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Utilization of Multi-Stakeholder Visualization in Medical Management Strategy Development: A Case Study of the BSP Cardiovascular Detection Project

Shunjia Zhang[1] and Yuan Liu[2,*]

[1]Hunan University, Changsha, Hunan, China
[2]Beijing Institute of Fashion Technology, Beijing, China

ABSTRACT

In the wake of the rapid advancement of medical informatization, the diversity of stakeholders involved in medical scenarios has expanded, rendering traditional management models inadequate for addressing the needs of multi-party collaboration. Against the backdrop of cardiovascular health detection management, this study delves into the requirements of five distinct stakeholder groups: testers, customer service representatives, nurses, doctors, and management personnel. It aims to design a suite of visualization tools to bolster management decision-making processes. The implementation of the tool drew upon educational methods and tools, such as problem-based learning and collaborative learning. By comprehensive user research, we pinpoint gaps in existing medical management systems concerning stakeholder inclusion and visual decision support, subsequently proposing a web- and mobile-based visualization solution. The present study utilizes semi-participatory observation and in-depth interviews to gather requirements and devises a visualization system encompassing data statistics, workflow optimization, and information architecture. Practical implementation reveals that the tool substantially improves collaboration efficiency among various roles, offers intuitive data support for management, and refines resource allocation decisions. This present study provides new visual design ideas and practical references for multi-stakeholder collaborative management in medical scenarios.

Keywords: Multi-stakeholder visualization tools, Medical informatization, Cardiovascular detection, UX design

INTRODUCTION

The relentless progression of medical informatization is fundamentally transforming management models within the healthcare sector, with multi-stakeholder collaboration emerging as a pivotal element in enhancing medical efficiency. Traditional research has primarily concentrated on the needs of patients and healthcare professionals, inadvertently neglecting the critical

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contributions of support staff, such as customer service representatives and testing technicians, to medical processes. This present study leverages the BSP Cardiovascular Detection Project as a practical case study to investigate the design and application of visualization tools in multi-stakeholder collaborative environments.

As the complexity of medical information systems increases, management faces significant challenges in resource allocation and decision-making. Current mainstream practices include the integrated "medical-nursing-administration" platform of West China Hospital, which unifies clinical, nursing and management data to realize whole-process collaborative management of chronic diseases, effectively boosting patient satisfaction and resource circulation efficiency (Zhang et al., 2024). The DRG intelligent platform of Jinshan Hospital Affiliated to Fudan University connects medical insurance and clinical data to assist precise cost control and departmental resource allocation (Cai and Zhou, 2023). Such models have solved prominent problems including data silos, fragmented business processes and experience-based decision-making, promoting the transformation of resource allocation from extensive to refined mode. Nevertheless, several deficiencies still exist. Cross-role collaborative design is lacking, and data linkage among customer service, medical staff and management remains weak. Visualization tools are poorly matched with specialized scenarios such as cardiovascular medicine, making it hard to support professional decision-making. Meanwhile, system expansion and customization cost highly, and the capability of heterogeneous data fusion and real-time decision support is still insufficient. On one hand, they need to integrate data streams from various sources, including testers, customer service representatives, nurses, and doctors. On the other hand, they lack effective visualization tools to support rapid decision-making. Existing solutions often suffer from two major limitations: first, they serve only a single user group and lack cross-role collaborative design; second, their visualization forms are not well-matched with specialized medical scenarios, making it difficult to meet the decision-making needs of professional fields such as cardiovascular detection.

This present study adopts design research methods as its core and systematically advances tool development through four key stages:

1) In the requirement investigation stage, semi-participatory observation and in-depth interviews are used to collect work pain points from five core stakeholder groups;
2) In the requirement analysis stage, user journey maps and the KJ method (Kawakita Jiro method, also known as the affinity diagram method) are employed to identify three core needs: information visualization, process visualization, and status visualization;
3) In the tool design stage, differentiated visualization interfaces are developed based on the Ant Design system;
4) In the evaluation stage, usability testing is conducted to verify the design effectiveness. The study pays particular attention to customer service representatives and management personnel, given their pivotal roles in patient experience and resource allocation. Distinguishing itself from conventional single-role or clinician-centric designs, this research adopts a multi-stakeholder collaborative visualization framework and develops

role-tailored web and mobile interfaces to enable real-time cross-role coordination and data-driven decision-making. Expanding the analytical framework for medical stakeholders;

Practical application shows that the visualization tool significantly optimizes medical management processes, the rate of redundant information entry is greatly reduced, and the decision-making cycle for management is significantly shortened. These improvements are verified through multiple approaches, including stakeholder questionnaires, and in-depth interviews, providing comprehensive quantitative and qualitative evidence for tool effectiveness.These achievements validate the value of multi-stakeholder collaborative visualization design and provide new ideas for informatization construction in specialized medical scenarios. The main contributions of this study are:

1) Expanding the analytical framework for medical stakeholders;
2) Developing a visualization design scheme adapted to specialized fields;
3) Establishing a multi-dimensional indicator system for evaluating the effectiveness of medical management tools.

Stakeholder Analysis in Medical Scenarios

The medical scenario represents a complex ecosystem involving numerous stakeholders. Traditional research has primarily focused on two major groups: patients and healthcare professionals (Freeman, 2010). As direct recipients of medical services, patients' needs and experiences have consistently been the focus of research (Shortell et al., 1996); healthcare professionals, including doctors and nurses, are the main providers of medical services, and their work efficiency and workflow optimization have attracted significant attention (Berry and Bendapudi, 2007). Nonetheless, with the development of medical informatization, the stakeholder network in medical scenarios has become more intricate (Kaplan and Norton, 1992). According to our research findings, five stakeholder groups—customer service representatives, testing technicians, medical equipment managers, data analysts, and management personnel—need to be considered but have not received sufficient attention (Ware, 2012). The consideration of these newly added stakeholders is crucial because the efficiency of customer service representatives directly affects patient experience and institutional operational efficiency (Tufte, 1983); optimizing the workflow of testing technicians can significantly enhance detection efficiency (Keim et al., 2008); taking into account the needs of medical equipment managers can extend the service life of equipment (Thomas and Cook, 2005); the involvement of data analysts can improve data quality (Amar et al., 2005); and management decisions require comprehensive and accurate data support (Few, 2006). Neglecting any link may lead to system inefficiency and impact overall service quality.

We ultimately focused on in-depth analysis of the two types of stakeholders, namely customer service staff and management, mainly based on three considerations Firstly, from the perspective of research feasibility, the data accessibility of customer service and management is relatively high (customer

service call records and management decision-making data can be directly collected), and these two types of roles have the highest degree of digitalization in the existing system, which is convenient for visualization transformation; secondly, from the perspective of research value, customer service, as the first touchpoint of patient experience, directly affects service satisfaction, while management, as the decision-making core of resource allocation, has the most urgent need for visualization. There is a typical problem of information asymmetry between the two, and visualization can generate the greatest synergy benefits; Finally, considering the priority of technical implementation, the work of detection technicians and medical equipment managers relies more on hardware system integration, which goes beyond the scope of pure software visualization solutions, while the needs of data analysts can be covered through an optimized management view. It should be noted that this choice is based on the consideration of the research's phased nature. In subsequent studies, we will incorporate the roles of other stakeholders in phases to build a more complete visualization system for medical management.

Application of Visualization Tools in Medical Scenarios

The application of visualization tools in medical scenarios primarily manifests in the following aspects: On the web side, data visualization dashboards are widely employed in hospital management systems (Mayo Clinic, 2020; Kaiser Permanente, 2019). For instance, the operational dashboard developed by Mayo Clinic visualizes key metrics such as outpatient volume and equipment utilization rates, assisting managers in identifying bottlenecks (Isenberg et al., 2011). The appointment system at Kaiser Permanente optimizes physician scheduling by visually displaying appointment densities across different time slots (Shneiderman, 1996). These systems generally adopt a "overview-detail" visualization model, initially presenting key metrics before supporting drill-down analysis (Norman, 2013). On the mobile side, applications like WeDoctor visually display nearby medical resources on maps to help patients locate services quickly (Nielsen, 1993), while Chunyu Doctor uses a timeline format to clearly present appointment processes (Topol, 2019). These designs significantly reduce cognitive load for users and enhance service efficiency (Lupton, 2020). In terms of innovative visualization applications, some systems have begun experimenting with predictive visualizations, such as using heatmaps to forecast peak outpatient hours (Bates et al., 2018) or analyzing drug interactions through relational network diagrams (Kilsdonk et al., 2016). These forward-looking visualization tools can provide managers with deeper decision support.

But most existing visualization tools cater solely to single user groups, lacking support for collaborative work among multiple stakeholders. Our research addresses this gap by developing a multi-role visualization management system.

METHODOLOGY

The development of visualization tools in this study followed an iterative process encompassing problem identification, solution design, implementation, and evaluation (Mayo Clinic, 2020). The research process was divided into four stages:

1) During the requirements gathering phase, semi-participatory observation and in-depth interviews were employed to collect needs. We conducted 10 complete observation sessions of the testing process, totaling over 40 hours. Based on these observations, we conducted in-depth interviews with 10 individuals representing five stakeholder groups to understand their workflows, pain points, and needs for visualization tools.

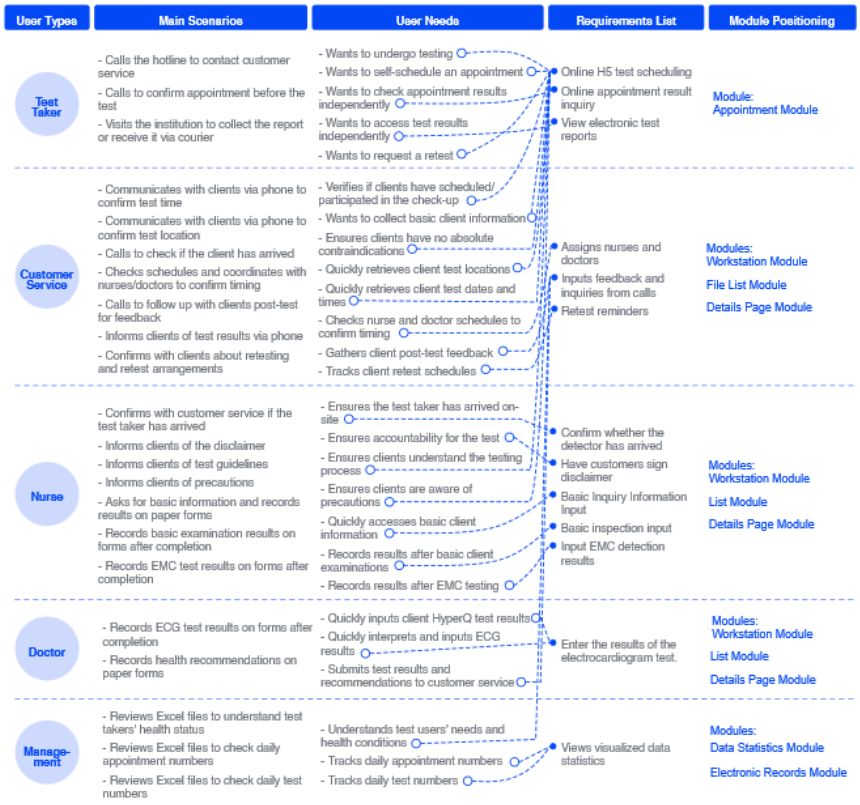


Figure 1: Mapping of requirements and functional.

2) In the requirements analysis phase, user journey maps were used to analyze touchpoints and pain points for each role before, during, and after testing. The KJ method was employed to categorize requirements into information visualization needs, process visualization needs, and status visualization needs. For management, we identified the need to monitor indicators such as appointment volume, testing volume, and positivity rates; for healthcare professionals, the focus was on real-time status visualization of the testing process; and for customer service and testers, clear visualization of appointment status was required. During the tool design phase, based on the Ant Design system, differentiated interfaces were constructed for different roles: the management dashboard integrated appointment trend charts, testing volume statistics, positivity rate distributions, appointment trend heatmaps, and regional distribution maps; the healthcare professional workstation utilized red-yellow-green status cards and flowcharts for guidance; the customer service interface

developed intelligent calendar views with automatic reminder functions; and the tester mobile app implemented radar charts for test reports and timeline comparisons of historical data.

3) In the evaluation phase, cognitive walkthroughs and usability testing were conducted to validate design effectiveness. Five stakeholder representatives were invited to complete typical tasks, with completion times and error rates recorded. After collecting feedback, two rounds of iterative optimization were performed, focusing on improving data filtering and outlier indication functions. Visualization design adhered to principles such as consistency, progressive disclosure, immediate feedback, and multi-platform adaptability (Norman, 2013; Nielsen, 1993; Topol, 2019; Lupton, 2020; Bates et al., 2018; Kilsdonk et al., 2016).

Table 1: Summary diagram of feedback on efficiency improvements.

Terminal Type	Function Module or Process	Number	Desoription of Ways of Improving
Web Product	Form Page	1	The entire process is from traditional form filling to platform information input
		2	The entire process is from traditional fom filling to platform information input
	Global Page	3	Present irreversible prompts,provide operation prediction
	Data Visualization Page	4	Top card adds gradient color blocks to highlight information hierarchy importance and efficiency
Mobile H5	Global Page	5	Efficient input of system information from mobile end after phone communication
	Research Process	6	Provide time node options.Time selection format for efficiency improvement
		7	Explanation guidance,increased user memory burden efficiency

Discussion and Results

This present study adopted an iterative development approach, systematically advancing the development of visualization tools through four key stages. To further verify the actual usability and experience improvements brought by the system, in-depth interviews were conducted with 10 users covering five core stakeholder groups, including 2 testers, 2 customer service representatives, 2 nurses, 2 doctors, and 2 managers. The interview results revealed consistent pain points in the traditional workflow: testers suffered from medical terminology barriers and privacy anxiety during telephone registration; customer service staff were burdened by repeated telephone communications and information entry; nurses and doctors complained about high error rates and low efficiency in paper-based form filling; and managers lacked real-time and intuitive data support for decision-making. After using the proposed visualization system, all interviewees confirmed significant reductions in repetitive workload, smoother cross-role collaboration, and clearer information presentation.

During the requirements analysis phase, this study systematically identified three core visualization needs by conducting an in-depth analysis of user journey maps for five user roles. The tester journey map uncovered three major pain points across six key touchpoints: barriers to understanding medical terminology during past medical history completion, inconvenience of frequent multi-platform switching in geographic location inquiries, and a sharp rise in privacy anxiety during information entry. These findings directly guided the mobile app design: visual symptom diagrams replaced text-based options, a map API was integrated to realize in-hospital navigation, and real-time prompts for data encryption status were added. In addition, the journey maps revealed obvious efficiency bottlenecks in the workflow of medical staff. Nurses suffered emotional depletion from handling massive forms during tester information registration, while doctors were troubled by overly hierarchical information structures when reviewing electronic medical records. Through clustering analysis using the KJ method, we converted these research insights into specific design specifications. A batch entry and intelligent validation component was developed for nurse workstations to greatly reduce repetitive operations; a medical record navigator was designed for doctor interfaces to ensure a high first-screen display rate of key information; and a risk heatmap was constructed for management decision-making. All design practices strictly followed three principles summarized from requirement analysis: immediate feedback, cognitive load reduction, and cross-platform consistency, enabling visualization tools to accurately address the core pain points in the actual workflow of each role.

In web-based visualization design, the management dashboard adopted a "total-detail" structure, displaying core metrics such as today's appointment count and this week's testing volume at the top, with gradient-colored cards used for emphasis. The middle section showcased a regional testing volume distribution map, enabling click-through access to district-level details. The bottom section displayed occupational distribution bar charts and positivity rate trend charts, both equipped with time range filtering options. The doctor workstation employed status tags and color coding to visually represent task progress. The nurse interface utilized flowcharts to guide standard operations and provided real-time updates on testing data entry status. In mobile visualization design, the tester appointment system featured a visual time selector presenting appointment densities as a heatmap. Test reports employed radar charts to display five key indicators and compare them with normal ranges. Historical records were organized in a timeline format, supporting swipe navigation to track changes in past test results.

For multi-role collaborative visualization, the system implemented a status propagation mechanism: when customer service assigned testing tasks, the nurse workstation updated the pending consultation list in real time; after nurses completed initial testing, the doctor interface automatically displayed cases pending review; and the management dashboard aggregated data from the entire process. This end-to-end visualization substantially enhanced collaboration efficiency, reducing the average task handover time from 15 minutes to instant updates. In terms of data visualization innovation, the system introduced two novel visualizations: a risk matrix diagram and a

resource load heatmap. After the system launch, appointment efficiency improved significantly, and average waiting times for testers decreased. Management reported that data visualization shortened decision-making cycles, highlighting that map visualization helped identify regional service gaps, guiding the establishment of new testing sites. Healthcare professionals noted that status visualization streamlined work handoffs and reduced information re-entry.

This study systematically assessed the efficiency improvements brought by visualization tools across various operational links. According to the efficiency improvement data in the following table, the digital transformation of web-based form pages markedly enhanced information entry efficiency, and the newly added navigation menu reduced the time to locate key functions to an average of 8 seconds . The irreversible prompt mechanism in global page design effectively minimized misoperations, while the gradient-colored block design in data visualization pages significantly increased management's attention to key indicators. The shift to mobile H5 yielded even more remarkable results: after replacing traditional phone communication with systematic information input, customer service representatives reduced the time to handle a single appointment from 15 minutes to 4 minutes; the optimized time selector improved appointment success rates; and intelligent guidance prompts substantially reduced users' memory burdens. These improvements collectively form the efficiency enhancement matrix of the visualization tool, among which the comprehensive performance improvement of the data visualization module is the most prominent. The average task completion time for each role has been significantly shortened, and the error rate has also been tremendously reduced. The test results show that by accurately grasping the operational characteristics of different terminals, this visualization tool has successfully transformed from the traditional operation mode to an intelligent visualization workflow.

Conclusion and Reflection

This present study designed and developed a visualization management system for multiple medical stakeholders, effectively supporting management decision-making and collaboration among various roles through collaborative design for both Web and mobile platforms. Practice has demonstrated that comprehensive consideration of stakeholders and appropriate visualization design can significantly enhance medical management efficiency. The primary contributions of this research include identifying often-overlooked medical stakeholder groups, particularly customer service staff, testing personnel, and management; developing a role-based visualization design scheme that provides comprehensive support from strategic decision-making to operational execution; and validating the value of visualization tools in improving medical management efficiency, notably reducing the average decision-making cycle. Through detailed case studies, this paper emphasizes the importance of focusing on often-overlooked non-core stakeholders in system design and demonstrates the practical value of user-centered design approaches in enhancing collaboration efficiency within complex healthcare

systems. However, the study also has some limitations, such as a relatively small sample size, being based solely on practices from a single institution, which means the generalizability of the conclusions remains to be verified; the visualization design primarily serves structured data and lacks sufficient handling of unstructured medical records; and the system offers limited support for predictive analysis, suggesting potential for integrating more machine learning algorithms in the future. For the future development of medical visualization tools, we suggest strengthening cross-institutional data visualization and supporting the collaboration of regional medical resources; and emphasize the usability design of visualization tools to lower the usage threshold for all roles. The practical significance of this study lies in offering new insights for medical informatization construction: effective management not only requires technological investment but also necessitates a comprehensive consideration of the needs and collaborative relationships of all stakeholders. Visualization, as a communication medium, can bridge cognitive gaps between different roles, create shared mental models, and ultimately enhance the overall quality of medical services.

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