


## Decision Engineering in Healthcare: How Medical Professionals Prioritize Resource Distribution

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### ABSTRACT

The equitable distribution of healthcare resources remains a pressing challenge across diverse healthcare systems globally. This study aims to explore the decision-making processes employed by medical professionals in the allocation of healthcare resources, emphasizing the ethical, technological, and management dimensions that influence these decisions. A qualitative research approach was employed, utilizing semi-structured interviews to collect data from a diverse group of 27 medical professionals, including physicians, nurses, and hospital administrators. Interviews were conducted until theoretical saturation was reached, ensuring a comprehensive exploration of decision-making processes. The data were analyzed using thematic analysis to identify recurring themes and patterns. Three main themes were identified: Ethical Considerations, Technology in Decision Making, and Resource Management. These encompassed several categories: under Ethical Considerations, Patient Equity, Decision Transparency, Ethical Dilemmas, and Prioritization Criteria were discussed; Technology in Decision Making included Data Utilization, Decision Support Systems, and Integration Challenges; Resource Management covered Allocation Efficiency, Resource Distribution Challenges, Impact on Patient Care, and Human Factors. Each category highlighted specific issues and strategies relevant to healthcare resource distribution. The study highlights the complex interplay of ethical dilemmas, technological advancements, and practical resource management challenges in healthcare decision-making. It underscores the need for an integrated approach that addresses these dimensions to improve the equity and efficiency of resource distribution in healthcare settings.

**Keywords:** *Healthcare Decision-Making, Resource Allocation, Ethical Considerations, Technology in Healthcare, Resource Management*

## 1. Introduction

The equitable distribution of healthcare resources is a perennial challenge globally, accentuated by variations in economic, geographical, and demographic factors. Decisions on how these resources are allocated are crucial as they affect the overall efficiency of healthcare systems and impact patient outcomes significantly. Decision engineering in healthcare, therefore, is not merely a managerial task but a complex ethical engagement that requires a deep understanding of multifaceted human, societal, and technological factors (Vahedi et al., 2020; Zandian et al., 2018).

Healthcare systems across the world grapple with the allocation of limited resources across an ever-increasing demand for medical services. Studies such as those by Ao et al. (2022) and Dong et al. (2022) highlight the disparities in resource allocation within national healthcare systems, observing how rural and underserved areas frequently suffer from inadequate healthcare provisions (Ao et al., 2022; Dong et al., 2022). Similarly, Akbarialiabad et al. (2021) discuss how external factors like sanctions have exacerbated healthcare challenges by straining resource distribution in Iran, pointing to the need for robust decision-making frameworks that can adapt to political and economic upheavals (Akbarialiabad et al., 2021).

Further complicating this landscape is the distribution of healthcare professionals, which is often skewed towards urban centers, leaving peripheral and rural areas underserved. This geographical inequity in healthcare access is extensively documented by researchers like Manesh et al. (2021) and Rój (2020), who note the persistent gaps in healthcare human resource distribution (Manesh et al., 2021; Rój, 2020). Such disparities not only undermine healthcare equity but also sustainability, as inadequate resource distribution can lead to overburdened facilities and compromised patient care in densely populated or more affluent areas.

Technological advancements offer promising avenues for enhancing healthcare resource allocation. Innovations in data management and clinical decision support systems, as discussed by Semenov et al. (2019), suggest that technology could play a pivotal role in addressing disparities (Semenov et al., 2019). Yet, the integration of such technologies brings its own set of challenges, such as ensuring the confidentiality of patient data and the need for significant investments in infrastructure and training, which might not be feasible for all regions.

Chronic conditions further strain resource distribution, demanding long-term management strategies that can overwhelm healthcare systems not equipped with adequate resources or planning. Farré et al. (2016) and Azadnajafabad et al. (2021) explore how chronic disease management requires a substantial and sustained allocation of medical resources, underscoring the importance of strategic planning and prioritization in healthcare decisions (Azadnajafabad et al., 2021; Farré et al., 2016).

Patient safety and healthcare outcomes, as emphasized by Behzadifar et al. (2019), are directly influenced by how well resources are managed and allocated. Poor resource allocation can lead to higher incidences of medical errors and reduced quality of care, highlighting the critical nature of effective decision engineering in healthcare (Behzadifar et al., 2019).

This article seeks to explore these issues through qualitative research, focusing on how medical professionals make resource distribution decisions within various healthcare settings. By conducting semi-structured interviews with a diverse group of healthcare providers, this study aims to achieve theoretical saturation in understanding the mechanisms, challenges, and ethical considerations that underlie resource distribution decisions. The insights garnered will not only contribute to academic discourse but also offer practical guidance for policymakers and healthcare administrators striving to optimize resource allocation in increasingly complex healthcare landscapes.

## 2. Methods and Materials

### 2.1. Study Design and Participants

This study utilized a qualitative research design to explore decision engineering practices in healthcare, focusing on how medical professionals prioritize resource distribution. We aimed to understand the underlying mechanisms, challenges, and strategies through the insights of the professionals directly involved in this process.

The participants comprised a diverse group of medical professionals, including physicians, nurses, hospital administrators, and department heads, who have direct experience in resource allocation in healthcare settings. They were recruited from various healthcare facilities, including urban and rural hospitals, to ensure a wide range of insights and experiences.

The study was designed to reach theoretical saturation, a point at which no new information or themes are observed in the data. This was achieved after conducting interviews

with a sufficient number of participants, ensuring comprehensive coverage of the subject matter. Theoretical saturation was used as a benchmark to conclude data collection, ensuring the depth and reliability of the information gathered.

All participants provided written informed consent, were informed of their rights to confidentiality and anonymity, and were allowed to withdraw from the study at any time without any consequences.

## 2.2. Measures

### 2.2.1. Semi-Structured Interview

Data were collected through semi-structured interviews, which were designed to allow participants to freely express their views while ensuring that all relevant topics were covered. The interview guide included open-ended questions addressing topics such as criteria for resource prioritization, decision-making processes, the role of technology in decision engineering, and the ethical considerations involved.

The interviews, each lasting between 45 to 60 minutes, were conducted by researchers trained in qualitative data collection methods. All interviews were recorded with the consent of the participants and later transcribed verbatim for analysis.

**Table 1**

*The Results of Qualitative Analysis*

Categories	Subcategories	Concepts
Ethical Considerations	Patient Equity	- Socioeconomic status - Access to care - Health disparities
	Decision Transparency	- Communication strategies - Policy explanations - Stakeholder engagement
	Ethical Dilemmas	- Rationing of care - End-of-life decisions - Emergency prioritization - Personal values vs. professional guidelines
	Prioritization Criteria	- Severity of condition - Urgency of need - Probability of benefit
Technology in Decision Making	Data Utilization	- Electronic health records - Patient monitoring data - Historical data analysis
	Decision Support Systems	- Algorithmic recommendations - Predictive analytics - Clinical decision support tools
	Integration Challenges	- System interoperability - Data privacy - Technology adoption barriers

## 2.3. Data Analysis

The transcribed interviews were analyzed using thematic analysis, a method for identifying, analyzing, and reporting patterns (themes) within data. The analysis was iterative, where initial codes were generated from the data and continually refined. This process involved reading and rereading the transcripts, noting initial ideas, and systematically coding the data to construct meaningful patterns.

## 3. Findings and Results

In this study, a total of 27 medical professionals participated, providing a broad spectrum of insights into the decision engineering processes in healthcare. The demographic composition of the participants included 14 physicians (51.9%), 8 nurses (29.6%), and 5 hospital administrators (18.5%). Among these, 15 participants (55.6%) were female, and 12 (44.4%) were male, reflecting a balanced gender representation. The ages of the participants ranged from 28 to 62 years, with a median age of 45 years. Participants hailed from a variety of healthcare settings: 12 (44.4%) worked in urban hospitals, 10 (37%) in suburban facilities, and 5 (18.5%) in rural healthcare centers.

Resource Management	Allocation Efficiency	<ul style="list-style-type: none"> <li>- Resource utilization</li> <li>- Waste reduction</li> <li>- Cost-effectiveness</li> </ul>
	Resource Distribution Challenges	<ul style="list-style-type: none"> <li>- Supply shortages</li> <li>- Distribution logistics</li> <li>- Geographical disparities</li> </ul>
	Impact on Patient Care	<ul style="list-style-type: none"> <li>- Wait times</li> <li>- Quality of care</li> <li>- Patient satisfaction</li> </ul>
	Human Factors	<ul style="list-style-type: none"> <li>- Staff workload</li> <li>- Decision fatigue</li> <li>- Training and education needs</li> <li>- Emotional impact on staff</li> </ul>

The thematic analysis of the semi-structured interviews with 27 healthcare professionals yielded three principal themes, each comprising several categories with distinct concepts that illustrate the nuanced aspects of decision engineering in healthcare.

Ethical Considerations emerged as a pivotal theme. Under Patient Equity, participants expressed concerns about ensuring fair access across diverse patient populations. One physician noted, "We continually strive to balance care delivery so that patient's socioeconomic status does not dictate the quality of care they receive." Decision Transparency was highlighted as crucial for maintaining trust, with one administrator stating, "Transparency in how decisions are made not only builds trust but also facilitates better understanding and compliance among stakeholders." Ethical Dilemmas often involved tough choices, as reflected in a nurse's comment: "Every day, we face situations where we have to choose who gets what resource, which is always a morally challenging decision." Lastly, Prioritization Criteria was discussed in terms of clinical urgency and potential outcomes, with a doctor explaining, "We prioritize based on a combination of clinical urgency and the potential for patient recovery."

Technology in Decision Making was the second theme, where Data Utilization was seen as a cornerstone for informed decisions. A participant emphasized, "Utilizing data from electronic health records allows us to make evidence-based decisions efficiently." In Decision Support Systems, the potential for technology to aid decision-making was clear, as one physician mentioned, "Decision support systems can drastically reduce errors and optimize our resource distribution." However, Integration Challenges related to adopting new technologies were also significant, with a nurse pointing out, "Integrating new technologies is often hindered by both systemic inertia and technical issues."

Resource Management included discussions on Allocation Efficiency, where a hospital administrator noted, "Efficient resource management means less waste and more care where it's needed most." The Resource Distribution Challenges category highlighted logistical issues, especially in rural settings, as mentioned by one doctor: "Getting resources to rural areas is a logistical challenge that requires innovative distribution strategies." Impact on Patient Care revealed that resource decisions directly affect patient outcomes, as stated by a nurse: "When resources are tight, patient care can suffer, leading to longer recovery times and lower satisfaction." Lastly, Human Factors reflected on the personal impact on staff, with a physician expressing, "The emotional toll on our staff is considerable, affecting their decision-making and overall well-being."

#### 4. Discussion and Conclusion

In our study, three main themes were identified, each encompassing several categories that reveal the complex dimensions of decision engineering in healthcare. The themes included "Ethical Considerations," "Technology in Decision Making," and "Resource Management." These themes reflect the multifaceted challenges and considerations involved in healthcare resource distribution, encompassing ethical dilemmas, technological integration, and practical management issues.

The theme of "Ethical Considerations" emerged strongly in our findings, highlighting the moral complexities inherent in healthcare decision-making. Categories within this theme included Patient Equity, Decision Transparency, Ethical Dilemmas, and Prioritization Criteria. Patient Equity addressed issues like socioeconomic status, access to care, and health disparities, reflecting concerns about fair treatment across different patient groups. Decision Transparency focused on the need for clear communication strategies, policy explanations, and stakeholder engagement

to maintain trust and clarity in decision processes. Ethical Dilemmas encapsulated the tough choices faced by healthcare providers, such as rationing of care, end-of-life decisions, and emergency prioritization, often influenced by conflicts between personal values and professional guidelines. Lastly, Prioritization Criteria explored how decisions are made based on the severity of condition, urgency of need, and probability of benefit, highlighting the criteria used to navigate resource constraints.

The second main theme, "Technology in Decision Making," covered how technological advancements are influencing healthcare resource distribution. This theme included categories such as Data Utilization, Decision Support Systems, and Integration Challenges. Data Utilization involved leveraging electronic health records, patient monitoring data, and historical data analysis to inform decision-making. Decision Support Systems were discussed in terms of their role in providing algorithmic recommendations, predictive analytics, and clinical decision support tools that assist in making more informed and efficient decisions. Integration Challenges pointed to issues like system interoperability, data privacy concerns, and barriers to technology adoption, which can hinder the effective use of technology in healthcare settings.

The final theme, "Resource Management," addressed the strategies and obstacles in the effective allocation and management of healthcare resources. Categories under this theme included Allocation Efficiency, Resource Distribution Challenges, Impact on Patient Care, and Human Factors. Allocation Efficiency dealt with optimizing resource utilization, reducing waste, and enhancing cost-effectiveness. Resource Distribution Challenges captured the difficulties in managing supply shortages, distribution logistics, and geographical disparities. Impact on Patient Care revealed how resource decisions affect wait times, quality of care, and patient satisfaction. Lastly, Human Factors discussed the effects of staff workload, decision fatigue, training needs, and emotional impacts on healthcare providers, underscoring the human element in healthcare resource management.

One prominent theme that emerged from the interviews was the ethical complexity surrounding healthcare decisions. Participants frequently discussed the balance between equity and efficiency, reflecting a pervasive dilemma in healthcare settings worldwide. Similar ethical concerns have been reported by Akbarialiabad et al. (2021), who highlighted how external pressures such as sanctions can exacerbate resource allocation challenges, forcing healthcare providers

to make tough decisions under resource scarcity. This aligns with our findings, where participants often cited external and systemic pressures as significant factors influencing their decision-making processes (Akbarialiabad et al., 2021).

Another significant finding was the potential and challenges associated with integrating technology into healthcare decision-making. Participants expressed optimism about the role of data analytics and decision support systems in improving resource allocation efficiency. This is corroborated by Semenov et al. (2019), who demonstrated the effectiveness of a medical data management platform in providing clinical decision support (Semenov et al., 2019). However, consistent with the challenges noted by Meng et al. (2019) regarding the uneven distribution of high-quality healthcare resources, our study participants also reported disparities in technological adoption and integration, suggesting that while technology offers solutions, it also requires careful implementation to avoid exacerbating existing inequalities (Meng et al., 2019).

Geographic disparities in resource distribution were also highlighted in our study, with rural areas often receiving fewer resources than urban centers. This finding echoes the work of Manesh et al. (2021) and Rój (2020), who documented similar disparities in the distribution of healthcare human resources (Manesh et al., 2021; Rój, 2020). The participants in our study emphasized the need for policies that specifically address these geographic disparities, suggesting targeted allocations and strategic placements of resources as possible solutions.

The impact of resource allocation decisions on patient care and safety was a critical concern among participants. They noted that inadequate resource distribution could lead to compromised care quality and safety, a finding supported by Behzadifar et al. (2019), who linked poor resource allocation to reduced patient safety culture (Behzadifar et al., 2019). Our study's insights into how resource distribution affects patient outcomes highlight the need for a systemic approach that incorporates both clinical and managerial perspectives to enhance overall healthcare delivery.

Finally, our findings underscore the importance of sustainability in resource distribution, particularly in managing chronic diseases, which require long-term resource commitment. This is in line with the observations by Farré et al. (2016), who discussed the economic burdens of chronic heart failure management. Participants advocated for more strategic, long-term planning in resource allocation to better manage both acute and chronic healthcare demands (Farré et al., 2016).



This study provided an in-depth examination of decision engineering in healthcare, specifically focusing on how medical professionals prioritize resource distribution. The findings highlighted several key areas: ethical considerations in decision-making, the impact of technology on resource allocation, geographic disparities in resource distribution, the effects of resource allocation on patient care and safety, and the necessity for sustainable long-term planning. These insights reveal the complexity and the multidimensional nature of decision-making in healthcare environments.

In conclusion, our study elucidates the critical nature of decision engineering in healthcare, shedding light on the diverse factors that influence resource distribution decisions. By integrating perspectives from a range of medical professionals, the research underscores the need for balanced, ethical decision-making that considers both immediate patient needs and long-term healthcare sustainability. The findings advocate for a nuanced approach to resource allocation that is sensitive to ethical dilemmas, geographical inequities, and the potential of technological advancements, aiming to enhance the overall effectiveness and equity of healthcare systems.

This study is not without its limitations. The qualitative nature of the research, while in-depth, restricts the generalizability of the findings across broader populations or different healthcare systems. Additionally, the theoretical saturation approach, though rigorous, might not capture all possible perspectives, particularly those of less represented groups or emerging challenges that were not prevalent at the time of the interviews. The focus on semi-structured interviews, while providing rich qualitative data, also means that certain quantitative aspects of decision-making were not explored.

Future research should aim to address these limitations by incorporating quantitative methods to validate and extend the qualitative findings. Studies could employ mixed-methods approaches to explore how the insights gathered here hold up across different demographic and geographic contexts. Additionally, future research could also investigate the impact of recent healthcare reforms and technological innovations on resource distribution decisions, providing a dynamic and updated perspective on the evolving challenges in healthcare.

For practice, this study suggests that healthcare institutions should focus on developing clear, transparent policies that support ethical decision-making while considering local needs and conditions. Training programs

that enhance awareness and application of ethical principles in resource allocation should be standard. Furthermore, the adoption and integration of advanced decision-support technologies could be accelerated to help balance efficiency and equity. Healthcare leaders should also advocate for policies that address geographic disparities in resource distribution, ensuring that rural and underserved areas receive adequate attention and resources. These practices, informed by the findings of this study, could lead to more equitable and effective healthcare systems, ultimately improving patient outcomes.

### Authors' Contributions

Authors contributed equally to this article.

### Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

### Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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### Declaration of Interest

The authors report no conflict of interest.

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### Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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