Two-Stage Construction of Lean Healthcare Contradiction Matrix Based on LDA Topic Model and TRIZ Theory

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Abstract. Lean healthcare practice cases can serve as a valuable source of management experience and provide crucial insights for hospitals that are seeking to adopt lean management practices. This paper proposes a method for constructing a lean healthcare contradiction matrix using practice cases, which utilizes the problem-oriented systematic knowledge representation abilities of the TRIZ contradiction matrix. The method involves constructing contradiction pairs based on LDA topic model, constructing a contradiction matrix based on qualitative research and TRIZ theory, and obtaining the text of medical practice cases through the use of web crawling tools. Using LDA topic model, eight parameters were identified. Thirteen principles corresponding to contradiction pairs were obtained using the qualitative research coding analysis method, leading to the establishment of a lean healthcare contradiction matrix. The matrix provides a systematic knowledge retrieval mechanism for lean healthcare treatment and theoretical support for the implementation of lean management in hospitals.

Keywords: Lean healthcare; TRIZ; Contradiction matrix; Qualitative analysis; LDA topic model

1 Introduction

Hospitals only rely on the traditional problem-solving ideas of performance appraisal[1,2], it is difficult to solve the fine, quality and benefit challenges of hospital operation and management from the source[3,4,5](Govindan et al.,2022; Wang et al.,2022; Zhong et al.,2022; Wang et al.,2022). At present, lean management is gradually playing an important role in medical operation[6,7,8](Vanichchinchai et al.,2021; Mousavi et al.,2019; Abdallah et al.,2020). The core idea of lean management is to reduce waste, take the customer as the center, and provide customers with satisfactory products and services[9,10] (Leite et al.,2020; Yu et al.,2022). This management concept and its corresponding management tools are applicable to the field of medical services[11] (Koonce et al.,2020).

Lean healthcare is the application of lean thinking and tools to the healthcare service field. The core of implementing lean healthcare is lean management[12,13] (Henrique et al., 2021; Rao et al., 2021). The Virginia Mason Medical Center in Seattle, Washington, USA, began implementing lean management principles in 2000[14].(Kamo et al.,2017), while hospitals in China began practicing lean healthcare in 2002[15] (Graban et al.,2018). There are numerous

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practical experience in lean healthcare case studies, which typically adopt a problem-oriented approach to problem solving[16] (Régis et al.,2019). However, each practice report addresses a specific problem and is fragmented [17,18](Wang et al., 2016; Gu et al., 2021), therefore, it is necessary to study the knowledge representation method of lean medical model in order to systematically extract and share lean medical knowledge scattered in practice reports and realize knowledge reuse and sharing.

There are three main types of knowledge representation categories for converting case experience into formalizations, but no knowledge representation studies have been found for lean healthcare case experience. The first category is to establish a case base or knowledge base[19] (Chen et al.,2018), but this method is difficult to apply due to the diversity, complexity, and fragmentation of lean healthcare cases. The second category is to establish the matching of the case base with the existing knowledge base[20] (Calvaresi et al.,2020), but there is a lack of a reliable and generally accepted knowledge base for lean healthcare. The third category is the use of empirical methods for knowledge representation based on existing theories or modeling[21,22] (Benítez et al.,2015; Song et al.,2016; Sprinkle et al.,2018), but the existing types of theories are difficult to apply to characterize lean healthcare experience with many specialized vocabularies, complex processes, and fragmented distributions.

Highlights:

1) Proposing a new two-stage knowledge mining method

2) Providing theoretical support for hospitals to implement lean management

3) Broadening new perspectives for knowledge discovery and healthcare

2 Design of the lean healthcare contradiction matrix construction method

2.1 Method overview

The main flow of the lean healthcare contradiction matrix construction method is shown in Figure 1. The parallelogram in the figure represents the input and output; the diamond represents the judgment condition; the rectangle represents the work content; the arrow represents the process direction.

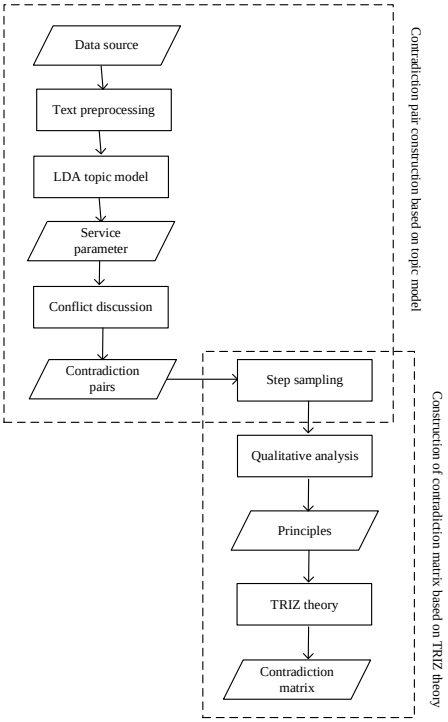

Figure.1 Build the main flow

The lean healthcare contradiction matrix construction method is comprised of two stages. The first stage involves the construction of contradiction pairs based on LDA topic model, with the goal of obtaining management parameters from these cases. The second stage involves the construction of the contradiction pairs and principles relationship, based on qualitative research and TRIZ theory.

3 Empirical study of the lean healthcare conflict matrix construction method

3.1 Data collection and processing

In this study, a python crawler program was written to crawl the health world (https://www.cn-healthcare.com) as a data source. In order to ensure the completeness and rationality of the proportion of each part of the multi-source data, it is necessary to conduct manual sorting and analysis, and finally collect 5003 effective cases.

3.2 Construction of contradiction pairs

Key topic-related words were extracted using the TF-IDF method and analyzed using the LDA model with hyperparameters estimated by the Gibbs sampling method. Symmetric Dirichlet

prior parameters were set for hyperparameters α and β, with values of 50/T and 0.01, respectively. We used 100 iterations of Gibbs sampling and a document contribution threshold ε of 1/T. To balance simplicity and adaptability, we tested a range of topics from 1 to 50 and identified 17 as the best solution based on the perplexity curve, which stabilized at that point.

These parameters can be divided into two categories as shown in Table 1. Information technology, security, professionalism, and standardization are positive parameters. When their values increase, the hospital's performance improves, and patients receive better medical services. On the other hand, capital control, timeliness, efficiency, and staff growth are negative parameters. Increasing or enhancing positive parameters results in an increase in negative parameters, and decreasing negative parameters weakens positive parameters. Therefore, there is a conflict between information technology, security, specialization, and standardization, and capital control, timeliness, efficiency, and employee growth.

Table.1 Lean healthcare management parameters

category	Subcategories	Service property parameters	Specific content	Number of documents	TRIZ engineering parameters
A1	Information technology	Informatization	Use information system equipment to provide intelligent medical services	66	Degree of automation
	Intelligent operation		Using artificial intelligence to assist data detection	30	
	Financing Cooperation		Financing to complete clinical technology product development	44	
…	…	…	…	…	…
A7	Process communication	Standardization	Process communication between departmental systems	117	Adaptability
A8	Employee Motivation	Employee Growth	Provide for medical staff performance evaluation indicators	45	System complexity
	Employee Responsibility		Provide for medical staff-related responsibilities	52	

3.3 Construction of contradiction pairs and principles relationships

3.3.1 Construction of principles

Based on the triangular validation theory, this study utilized a hierarchical approach to extract representative data sources and ensure the reliability of the qualitative research method. Six types of data were included, namely expert lecture videos, competition documents, official information, expert interviews, original articles, and on-site surveys in different years, to ensure the qualitative research method's integrity and depth. A stratified sample was then taken from the acquired 1095 data with the help of Nvivo12 qualitative analysis software, and 110 data items were coded and analyzed at a time, with the process repeated until no new concepts or categories were found after comparison with the obtained ones. The data were processed using

the rooting theory coding technique, where open-ended and spindle coding yielded 32 initial categories and 13 main categories as shown in Table 2.

Table.2 Open coding and spindle coding results

Label	Initial category	Main category	Description
Lean continuous improvement methodology is implemented in steps based on value streams	Process separation	1 Split	Easy disassembly of medical service flow, hospital department layout, etc.
Separation and classification of departmental classes	Section separation		
Staff training time is divided into several phases	Time segment		
Visualization and Kanban method to differentiate and manage drug inventory, warehouse and stock levels	Layout separation		
…	…	…	…
Eliminate medical service system, links	Cancellation of links	12 Abandonment	Eliminate part of the medical service process to ensure quality
Packing supplies specification size modification, medical record font size and spacing change	Specification change	13 Parameter change	Changing parameters of equipment, medical records, etc. in the medical service process
Change the packaging material of the prescription of drinking tablets	Improved packaging		

3.3.2 Construction of the contradiction matrix

By adapting TRIZ engineering parameters to lean medical service attribute parameters, Altshuller's contradiction matrix analysis method can establish a corresponding relationship between lean medical service parameters and the invention principle. For example, improving information parameters without deteriorating safety parameters can be solved by using asymmetry and curved methods according to contradiction matrix analysis method. According to this method and expert intervention integration, the contradiction matrix is finally determined as shown in Table 3.

Table.3 Lean healthcare contradiction matrix

Improvement parameters		Deterioration parameters							
		A1	A2	A3	A4	A5	A6	A7	A8
		Informatization	Securitization	Specialization	Efficiency	Funds Control	Timeliness	Streamlined	Employees Growth
A1	Informatization		4,9	3,7	12,13,8	5,6,7,3	5,6	4,12,8,2	4,8,2
A2	Securitization	6,9,2		3,5	3,10,1,4	7	3,9,6,4	3,4,11,8	6,4
A3	Specialization	5,3,9,12	4,3		5,4	4,9	7,4,10,9	3,5	10,6
A4	Efficiency	4,3,5,	4,3,6	4,5,9		4,6	9,6,5	4,9,6	4,3,13

		1	13					12	
A5	Funds Control	9,8	7,5	5	4,3		10,3	6,3,7	4,7
A6	Timeliness	12,4	7,9	9,5	7,9	9,5		4,13,3,5	9,1
A7	Streamlined	5,4,1,12	4,9	9	12,7	9,4	3,4		4,3,8,9
A8	Employees Growth	5,3	4,10,3	10,9	4,3	3,10	10	4,6,12	

4. Application examples of contradiction matrix

Case 1: Patient prioritization and manpower allocation

As an example, we can use hospital A to address the conflict between patient prioritization and manpower allocation. By referring to the contradiction resolution matrix from this paper, we can identify the resolution principles of this conflict as segmentation, mechanical system substitution, abandonment, and pre-operation. hospital A adopts the segmentation principle, which involves separating consultations from five tests, and the pre-operation principle, which involves establishing a pre-hospitalization office.

Under the segmentation principle, patients first go to the outpatient customer service station to take the five tests after registering, instead of having the receiving doctor conduct them. The results of the tests are entered into the hospital's system, enabling the receiving physician to view them promptly. This separation reduces the physician's repetitive and inefficient work, allowing them to spend more time consulting and communicating with patients. Critical patients are identified during the initial five tests to ensure their safety.

5 Discussions and conclusions

5.1 Contributions to theory

This paper constructs a two-stage service pattern mining method, which provides a decision-making process for hospitals to make lean management decisions. The practice of lean medical practice in Chinese hospitals is scattered in various media, and the fragmented practice text is transformed into systematic knowledge, which is conducive to knowledge sharing and reuse.

5.2 Contributions to practice

It is helpful to provide decision support and assistance for hospital managers. It has practical guiding significance to lean management practice in hospitals. It is helpful to identify contradiction problems in hospital management and provide efficient management decisions and guidelines, so as to improve patient services, medical quality and medical operation efficiency.

5.3 Limitations and future research

This paper has the following shortcomings for further research: the current mining is problem-driven case experience, which forms conflict-centered knowledge, and there is a lack of mining system-oriented knowledge, which needs to be further explored in subsequent research.

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