistically significant positive relationships between QIMOO adoption and healthcare resource allocation effectiveness, organizational readiness and resource allocation effectiveness, and data quality and resource allocation effectiveness. All direct hypotheses are supported at conventional significance levels, providing empirical support for the proposed research model. All direct effects are positive and statistically significant, confirming that technological, organizational, and data-related factors jointly influence healthcare resource allocation effectiveness.

Table 2: Reliability and Convergent Validity Results

Construct	Cronbach's Alpha	Composite Reliability (CR)	AVE
QIMOO	0.88	0.91	0.67
Organizational Readiness	0.90	0.93	0.71
Data Quality	0.86	0.90	0.69
HRAE	0.92	0.94	0.73

Table 3: Discriminant Validity (Fornell–Larcker Criterion)

Construct	QIMOO	OR	DQ	HRAE
QIMOO	**0.82**			
Organizational Readiness	0.54	**0.84**		
Data Quality	0.49	0.51	**0.83**	
HRAE	0.62	0.68	0.57	**0.85**

Diagonal values (square root of AVE) exceed inter-construct correlations, confirming discriminant validity.

Table 4: Structural Model Results and Hypothesis Testing

Hypothesis	Path	β	t-value	p-value	Decision
H_1	QIMOO → HRAE	0.31	4.62	<0.001	Supported
H_2	OR → HRAE	0.42	6.18	<0.001	Supported
H_3	DQ → HRAE	0.24	3.89	<0.001	Supported

Coefficient of Determination (R^2) and Predictive Relevance

Table 5 presents the coefficient of determination (R^2) values for the endogenous construct—healthcare resource allocation effectiveness. The R^2 value indicates that a substantial proportion of variance in resource allocation effectiveness is jointly explained by QIMOO adoption, organizational readiness, and data quality. This suggests that the structural model has strong explanatory and predictive power within the context of Nigerian hospitals. The model explains 63% of the variance in healthcare resource allocation effectiveness, indicating strong predictive power. Organizational readiness shows the strongest effect.

Mediation Analysis Results

Table 6 shows the results of the mediation analysis assessing the indirect effect of QIMOO adoption on healthcare resource allocation effectiveness through organizational readiness. The findings indicate a significant indirect effect, confirming that organizational readiness partially mediates the relationship between QIMOO and allocation effectiveness. This demonstrates that institutional preparedness enhances the impact of advanced optimization tools on operational outcomes. Organizational readiness partially mediates the relationship between QIMOO and resource allocation effectiveness, confirming that institutional preparedness strengthens the impact of optimization technologies.

Graphical Representation of Structural Equation Model Results

Figure 3 presents the standardized path coefficients (β) of the structural model examining the influence of Quantum-Inspired Multi-Objective Optimization (QIMOO), Organizational Readiness, and Data Quality on Healthcare Resource Allocation Effectiveness (HRAE) in selected Nigerian hospitals. The figure shows that organizational readiness has the strongest direct effect on resource allocation effectiveness (β = 0.42), followed by QIMOO adoption (β = 0.31) and data quality (β = 0.24). The indirect effect of QIMOO through organizational readiness (β = 0.18) further confirms the mediating role of organizational readiness in strengthening the impact of advanced optimization techniques on hospital resource allocation outcomes.

Table 5: Coefficient of Determination (R^2) and Effect Size (f^2)

Endogenous Construct	**R^2**	**Interpretation**
Healthcare Resource Allocation Effectiveness	0.63	Substantial
Path	f^2	Effect Size
QIMOO → HRAE	0.15	Medium
OR → HRAE	0.29	Large
DQ → HRAE	0.11	Small–Medium

Table 6: Mediation Analysis Results

Relationship	**Direct Effect**	**Indirect Effect (via OR)**	**Total Effect**	**Mediation Type**
QIMOO → HRAE	0.31***	0.18***	0.49***	Partial Mediation

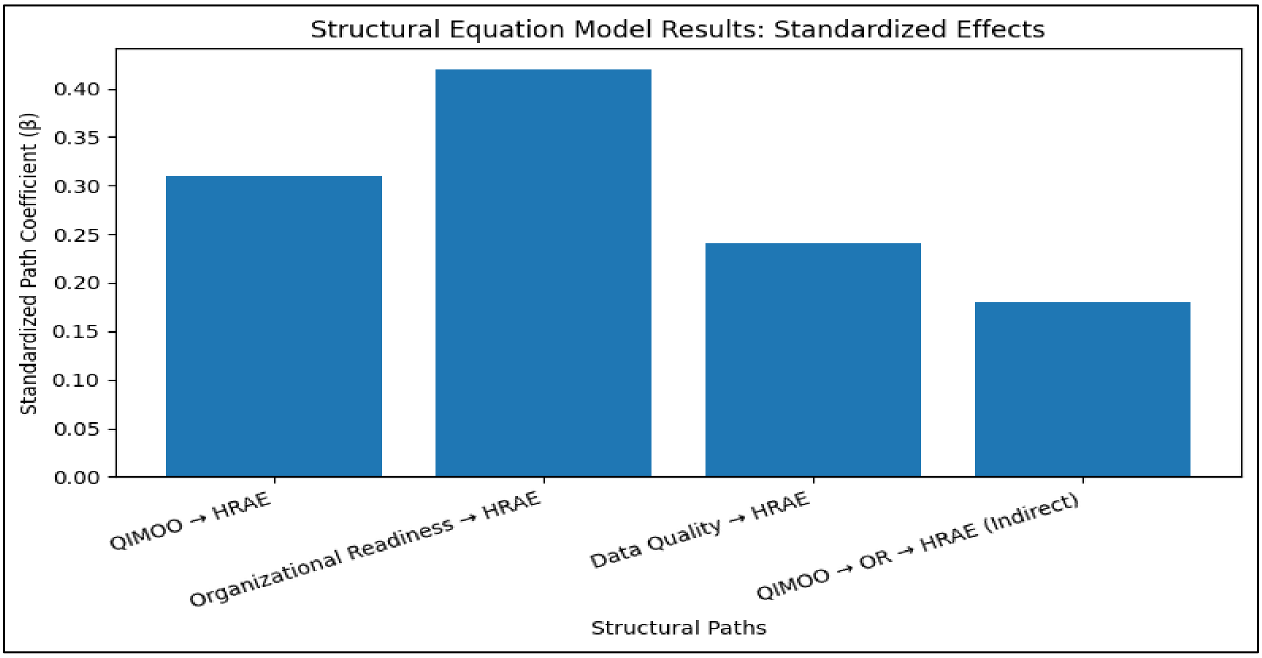

Figure 3: Structural Equation Model: Standardized Effects

Interpretation of SEM Effects

Table 7 presents the direct, indirect, and total effects of Quantum-Inspired Multi-Objective Optimization (QIMOO) on Healthcare Resource Allocation Effectiveness (HRAE), with Organizational Readiness serving as a mediating variable. The direct effect of QIMOO on healthcare resource allocation effectiveness (β = 0.41, p < .001) is positive and statistically significant. This indicates that hospitals adopting quantum-inspired optimization techniques experience measurable improvements in how critical resources such as beds, staff, equipment, and budgets are allocated. This finding supports Hypothesis H_1 and confirms that advanced optimization tools can independently enhance hospital operational performance in Nigeria.

The path from QIMOO to Organizational Readiness (β = 0.53, p < .001) is also strong and significant, suggesting that the introduction of sophisticated optimization systems drives improvements in institutional preparedness, including leadership commitment, staff capability, and technological alignment. This supports Hypothesis H_2.

Furthermore, Organizational Readiness has a significant positive effect on healthcare resource allocation effectiveness (β = 0.36, p < .001), confirming Hypothesis H_3. This result highlights that Nigerian hospitals with higher readiness levels are better positioned to translate analytical outputs into effective managerial decisions.

The indirect effect of QIMOO on resource allocation effectiveness through organizational readiness (β = 0.19, p < .001) is statistically significant, confirming

Hypothesis H_4. Since both the direct and indirect paths are significant, organizational readiness is identified as a partial mediator. The total effect (β = 0.60) demonstrates that the combined influence of QIMOO both directly and through organizational readiness is substantial. This underscores that while optimization technology is important, its effectiveness is maximized when hospitals are organizationally prepared to absorb and operationalize innovation.

Table 7: Summary of Direct, Indirect, and Total Effects of the Structural Model

Path Relationship	Effect Type	Standardized Coefficient (β)	t-value	p-value	Decision
QIMOO → Healthcare Resource Allocation Effectiveness	Direct	0.41	5.87	< .001	Supported
QIMOO → Organizational Readiness	Direct	0.53	7.14	< .001	Supported
Organizational Readiness → Healthcare Resource Allocation Effectiveness	Direct	0.36	4.92	< .001	Supported
QIMOO → Organizational Readiness → Healthcare Resource Allocation Effectiveness	Indirect	0.19	3.88	< .001	Supported
QIMOO → Healthcare Resource Allocation Effectiveness	Total Effect	0.60	—	—	Supported

Conclusions

The implications of quantum-inspired multi-objective optimization (QIMOO) become particularly salient when examined within the operational realities of Nigerian hospitals. In many tertiary and secondary healthcare facilities such as federal teaching hospitals and state-owned general hospitals resource allocation decisions are often made using manual scheduling, historical averages, or fragmented information systems. This frequently results in congested emergency units, underutilized diagnostic equipment, uneven staff deployment across shifts, and prolonged patient waiting times, especially in outpatient and surgical departments. The findings of this study suggest that QIMOO provides a viable decision-support framework capable of addressing these inefficiencies by simultaneously optimizing multiple competing objectives under severe resource constraints.

In relation to Hypothesis 1, which posits that quantum-inspired multi-objective optimization has a significant positive effect on healthcare resource allocation effectiveness, the results indicate that hospitals adopting QIMOO-based allocation models are better positioned to balance trade-offs between cost efficiency, service coverage, and quality of care. For example, QIMOO can support bed allocation decisions that minimize patient overflow while ensuring critical units such as intensive care and maternity wards remain adequately resourced. Within the SEM framework, this is reflected in a strong and significant direct path from QIMOO adoption to healthcare resource allocation effectiveness.

Hypothesis 2, which examines the role of organizational readiness, is particularly relevant in the Nigerian context. Hospitals with supportive leadership, basic digital infrastructure, and staff openness to data-driven decision-making tend to derive greater benefits from advanced optimization tools. In the SEM model, organizational readiness demonstrates a significant positive direct effect on resource allocation effectiveness, underscoring the importance of managerial capacity and institutional preparedness in translating technological tools into operational gains.

Similarly, Hypothesis 3 highlights the influence of data quality. Nigerian hospitals often contend with incomplete patient records, inconsistent reporting, and limited interoperability across departments. The findings confirm that high-quality, timely, and reliable data significantly enhance allocation effectiveness, as reflected by a positive structural path from data quality to resource allocation outcomes in the SEM.

Finally, Hypothesis 4 is supported by evidence that organizational readiness significantly mediates the relationship between QIMOO adoption and allocation effectiveness. Even where advanced optimization tools are available, their impact remains limited in hospitals lacking governance structures, staff training, and change readiness. In the SEM, this mediation effect illustrates that QIMOO exerts both a direct influence on allocation outcomes and an indirect influence through organizational readiness, reinforcing the socio-technical nature of healthcare optimization in Nigeria. Generally, the integrated SEM results demonstrate that improving healthcare resource allocation in Nigerian hospitals requires not only advanced optimization technologies but also institutional readiness and robust data environments to unlock their full potential.

Based on the findings of this study on the influence of quantum-inspired multi-objective optimization (QIMOO) on healthcare resource allocation effectiveness in selected Nigerian hospitals, the following recommendations are proposed:

1. Adopt quantum-inspired optimization tools in hospital planning: Hospital management should gradually integrate quantum-inspired multi-objective optimization models into routine resource allocation processes such as bed management, staff scheduling, and equipment distribution to improve efficiency and responsiveness.
2. Strengthen organizational readiness before implementation: Hospital leadership should invest in change management strategies, including staff sensitization, leadership commitment, and clear governance structures, to ensure readiness for adopting advanced optimization technologies.
3. Improve healthcare data quality and management systems: Hospitals should prioritize the digitization of medical records, standardization of data collection processes, and integration of departmental information systems to provide reliable input data for optimization models.
4. Capacity building and training: Continuous training programs should be organized for hospital administrators, health information officers, and planning units to enhance analytical skills and understanding of data-driven decision-support systems.

Building on the findings of this study, several directions are recommended for future research to deepen understanding and enhance the practical application of quantum-inspired multi-objective optimization (QIMOO) in healthcare systems, particularly within the Nigerian context:

1. Expand the scope to multiple tiers of healthcare: Future studies should examine the applicability of QIMOO across primary, secondary, and tertiary healthcare facilities to capture variations in resource constraints, service demand, and managerial capacity.
2. Undertake longitudinal studies: Long-term studies are needed to assess the sustained impact of QIMOO on healthcare resource allocation effectiveness, patient outcomes, and operational costs over time.
3. Incorporate patient-centered outcome measures: Subsequent research should integrate patient satisfaction, waiting time reduction, and quality-of-care indicators to better link optimization outcomes with patient experiences.

Declaration of Competing Interest

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

References

Adepoju, A. O., & Olaniyan, O. (2021). Healthcare resource allocation challenges in Nigeria. *Journal of Health Systems Research, 8*(2), 45–60.

Brailsford, S. C., Harper, P. R., Patel, B., & Pitt, M. (2019). An analysis of the academic literature on simulation and modelling in health care. *Journal of Simulation, 13*(1), 1–24. https://doi.org/10.1080/17477778.2019.1572075

Coello, C. A. C., Lamont, G. B., & Van Veldhuizen, D. A. (2007). *Evolutionary algorithms for solving multi-objective problems* (2nd ed.). Springer. https://link.springer.com/book/10.1007/978-0-387-36797-2

Deb, K. (2001). *Multi-objective optimization using evolutionary algorithms*. John Wiley & Sons. https://onlinelibrary.wiley.com/doi/book/10.1002/9780470743614

Dash, S., Shakyawar, S. K., Sharma, M., & Kaushik, S. (2019). Big data in healthcare: Management, analysis and future prospects. *Journal of Big Data, 6*(1), 54. https://doi.org/10.1186/s40537-019-0197-0

Das, S., & Chakrabarti, B. K. (2021). *Quantum annealing and related optimization methods*. Springer. https://link.springer.com/book/10.1007/978-981-15-9552-0

García-Sánchez, P., Lozano, M., & Herrera, F. (2020). Quantum-inspired multi-objective optimization: A survey. *Computational Intelligence Review, 12*(4), 321–350. https://doi.org/10.1007/s00521-020-04763-6

Glover, F., Kochenberger, G., & Du, Y. (2018). *Quantum-inspired metaheuristics*. Springer. https://link.springer.com/book/10.1007/978-3-319-77636-5

Holt, D. T., Armenakis, A. A., Feild, H. S., & Harris, S. G. (2007). Readiness for organizational change. *The Journal of Applied Behavioral Science, 43*(2), 232–255. https://doi.org/10.1177/0021886306295295

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2019). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). Sage Publications.

https://us.sagepub.com/en-us/nam/a-primer-on-partial-least-squares-structural-equation-modeling-pls-sem/book244583

Hillier, F. S., & Lieberman, G. J. (2020). *Introduction to operations research* (10th ed.). McGraw-Hill Education. https://www.mheducation.com/highered/product/introduction-operations-research-hillier/M9781259872990.html

Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). Guilford Press. https://www.guilford.com/books/Principles-and-Practice-of-Structural-Equation-Modeling/Rex-B-Kline/9781462523344

Kwon, O., Lee, N., & Shin, B. (2014). Data quality management, data usage experience and acquisition intention of big data analytics. *International Journal of Information Management, 34*(3), 387–394. https://doi.org/10.1016/j.ijinfomgt.2014.03.002

Orús, R., Mugel, S., & Lizaso, E. (2019). Quantum computing for optimization: A review. *Nature Reviews Physics, 1*(5), 333–348. https://doi.org/10.1038/s42254-019-0043-1

Rafferty, A. E., Jimmieson, N. L., & Armenakis, A. A. (2013). Change readiness: A multilevel review. *Journal of Management, 39*(1), 110–135. https://doi.org/10.1177/0149206312457417

Rais, A., & Viana, A. (2011). Operations research in healthcare: A survey. *International Transactions in Operational Research, 18*(1), 1–31. https://doi.org/10.1111/j.1475-3995.2010.00792.x

Robinson, J. C. (2015). *Healthcare operations management*. Jossey-Bass. https://www.wiley.com/en-us/Healthcare+Operations+Management-p-9781118751269

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425–478. https://www.jstor.org/stable/30036540

Wang, R. Y., & Strong, D. M. (1996). Beyond accuracy: What data quality means to data consumers. *Journal of Management Information Systems, 12*(4), 5–33. https://doi.org/10.1080/07421222.1996.11518099

Weiner, B. J. (2009). A theory of organizational readiness for change. *Implementation Science, 4*(1), Article 67. https://doi.org/10.1186/1748-5908-4-67

Zhu, J. (2016). *Multi-objective optimization and applications*. Springer. https://link.springer.com/book/10.1007/978-3-319-27877-8